GEOGRAPHIC VARIATION IN MELAMPSORA RUST RESISTANCE IN EASTERN COTTONWOOD IN THE LOWER MISSISSIPPI VALLEY

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Abstract.—Eastern cottonwood clones originating from 36 young natural stands along the Mississippi River from Memphis, Tennessee, to Baton Rouge, Louisiana, were evaluated in a nursery near Greenville, Mississippi for resistance to Melampsora rust. In general, the northern sources had more rust and were more variable in rust susceptibility than the southern sources. Eleven percent of the clones from the 6 northernmost sources and 0.5 percent of the clones from the 24 southernmost sources appeared to be highly resistant to rust. Clones with slightly less rust resistance were about evenly distributed over the geographic range.

Additional keywords: *Populus deltoides*, *Melampsora medusae*.

INTRODUCTION

Melampsora rust of eastern cottonwood (*Populus deltoides* Bartr.), caused by *Melampsora* spp. can result in premature defoliation and reduced growth. In the Midwest, growth losses can be severe. As early as 1913, Williamson regarded rust as the most common and injurious disease of cottonwood in the Mississippi River Valley. In the South, heavy rust infections have usually occurred late in the season and have not greatly reduced growth. Toole (1967) noted the prevalence of Melampsora rust on cottonwood in the Mississippi Delta area and determined that the causal organism was *M. medusae* Thum. Wilcox and Farmer (1967) found that Melampsora rust had little effect on the growth of cottonwood in Mississippi during the first growing season, but diameter and height growth were reduced the next year.

Because of river channelization and flood control efforts, site conditions have become unfavorable in many areas for the establishment of new natural cottonwood stands. Therefore, several thousand acres must be planted to cottonwood each year to meet future needs. Growers in the South recently have started to use clones with superior growth characteristics, but these clones are not resistant to Melampsora rust (Mohn *et al*. 1970). Resistant clones are needed in order to provide a margin of protection against possible increasing severity of the disease.

Jokela (1966), Wilcox and Farmer (1967), Farmer and Wilcox (1968), Farmer (1970), and Thielges and Adams (1975) have shown that heritability for Melampsora rust resistance is high. However, a better understanding of the variability within and among stands for resistance to Melampsora rust and of the geographic trends associated with the variability is needed. This paper describes the pattern of variability of genetic resistance to Melampsora rust for a part of the lower Mississippi River where major breeding and commercial planting efforts are underway.

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MATERIALS AND METHODS

Forty clones from each of 36 two- to four-year-old stands (1440 clones) along the Mississippi River from Memphis, Tennessee, to Baton Rouge, Louisiana, were studied. During the fall of 1971, nearly all stands that were of these ages and were visible from the river were sampled, and within each stand, trees that appeared suitable for propagation were chosen at random. The amount of natural selection within the stands and the number of parents contributing to a stand were unknown and probably varied greatly. The trees were cloned and maintained in a nursery for 3 years before a new nursery was established in 1975 at Huntington Point, 10 miles north of Greenville, Mississippi.

Replication of such a large number of clones was impractical; therefore, sources were replicated, but clones were not. The 36 sources were arranged in a randomized complete-block design with four replications. Within each replication, each source was represented by a main-plot of 10 clones. Each clone was represented by a sub-plot of 10 unrooted cuttings. Cuttings were spaced at 7 x 40 inches. Before planting,, unsuitable cuttings were discarded to minimize non-genetic contribution to variability.

The site was riverfront Commerce silt loam, was nearly level, and was very uni-form. A shallow covering of moving river overflow water occurred in late March and early April. The flood did not appear to introduce any variability into the experiment but did kill the shoots of early foliators and caused a one-month delay in the growing season which allowed all clones to start growing at the same time.

Rust was first noticed in the nursery in late September. Spores had characteristics of M. medusae. Rust incidence was scored on October 21 and 22, when only a few clones were showing defoliation on the upper stem or crinkling of leaves. Clones (10--ramet plots) were scored according to the following rating system:

1 = no uredia found in a diligent search of the leaves in the plot
2 = uredia infrequent and found only with difficulty
3 = uredia present on several leaves
4 = uredia numerous on most leaves; occasional crinkled leaves
5 = large number of crinkled leaves; some defoliation in upper crown

No attempt was made to record differences within clones because the close spacing resulted in far fewer leaves per tree than would occur under field conditions. Fifteen of the 1440 clones were not considered due to poor survival. The rating system was on an ordinal scale and analysis of variance procedures are not strictly applicable.

The mean rating for each source (main-plot) in each replication was computed. These values were then subjected to randomized block analysis of variance, and Duncan's new multiple range test at the 0.05 level of significance was used to compare sources. Similar procedures were used to analyze the variance among clones within main-plots (transformed to $\log_{10}(X + 1)$) where X is the variance of the ratings for the 10 or fewer clones of a given source and block.

Environmental and observational error within main-plots could not be separated from genotypic variance, but much of the variation within main-plots was undoubtedly genetic since other studies have shown that heritability for rust resistance is high.

Conditions were suitable for high heritability in the present study. There was almost no damage from leaf-feeding insects. All sources appeared to be uniformly vigorous and had abundant green leaves when scored. The various degrees of susceptibility were well distributed throughout the nursery providing abundant inoculum.

Since rust intensity tends to increase with time, additional rust observations were made on the most resistant clones on October 30 and November 12. In addition, on November 12, observations were made on several leaf spots easily distinguished from rust to investigate the possibility that factors affecting rust resistance may also affect resistance to other leaf diseases. Ten fully expanded leaves were taken at random from the upper one-third of the crowns of each of the clones that had no rust pustules on October 30, and from the nearest clone from the same main-plot having a "3" rating and adequate leaves for sampling. Leaves were examined in the laboratory and fungus genera associated with the various types of spots were determined for clones resistant to Melampsora rust and for the clones having a moderate amount of rust. The frequency of lesions larger than 1 mm in diameter associated with each of these organisms was recorded and subjected to a paired-observation t-test at the 0.05 level of significance.

RESULTS

In general, the more northern sources had a higher mean level of rust than the southern sources. However, the resistance of northern sources was more variable than that of southern sources, and some of the northern sources had a greater proportion of both highly resistant clones and highly susceptible clones than the southern sources (Table 1).

Thirty-two of the 1,425 clones that were scored received a rating of 1, and 217 clones were rated 2. Together these are about 17 percent of the clones studied. These clones are about equally distributed throughout the geographic range studied, but 26 of the 32 clones rated 1 were from five of the six northernmost sources. One hundred thirty-three clones were given a score of 5, and 122 of these were from the 18 northernmost sources.

By October 30, rust had increased and 11 of the 32 highly resistant clones had developed a few pustules. By November 12, an additional 15 clones had developed a few pustules, leaving six clones with no pustules. Increased intensity of rust with time is consistent with the results of Thielges and Adams (1975).

Detailed examination of leaves from 21 *Melampsora* resistant clones and the same number of clones having an average amount of Melampsora rust revealed the presence of leaf spots associated with *Septoria*, *Cercospora*, *Phyllosticta*, *Alternaria*, and *Gloeosporrium* spp. It appeared that *Melampsora*-infected clones had more *Cercospora*, *Alternaria*, and *Gloeosporium* than *Melampsora*-free clones (Table 2). The difference, however, was significant only for *Cercospora*.

DISCUSSION

The tendency for the more southern clones in this study to be on the average less susceptible to rust than the northern clones can be explained by the early growth cessation of northern material, which makes it more vulnerable to attack than southern material, or by the natural downstream movement of genes. If genes flow downstream, southern material has the advantage of having its own resistance genes plus ones received from northern sources.

Table 1.--Incidence of Melampsora rust on clones of different geographic origin.

Source	Latitide (N)	Number of clones in each rust score class: 1	2	3	4	5	Mean score[1]		Variance[1 2]	
1	34° 57'	2	6	14	8	10	3.45	b-d	.33	a-c
2	34° 45'	3	0	8	10	19	4.05	a	.36	a-b
3	34° 43'	0	5	7	11	17	4.00	a	.34	a-c
4	33° 57'	9	10	11	6	4	2.65	j	.37	a
5	33° 57'	6	13	9	8	4	2.78	h-j	.32	a-c
6	33° 57'	6	10	15	6	3	2.75	i-j	.36	a-b
7	33° 46'	0	1	11	15	13	4.00	a	.22	a-g
8	33° 45'	0	4	18	7	11	3.63	a-b	.28	a-d
9	33° 35'	0	3	18	16	3	3.48	b-c	.12	d-g
10	33° 30'	0	5	20	8	7	3.43	b-e	.20	a-g
11	33° 06'	0	1	23	12	4	3.48	b-c	.16	c-g
12	33° 02'	0	6	19	10	5	3.35	b-f	.26	a-f
13	32° 52'	1	6	21	6	6	3.25	b-h	.27	a-e
14	32° 51'	0	6	21	10	3	3.25	b-h	.22	a-g
15	32° 45'	0	4	24	8	4	3.30	b-g	.19	a-g
16	32° 38'	0	7	22	7	4	3.20	b-i	.21	a-g
17	32° 16'	1	14	20	3	2	2.78	h-j	.19	a-g
18	32° 07'	1	8	21	7	3	3.08	c-j	.26	a-f
19	32° 05'	0	10	25	5	0	2.88	f-j	.12	d-g
20	32° 03'	0	6	23	10	1	3.15	c-i	.18	b-g
21	31° 59'	0	6	30	3	1	2.98	d-j	.12	d-g
22	31° 56'	0	7	27	4	2	3.03	c-j	.18	b-g
23	31° 52'	0	7	30	2	0	2.88	f-j	.08	f-g
24	31° 44'	0	6	29	4	1	3.00	c-j	.13	d-g
25	31° 40'	0	5	33	2	0	2.93	f-j	.07	g
26	31° 37'	0	10	24	5	1	2.93	f-j	.16	c-g
27	31° 31'	0	8	28	1	1	2.88	f-j	.10	d-g
28	31° 11'	1	6	30	2	0	2.85	g-j	.11	d-g
29	31° 10'	0	3	29	6	0	3.08	c-j	.09	e-g
30	31° 05'	1	7	29	3	0	2.85	g-j	.12	d-g
31	31° 01'	0	4	31	2	2	3.05	c-j	.13	d-g
32	30° 59'	1	5	23	6	1	3.05	c-j	.19	a-g
33	30° 37'	0	3	31	3	1	3.05	c-j	.10	d-g
34	30° 37'	0	1	34	4	0	3.08	c-j	.05	g
35	30° 36'	0	6	29	5	0	2.98	d-j	.10	d-g
36	30° 31'	0	8	25	6	0	2.95	e-j	.13	d-g
Total		32	217	812	231	133				
Mean							3.15		.19	

[1] Values not sharing a common letter are different at the 5-percent level, Duncan's new multiple range test.
[2] Within source variance, transformed to $\log_{10}(X + 1)$, averaged over four replications.

Table 2.--Mean number per leaf of various leaf spots on 21 rust-resistant clones and 21 clones with an average amount of rust.

	Rust resistant	Rust susceptible
Septoria	2.0	1.7
Cercospora[1]	.7	1.4
Phyllosticta	.4	.3
Alternaria	.6	1.1
Gloeosporium	.3	.7

[1] Difference significant at .05 level as determined by paired observation t-test.

Besides the north-south trend, it appears that major genes for rust resistance exist at the northern end of the range studied and that these genes have not yet become established farther south. The resistance genes probably came from farther north and probably will move downstream. A similar situation appears to be occurring with Septoria leaf spot resistance, which was found in 10 of these same 1425 clones and only in the eight northernmost sources (Cooper and Filer, in press).

The results of this study apply to the strain of rust present in the Huntington Point nursery in 1975. The extent of genetic variability in the rust organism in the Lower Mississippi Valley is unknown; races of differing virulence may occur in different areas or at different times. Response to rust may differ from year to year as evidenced by only a 0.5 correlation between rust scores obtained in two successive years by Wilcox and Farmer (1967). The low correlation may have been caused by differences in observers, scoring criteria, and date of scoring as well as host plant x environment interaction and differences in the rust organism. Clones identified as rust resistant based upon performance in a single environment should be retested under other conditions and at different locations in order to sample environments and rust populations sufficiently to provide some assurance that an adequate level of resistance can be maintained.

Sufficient rust resistance is needed in commercial clones to prevent serious growth losses. An added margin of protection for those years when rust is particularly severe would be desirable. Selection for complete resistance to rust, however, is probably unnecessary and may be unwise. Such selection might result in vertical resistance that is easily bypassed by changes in the rust organism rather than in relatively stable horizontal resistance built upon the cumulative effects of many genes. At present there is no need to take the geographic distribution of Melampsora rust resistance into consideration in a cottonwood breeding program in the South. If the need for a high level of resistance develops, it may be necessary for the breeder to restrict selection activities to a limited geographic area such as the northern stands in the present study and to assume the risks associated with vertical resistance.

LITERATURE CITED

Cooper, D. T., and Filer, T. H., Jr. 1976. Resistance to Septoria leaf spot in eastern cottonwood. Plant. Dis. Rept. (In press).

Farmer, R. E., Jr. 1970. Genetic variation among open-pollinated progeny of eastern cottonwood. Silvae Genet. 19: 149-151.

Farmer, R. E., Jr., and Wilcox, J. R. 1968. Preliminary testing of eastern cottonwood clones. Theoret. and Appl. Genet. 38: 197-201.

Jokela, J. J. 1966. Incidence and heritability of Melampsora rust in Populus deltoides Bartr. In Breeding Pest Resistant Trees. p. 111-117, Pergamon Press, N.Y.

Thielges, B. A., and Adams, J. C. 1975. Genetic variation and heritability of Melampsora leaf rust resistance in eastern cottonwood. For. Sci. 21(3): 278-282.

Toole, E. R. 1967. Melampsora medusae causes cottonwood rust in lower Mississippi Valley. Phytopathology 57(12): 1361-1362.

Wilcox, J. R., and Farmer, R. E., Jr. 1967. Variation and inheritance of juvenile characters of eastern cottonwood. Silvae Genet. 16: 162-165.

Williamson, A. W. 1913. Cottonwood in the Mississippi Valley. USDA Bull. No. 24, 62 p.