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Genetic variation of Melampsora leaf rust resistance in progenies of crossings between and within Populus tremula and P. tremuloides clones

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Summary

A total of 49 families of controlled crosses between and within *Populus tremula* and *P. tremuloides* were investigated concerning their resistance to *Melampsora* leaf rust, presumably caused by *M. magnusiana*. The leaf rust attack was evaluated at the end of both the first and the second vegetation period and showed highly significant genetic variation between the interspecific crossings. The *P. tremuloides* families showed the highest resistance, *P. tremula* families were severely attacked. The interspecific hybrid families showed an intermediate behaviour. A quantitative genetic analysis of the data showed strong additive genetic variation. Therefore, *Melampsora* leaf rust resistance might be incorporated successfully into further breeding programs in aspen and hybrid aspen.

Key words: *Populus tremula*, *P. tremuloides*, inter- and intraspecific crossings, *Melampsora* leaf rust, resistance, additive genetic effects.

Zusammenfassung

Insgesamt 49 Familien aus kontrollierten Kreuzungen zwischen und innerhalb der *Leuce*-Pappelarten *Populus tremula* und *P. tremuloides* wurden nach der ersten und zweiten Vegetationsperiode auf Blattrostbefall bonitiert. Untersuchungen an verschiedenen Entwicklungsstadien des Parasiten ergaben, daß *Melampsora magnusiana* als Erreger dieser Rostkrankheit in Betracht kommt. Zwischen den Kreuzungsfamilien bestanden hoch signifikante Befallsunterschiede. *P. tremuloides*-Familien zeigten die größte Resistenz gegen den Pilz, *P. tremula*-Familien waren dagegen am stärksten befallen. Die interspezifischen Hybridfamilien verhielten sich intermediär. Eine quantitativ-genetische Analyse ergab, daß sich die Rostresistenz wie ein quantitatives Merkmal verhält, d.h. sie wird offenbar durch zahlreiche Gene mit additiver Wirkung vererbt. Die Selektion blattrostresistenter Elternbäume führt demnach zu resistenteren Nachkommen. Rostresistenz kann daher mit Erfolg in die weiteren Züchtungsprogramme bei Aspe integriert werden.

1. Introduction

The European aspen *Populus tremula* L. and the north American aspen *P. tremuloides* MICHX. of the poplar section *Leuce* DUBY, and their hybrids are fast growing hardwood species, which are used in the paper industry as well as for biomass and energy production. Aspens are valuable and tolerant forest tree species for marginal sites. Therefore, they are gaining more and more importance in silviculture. The interspecific hybrids between the two aspen species exhibit often a better growth performance than the parent species, as many hybridization programs have shown (MELCHIOR and SEITZ 1966, HATTEMER and SEITZ 1967, MELCHIOR 1985, WEISGERBER 1983).

In connection with the testing of the general performance also the behaviour against the more important fungal diseases should necessarily be known. Aspens can be attacked by a wide range of leaf, twig, branch, and stem diseases (BUTIN 1957, FAO 1979). One of the commonest, most serious, and widely distributed leaf disease of aspens is the *Melampsora* leaf rust, caused by several species (GREMMEN 1954, PINON 1973, FAO 1979, BUTIN 1983), which are difficult to distinguish morphologically. Heavy rust infection can result in an early leaf fall, a reduction of increment, an increase of susceptibility to winter frost, an easy entry to other parasites, and a higher mortality of young plants (BUTIN and ZYCHA 1973, FAO 1979, SCHWERDTFEGER 1981, PHILLIPS and BURDEKIN 1982, BUTIN 1983). But poplar species show a high genetic variation of resistance to *Melampsora* rust species. These differences should be integrated into breeding programs of aspen.

In the following paper results are given on the genetic variation of *Melamsora* leaf rust infection of crossings between and within *Populus tremula* and *P. tremuloides*. The crossings were made originally with the purpose to study growth performance of families, combining ability and possible heterosis. Results on such traits will be published elsewhere (GALLO and MELCHIOR, in preparation).

2. Materials and Methods

2.1. *Origin of the aspen clones*

For the crossing experiments five female and three male clones of *P. tremula*, and two female and four male clones of *P. tremuloides* were used. The origin of the parent trees is shown in *Table 1*. The clones were selected phenotypically on the basis of their growth performance, stem form

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Dedictated to Dr. G. H. MELCHIOR on his 60th birthday

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Table 1. — The parent clones of *Populus tremula* and *P. tremuloides.*

clone nr.	female	male	provenance
Populus tremula L.			
Brauna 11	x		Saxony, GDR
Groß-Dubrau 1	x		Saxony, GDR
Wedesbüttel 51	x		East Prussia, USSR
Wedesbüttel 52		x	East Prussia, USSR
Wedesbüttel 66		x	East Prussia, USSR
Wedesbüttel 95	x		East Prussia, USSR
CVS 52		x	Luborec, CSSR
C 61	x		Raztocno, CSSR
Populus tremuloides Michx.			
Ihlendieksweg 1		x	Maple, Ontario, Canada
Ihlendieksweg 3	x		Maple, Ontario, Canada
Ihlendieksweg 5	x		Maple, Ontario, Canada
T 428		x	Maple, Ontario, Canada
T 44-60		x	Upper Michigan, USA
T 141		x	New Hampshire, USA

and good combining ability, concerning especially cross fertility, in other breeding programs. Resistance to *Melampsora* leaf rust was no criterion for the phenotypic selection of these aspen clones. Therefore, for the purpose of the present study the trees were considered as random samples of the populations in respect to *Melampsora* leaf rust resistance.

The mother trees and most of the father trees are grown in the clonal archive of the Institute at Grosshansdorf. From the *P. tremuloides* clones T 44—60 and T 428 pollen was collected from selected trees in USA and Canada, respectively.

2.2. *Controlled pollination and mating design*

The clones had been crossed in the greenhouse in February and March 1983, according to a 7 × 7 factorial mating design *(Figure 1).* The crossings resulted in 49 different families, which belong to four main mating groups, namely two intra- and two interspecific crossing groups.

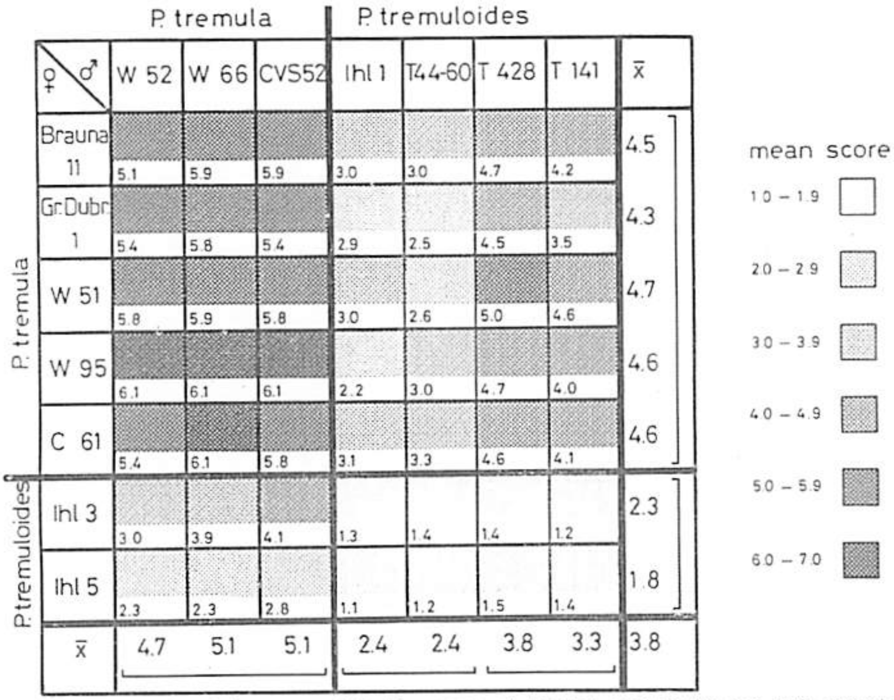
2.3. *Progeny test*

After sowing in May 1983 the seedlings were outplanted in a nursery trial in July 1983. The trial was located in Grosshansdorf, and was planted in a completely randomized blocks design with four replications, 6 × 5 plants of each family (= plot) in each replication, and with a spacing of 20 × 15 cm.

2.4. *Melampsora leaf rust attack*

The maximum of rust infected leaves was observed mostly in September, and the rust attack was scored at that time. In September 1983 only the average rust attack per plot was determined according to the following scale: 0 = no infection; 1 = less than 50% of the leaves of the plot were lightly infected (less than two uredinia per cm², single); 2 = more than 50% of the leaves of the plot were lightly infected; 3 = more than 50% of the leaves of the plot were strongly infected (more than two uredinia per cm², single or in groups).

The results of 1983 showed significant genetic variation between the families. Therefore, a more detailed examination of the individual trees of the families was conducted in September 1984. For that reason 24 trees per family (= six trees per plot) were scored. Each tree was assigned a single score value according to the following scale from 1 to 7: 1 = no infection; 2 = less than 10% of the leaves show individual uredinia; 3 = 11 to 30% of the leaves show several uredinia widely spread; 4 = 31 to 50% of the



		P. tremula			P. tremuloides				
	♀ \ ♂	W 52	W 66	CVS52	Ihl 1	T44-60	T 428	T 141	x̄
P. tremula	Brauna 11	5.1	5.9	5.9	3.0	3.0	4.7	4.2	4.5
	Gr.Dubr. 1	5.4	5.8	5.4	2.9	2.5	4.5	3.5	4.3
	W 51	5.8	5.9	5.8	3.0	2.6	5.0	4.6	4.7
	W 95	6.1	6.1	6.1	2.2	3.0	4.7	4.0	4.6
	C 61	5.4	6.1	5.8	3.1	3.3	4.6	4.1	4.6
P. tremuloides	Ihl 3	3.0	3.9	4.1	1.3	1.4	1.4	1.2	2.3
	Ihl 5	2.3	2.3	2.8	1.1	1.2	1.5	1.4	1.8
	x̄	4.7	5.1	5.1	2.4	2.4	3.8	3.3	3.8

Figure 1. — Mating design, mean infection scores of families, and female and male parents. Parents within a bracket do not differ significantly by Tukey's test ($\alpha = 0.05$).

Table 2. — Characters of *Melampsora* species of the *M. populina* complex on poplars of the section *Leuce* in central Europe.

species	uredinia	urediniospores			paraphyses				teliospores		alternate host	reference
	(mm)	form	length x width (µm)	wall (µm)	form	head length x width (µm)	length (µm)	wall (µm)	length x width (µm)	wall (µm)		
M. larici-tremulae Kleb.	0,5	oval to obovate	15-22 x 10-15	2	head oblong	8-17	40-45	3-5	40-60 x 7-12	1-2	Larix spp.	Gäumann (1959)
	--	oval to oblong	14-23 x 10-16	--	capitate, oblong	8-17	40-45	3-5	--	--	--	Pinon (1973)
	--	ovoid or globoid	14(20)24 x 13(15)19	2	claviform	16-18 x 14.5-16.5	52(59)67	3.2-4.2	--	--	Larix spp.	Cellerino and Anselmi (1979)
M. pinitorqua Rostr.	0.5	oval to elongate	15-22 x 11-16	2	head oblong	20-25 x 12-17	40-50	3-7	20-35 x 7-11	1	Pinus spp.	Gäumann (1959)
	--	ovoid to globoid	14-24 x 10-16	--	capitate	8-17	40-55	--	--	--	--	Pinon (1973)
M. rostrupii Wagner	1	oval, globoid to polygonal	18-25 x 14-18	3	globoid	15-23	50	3-6	25-40 x 5-12	1	Mercurialis perennis	Gäumann (1959)
	1	ovoid, globoid to triangular	17-28 x 14-18	--	capitate, globoid, elliptic	14-25	--	--	--	--	--	Pinon (1973)
	--	ovoid, globoid or angular	15(21.5)29 x 9(17)22	3	capitate, globoid	14-19 x 8-10	40(45)54	3-3.5	--	--	Mercurialis perennis	Cellerino and Anselmi (1979)
M. magnusiana Wagner	0.5	oval to oblong or polygonal	17-24 x 12-18	3	globoid	14-22	40-50	3-5	40-50 x 7-10	1-2	Chelidonium majus, Cory dalis cava, C. solida	Gäumann (1959)
	--	ovoid, globoid to triangular	17-24 x 12-19	--	globoid, apex flattened	--	--	--	--	--	--	Pinon (1973)
	--	ovoid, globoid or elongate	9(12)19 x 7(10)15	3	digitate or capitate	14-24 x 13-22	38(45)54	4.5-5.5	--	--	Chelidonium majus, Corydalis solida	Cellerino and Anselmi (1979)
M. spec.	0.5	polygon. 32% elong. 19% elliptic 19% globoid 15% ovoid 15%	18(22)26 x 13(16)19	3.4	globoid, apex flattened	11(18.5)25	--	2(5)11	29(44)56 x 7.5(10)16	1.4	?	present study