Susceptibility of *Populus* Species and Hybrids to Disease in the North Central United States

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ABSTRACT

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In test plantings of hybrid poplars in Iowa, Minnesota, and Wisconsin during 1976–1982, three foliar diseases and one canker disease were common and severe enough to be potentially damaging to yield. Disease incidence and severity varied by clone and location. Premature defoliation was caused by *Melampsora medusae, Marssonina brunnea,* and *Septoria musiva*. Highly susceptible trees were predisposed to environmental stress and infection by stress-related fungi. Stem breakage at cankers caused by *S. musiva* may preclude planting several of the tested clones in the north central United States. Successful plantation establishment and high biomass yields will require selecting disease-resistant clones.

Additional key words: disease resistance, intensive culture

Intensive culture of trees to provide economical woody biomass for fiber and energy has recently received much attention in the north central United States (3). Intensive management of plantations of rapidly growing, genetically improved trees can maximize fiber production. *Populus* is well suited for management and utilization because of its rapid growth, genetic diversity, ease of vegetative propagation, coppice regeneration, and suitability for energy and industrial uses.

Intensively cultured poplar plantations are expensive to establish and maintain (6); thus it is important that they be protected from diseases and insect injuries. Planting clones with a high degree of resistance to pathogens is the best preventive management strategy. Disease resistance is a major objective of most poplar selection and breeding programs. Little has been published on resistance of *Populus* clones to the major pathogens in the north central United States. In this paper, we report on diseases affecting several *Populus* species and hybrids in the north central United States.

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MATERIALS AND METHODS

Thirty-four clones from several interspecific crosses were planted in three areas. In 1976, plantations were established at the Rosemount Experimental Farm of the University of Minnesota, Dakota County (44° 30′N longitude, 93° W latitude) and at the Harshaw Forestry Research Farm near Rhinelander, WI, Oneida County (45° 30′N longitude, 89° 30′W latitude). In 1977, a plantation was established at the State Nursery, Iowa Conservation Commission, Ames, Story County (42° N, 93° 30′W latitude).

Twelve rooted hardwood cuttings per clone were planted in three four-tree plots at a spacing of 3 × 3 m in a completely randomized design. Weeds were controlled using glyphosate (Roundup) for the first 2 yr and by mowing thereafter. Incidence and severity of diseases were recorded in June, August, and September from 1976 to 1982. The following rating classes were used for all diseases: H = severe (premature defoliation throughout crown or multiple stem cankers), M = moderate (premature defoliation in lower crown and midcrown or few stem cankers or multiple branch cankers), L = slight (no defoliation or few branch cankers), and A = absent or trace. This rating method for foliar disease was similar to the one developed by Schreiner (7). Tree diameter and height were measured each September. A mean index of volume for each clone was calculated using the formula D^2H, where D is diameter at breast height and H is height of the surviving trees.

RESULTS

Survival and growth varied widely among clones and planting sites (Table 1). Stress from weed competition and associated dieback caused by *Cytospora chrysosperma* (Pers.) Fr. and damage caused by mowing and herbicide were the predominant causes for mortality of rooted cuttings during the first year. Later mortality resulted from foliar and canker diseases.

Several diseases were identified (Table 2). Most of these were foliar diseases that resulted in premature defoliation of highly susceptible clones. There was little variation in disease incidence or severity among replicates of the same clone at a particular site. Most clones were susceptible to more than one pathogen, but one usually predominated (Table 3). Severity of all diseases increased during the study. Clones stressed by premature defoliation each year became infected by *C. chrysosperma, Dothichiza populea* Sacc. & Br., and *Phomopsis macrospora* Kobayashi & Chiba. Branch and stem dieback was common on affected trees.

A late spring frost in 1981 at Rhinelander killed leaves and portions of the cambium of several clones. *Armillaria mellea* (Vahl ex Fr.) Karst. and bark saprophytes were present on these trees the following year.

Leaf rust caused by *Melampsora medusae* Thuem. was most severe at Rhinelander, where some clones were infected 1–2 mo earlier than in southern Minnesota or Iowa. Only clone NC5261, however, was highly susceptible. The other clones were obtained from *Populus* breeders who previously had selected them for rust resistance.

Marssonina brunnea (Ell. & Ev.) Magn. was severe on several clones of *P.* × *euramericana*, causing premature defoliation, and was particularly severe on clone DN26, causing lesions on green shoots. Clones highly susceptible to *M. brunnea* also were subject to a higher incidence of branch dieback related to environmental stresses than were resistant clones. Before 1978 at Rhinelander and 1980 at Rosemount, *M. brunnea* was of only minor importance. After those times, however, Marssonina leaf disease reached epidemic proportions each year at these locations. At Rosemount, *M.*

Table 1. Growth and survival of *Populus* clones in Minnesota (MN), Wisconsin (WI), and Iowa (IA) after 6, 6, and 5 yr, respectively

Parentage	Clone: Original number	Clone: North central number	Height[a] (m): MN	Height[a] (m): WI	Height[a] (m): IA	$D^2H^{a,b}$ (10^{-3} m^3): MN	$D^2H^{a,b}$ (10^{-3} m^3): WI	$D^2H^{a,b}$ (10^{-3} m^3): IA	Survival percentage: MN	Survival percentage: WI	Survival percentage: IA
P. deltoides × *P. trichocarpa*	NE205	NC5270	7.4	5.4	1.8	31.0	22.8	0.7	8.3	41.7	16.7
	NE216	NC5268	···	2.5	NP[c]	···	1.3	NP	0.0	8.3	NP
	NE348	NC5335	···	7.1	4.5	···	32.4	9.5	0.0	58.3	58.3
P. deltoides var. angulata × *P. trichocarpa*	NE252	NC5334	7.5	8.2	6.5	107.1	95.6	45.7	91.7	66.7	58.3
	NE372	NC5266	5.8	5.0	4.2	25.7	29.1	6.2	25.0	58.3	91.7
	NE374	NC5265	5.4	6.5	NP	15.8	68.0	NP	25.0	25.0	NP
P. deltoides var. *occidentalis* × *P. balsamifera* 'Northwest'	···	NC5261	2.5	5.2	1.8	1.6	13.4	1.0	25.0	83.3	25.0
P. balsamifera	···	NC7168	NP	5.0	NP	NP	16.4	NP	NP	50.0	NP
P. deltoides 'Walker'	FN4452	NC5273	···	4.9	0.7	···	10.7	0.1	0.0	75.0	8.3
P. deltoides 'D-37'	D37	NC5318	8.4	···	6.7	82.0	···	33.6	41.7	0.0	41.7
P. deltoides	D45	NC5319	9.3	···	7.5	90.5	···	86.7	83.3	0.0	41.7
Populus sp.	···	NC5258	9.1	5.1	···	95.0	13.6	···	83.3	66.6	0.0
	···	NC5351	3.3	7.8	NP	3.9	52.8	NP	50.0	83.3	NP
P. alba	PI 343437	NC4877	7.9	···	4.3	152.2	···	9.4	25.0	0.0	16.7
P. alba × *P. grandidentata* 'Crandon'	···	NC5339	8.8	4.6	8.7	120.5	18.8	144.7	100.0	41.7	58.3
P. canescens × *P. grandidentata*	IPC1	···	NP	NP	5.7	NP	NP	21.5	NP	NP	50.0
P. treumuloides × *P. tremula*	IPC2	···	NP	NP	6.2	NP	NP	22.3	NP	NP	66.7
P. nigra var. *betulifolia* × *P. trichocarpa*	NE298	NC5332	···	8.2	3.2	···	95.6	2.0	0.0	66.6	8.3
	NE299	NC5331	···	5.6	5.6	···	30.0	28.9	0.0	50.0	58.3
P. candicans × (*P.* × *berolinensis*)	NE386	NC5263	5.2	6.4	4.9	21.0	36.8	14.0	8.3	50.0	50.0
	NE387	NC5262	···	7.0	4.2	···	49.7	5.1	0.0	16.6	16.7
P. nigra var. *charkowiensis* × *P. nigra* var. *caudina*	NE19	NC5271	9.9	6.6	8.3	183.1	17.8	196.9	58.3	16.7	50.0
P. nigra × *P. laurifolia* 'Strathglass'	NE1	NC5272	···	6.7	1.7	···	34.2	0.1	0.0	66.7	8.3
P. tristis × *P. balsamifera* 'Tristis #1'	···	NC5260	5.5	6.3	3.6	34.2	33.9	4.3	91.7	66.6	16.7
P. deltoides var. *angulata* × *P. nigra* var. *plantierensis*	NE375	NC5264	5.9	6.6	5.7	33.2	68.1	26.2	75.0	58.3	41.7
P. deltoides × *P. nigra* var. *caudina*	NE366	NC5267	10.0	8.0	7.4	121.1	50.6	98.6	83.3	66.6	75.0
P. × *euramericana*	I-214	NC4878	5.5	3.9	5.6	32.8	7.6	29.1	41.7	37.5	41.7
	I-476	NC4879	7.0	6.5	NP	47.8	28.3	NP	50.0	8.3	NP
P. × *euramericana* 'B-56'	DN26	NC5324	3.2	4.4	···	2.7	4.7	···	16.6	25.0	0.0
P. × *euramericana* 'Ostia'	DN28	NC5325	5.3	2.6	6.1	18.7	1.6	72.6	58.8	8.3	58.3
P. × *euramericana* 'Canada Blanc'	DN30	NC5323	8.9	6.3	7.5	101.9	43.5	96.5	83.3	58.3	83.3
P. × *euramericana* 'Negrito de Granada'	DN31	NC5321	4.1	5.3	6.0	3.7	19.7	67.6	16.7	8.3	41.7
P. × *euramericana* 'Eugenei'	DN34	NC5326	9.1	6.8	5.8	113.7	35.2	20.0	66.7	83.3	66.7
P. × *euramericana* 'Jacometti'	I-78B	NC5322	8.5	6.1	7.9	96.9	17.8	162.0	50.0	16.7	16.7
P. × *euramericana* 'I45/51'	I-45/51	NC5328	8.1	6.1	6.8	115.8	41.0	46.8	83.3	41.7	41.7
P. × *euramericana* 'Wisconsin #5'	···	NC5377	10.4	6.6	4.6	106.1	32.4	6.6	100.0	58.3	25.0

[a] Mean of surviving trees.
[b] Formula for calculating index of volume for each clone: D = diameter at breast height and H = height of surviving trees.
[c] Not planted.

Table 2. Principal diseases detected on hybrid poplars in Wisconsin, Minnesota, and Iowa (1977–1982)

Disease	Causal agent[a]
Leaf rust	*Melampsora medusae*
Leaf spot and canker	*Septoria musiva* (*Mycosphaerella populorum* Thompson)
Leaf spot and shoot lesion	*Marssonina brunnea* (*Drepanopeziza punctiformis* Gremmen)
Leaf spot	*Septotinia podophyllina*
Ring spot	*Phyllosticta* spp.
Ink spot	*Ciborinia* spp.
Shoot blight	*Pollaccia radiosa* (Lib.) Baldacci & Cif. (*Venturia macularis*)
Dieback	*Cytospora chrysosperma* (*Valsa sordida* Nits.)
Dieback	*Phomopsis macrospora*
Canker and dieback	*Dothichiza populea* (*Cryptodiaporthe populea* (Sacc.) Butin)

[a] The first name refers to the imperfect state of the fungus. The name in parentheses refers to the perfect state if found.

brunnea infected leaves before *M. medusae*. *M. brunnea* was thus the most serious pathogen on clones susceptible to both fungi at this location.

P. trichocarpa hybrids were especially susceptible to leaf spot and canker caused by *Septoria musiva* Peck. Stems of highly susceptible clones were killed as a result of stem girdling by multiple cankers at the Rosemount and Ames plantings beginning in 1977. In contrast, Septoria leaf spot and canker were absent at Rhinelander until 1980 and 1981, respectively.

With the exception of the following four clones, *P.* × *euramericana* clones were resistant to *Septoria*. Clone DN28 was damaged slightly by cankers at Rosemount and Ames, as was clone I-214 at Rosemount, Clone NE375 sustained more cankers at Rosemount than at Ames, and clone NE366 was slightly damaged by cankers at Rosemount and Ames.

DISCUSSION

S. musiva, Marssonina brunnea, and *Melampsora medusae* were the most damaging pathogens to the hybrid poplars tested in all three areas. Disease incidence and severity varied by clone and location. A complex of diseases, insects, and abiotic factors affected the growth of the hybrid poplars. The index of volume for each clone does not necessarily reflect the potential of the various clones but provides a basis for comparing clone growth at each site.

Careful consideration must be given to the location where clones are field-tested if results are to be valid elsewhere. Leaf rust was of minor importance at Ames and Rosemount compared with Rhinelander, where the proximity to *Larix*, the alternate host of *M. medusae*, resulted in earlier and more severe infection. Susceptible clones that could be grown at Ames or Rosemount could not be grown successfully at Rhinelander because of

Table 3. Disease severity[a] on *Populus* clones grown at three locations in the north central United States from 1976 to 1982

Clone	Minnesota				Wisconsin				Iowa			
	Septoria leaf spot	Marssonina leaf spot	Melampsora leaf rust	Septoria canker	Septoria leaf spot	Marssonina leaf spot	Melampsora leaf rust	Septoria canker	Septoria leaf spot	Marssonina leaf spot	Melampsora leaf rust	Septoria canker
NE205	H	M	A	H	A	M	A	A	M	M	A	H
NE216	H	A	A	H	pf[b]	pf	pf	pf	np	np	np	np
NE348	H	M	A	H	L	L	L	A	H	L	A	L
NE252	H	A	A	H	L	A	A	L	H	A	A	M
NE372	H	L	A	H	A	M	M	A	H	L	L	M
NE374	H	A	A	H	pf	pf	pf	pf	np	np	np	np
NC5261	M	L	M	L	A	L	H	A	L	L	H	A
NC7168	np	np	np	np	L	A	L	A	np	np	np	np
FNS4452	pf	pf	pf	pf	A	H	A	A	M	H	A	A
D37	L	A	A	A	pf	pf	pf	pf	L	L	A	A
D45	M	L	A	A	pf	pf	pf	pf	M	A	L	A
NC5258	L	L	A	A	A	M	A	A	A	H	A	A
NC5351	H	H	A	M	A	H	A	A	np	np	np	np
PI 343437	A	L	A	A	pf	pf	pf	pf	pf	pf	pf	pf
NC5339	A	L	A	A	L	L	A	A	L	A	A	A
IPC1	np	np	np	np	np	np	np	np	A	A	A	A
IPC2	np	np	np	np	np	np	np	np	A	A	A	A
NE298	H	H	A	M	A	M	A	A	L	H	A	A
NE299	H	L	A	H	A	M	A	A	L	M	A	A
NE386	H	A	A	H	L	L	A	A	H	A	A	L
NE387	H	A	A	M	A	L	A	A	H	L	A	M
NE19	L	A	A	L	A	L	A	A	L	L	A	A
NE1	H	L	A	H	L	L	A	A	H	A	A	H
NC5260	L	A	A	A	L	L	A	A	A	H	A	A
NE375	H	L	A	H	A	L	L	A	H	L	A	M
NE366	L	L	A	L	L	L	A	A	M	L	A	L
I-214	L	L	A	L	A	L	A	A	L	L	A	A
I-476	A	M	A	A	A	M	A	A	np	np	np	np
DN26	L	H	A	A	A	H	A	A	np	np	np	np
DN28	L	M	A	L	A	H	A	A	L	L	A	L
DN30	L	M	A	A	A	H	A	A	L	M	A	A
DN31	L	M	A	A	A	M	A	A	L	M	A	A
DN34	L	M	A	A	L	M	A	A	L	M	A	A
I-78B	L	M	A	A	A	M	A	A	L	M	A	A
I-45/51	L	M	A	A	A	M	A	A	L	H	A	A
NC5377	L	M	L	A	A	H	A	A	L	M	A	A

[a] H = severe (premature defoliation throughout crown or many stem cankers), M = moderate (premature defoliation in lower and midcrown or few stem cankers, or multiple branch cankers), L = slight (no defoliation or few branch cankers), and A = absent or trace.
[b] pf = Planting failure and np = not planted.

their susceptibility to leaf rust. Clones planted at Rhinelander, where *Septoria* was not a serious problem until recently, were canker-free. However, these clones were severely damaged by cankers at Ames and Rosemount.

It became evident from this study that many pathogens endemic in native poplar stands can cause epidemic diseases in hybrid poplar plantations. Pathogens such as *Septotinia podophyllina* Whetzel, *Ciborinia* spp., *Phyllosticta* spp., and *Venturia macularis* (Fr.) Müll. & Arx are of periodic importance. The incidence and severity of the foliar diseases caused by these pathogens varied widely from year to year. Their greatest potential impact is on trees during the first few years after plantation establishment.

Marssonina and *Melampsora* were most severe on young trees, causing defoliation throughout tree crowns. On large trees, these pathogens usually affected only the lower crowns. In contrast, *Septoria* caused cankers on stems and branches of susceptible clones throughout the study period. Severely diseased trees commonly died. Wind breakage of stems with cankers also caused extensive damage.

Foliar diseases such as leaf rust can reduce potential biomass yields or lengthen rotations, adversely impacting plantations established for high yields on short rotations (8). Reduced root growth of defoliated trees can increase susceptibility to environmental stresses by reducing their uptake of water and mineral nutrients (1). Septoria canker can reduce the quality of fiber as well as cause mortality (5). Some clones were among the high-yielding group of clones even though they had numerous cankers. Their high growth rates may have partly compensated for damage caused by disease, but these clones are not suitable for windbreaks because of wind breakage or for plantations that will be coppiced because of increased disease severity (5). Clones with even slight damage from cankers cannot be recommended. On the basis of clones tested, *P.* × *euramericana* should be favored where *Septoria* is a problem.

Although many pathogens of poplars have been recorded (2), the genetic diversity in the genus makes it possible to obtain resistant clones through selection and breeding (4). It will be necessary to continue monitoring hybrid poplars in the north central United States to be sure that their early growth is indicative of growth throughout a rotation. Many of the clones tested were unsuitable because of their high susceptibility to foliar and canker diseases. To minimize plantation failure or reductions in potential growth and quality, we need a program that continually screens new clones for disease resistance to maintain a broad genetic base to provide diversity in plantings.

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