TOLERANCE OF COTTONWOOD TO DAMAGE BY COTTONWOOD LEAF BEETLE

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Abstract.--Wide variation in tolerance to the cottonwood leaf beetle was found in fourteen hundred eastern cottonwood clones, originating from 36 young natural stands along the Mississippi River from Memphis, Tennessee, to Baton Rouge, Louisiana. Expected genetic gains were large enough to justify further research.

Additional keywords: Host resistance, defoliation, Populus deltoides, Chrysomela scripta.

The cottonwood leaf beetle (Chrysomela scripta F.) causes defoliation and damage to young terminals in eastern cottonwood (Populus deltoides Bartr.). Severe infestations result in growth loss and reduce the quality of the main stem by causing crooks and forks. Damage is particularly severe in plantations along the lower Mississippi River.

Cottonwood trees can be protected from the leaf beetle with chemical insecticides. However, the need for precise timing and repeated applications, high costs, loss of desirable predators, and probable development of insecticide-resistant strains of the leaf beetle point to the need for cottonwood clones genetically resistant to the leaf beetle.

European scientists have studied insect resistanc9 in plantation poplars for several decades (Arru 1975). Benjamin and Berkot2/, at the University of Wisconsin, are studying leaf beetle resistance of cottonwood clones developed from callus tissue. No resistant clones are available in the United States.

MATERIALS AND METHODS

During fall 1971, about 40 clones from each of 36 two- to four-year-old stands of cottonwood along the Mississippi River from Memphis, Tennessee, to Baton Rouge, Louisiana, were selected for study. Within each stand, trees were chosen essentially at random. The amount of natural selection within stands and the number of parents contributing to each stand were unknown. The trees were cloned and maintained in the nursery for 4 years before an outplanting was established in February 1976 on the Fitler Managed Forest, 50 miles south of Greenville, Mississippi.

The 36 stands were arranged as a 6 x 6 triple lattice with 40 clones randomized within each stand in each of the three replications. Plot size was two trees. Spacing was 12 x 12 feet. Three 20-inch cuttings were used at each planting spot and thinned to the one best tree in July. Thus, most clones were represented by three two-tree plots at the time the trees were scored.

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The trees were scored for cottonwood leaf beetle damage during the last two weeks of October 1976. The amount of damage on the upper 24 inches of the main stem was ranked on a 1 to 11 scale as follows:

1 - leaf damage 0-10%, no terminal damage, active growth
2 - leaf damage 0-10%, no terminal damage, no active growth
3 - leaf damage 10-25%, no terminal damage, active growth
4 - leaf damage 10-25%, no terminal damage, no active growth
5 - leaf damage 25-50%, no terminal damage, active growth
6 - leaf damage 25-50%, no terminal damage, no active growth
7 - leaf damage 50-100%, no terminal damage, active growth
8 - leaf damage 50-100%, no terminal damage, no active growth
9 - leaf damage 50-100%, terminal damage
10 - leaf damage 25-50%, dead terminal
11 - leaf damage 50-100%, dead terminal

Thus, data did not represent a true interval scale and analysis of variance procedures are not strictly applicable. However, they were used since methods of estimating genetic gain using non-parametric procedures have not been developed.

Plot means from each geographic source were subjected to analysis of variance as follows:

Source	df	EMS
Rep	r-1	$\sigma_e^2 + c\sigma_r^2$
Clones	c-1	$\sigma_e^2 + r\sigma_c^2$
Rep x clones	(r-1)(c-1)	σ_e^2

Data were then subjected to analysis of variance over sources ignoring the restrictions of the triple lattice design as follows:

Source	df	EMS
Rep	r-1	$\sigma_{rs}^2 + s\sigma_r^2$
Sources	s-1	$\sigma_{rs}^2 + r\sigma_s^2$
Rep x sources	(r-1)(s-1)	σ_{rs}^2
Clones/source	(c-1)s	$\sigma_e^2 + r\sigma_c^2$
Clones x rep/source	(c-1)(r-1)s	σ_e^2

Within source heritabilities were computed as:

$$h^2 = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_e^2}$$

The predicted genotypic gain (PGG) from selecting the best clones within each geographic source was computed as:

$$PGG_{c/s} = i \frac{\sigma^2_c}{\sqrt{\sigma^2_c + \frac{\sigma^2_e}{r}}}$$

where i is the standardized selection differential from Becker (1967).

Similarly, predicted genotypic gain from selecting the best sources was computed as:

$$PGG_s = i \frac{\sigma^2_s}{\sqrt{\sigma^2_s + \frac{\sigma^2_{rs}}{r}}}$$

and the predicted genotypic gain from selecting the best clones within the best sources is the sum of $PGG_{c/s}$ and PGG_s.

RESULTS

Leaf beetle damage was severe in the study area. The mean rating was 6.56 (on the 1 to 11 scale), indicating that an average of approximately one-half of the leaf area was destroyed. Source means varied from 4.98 to 7.58. Although Duncan's new multiple range test revealed few significant differences (0.05 level) among sources, northern sources appeared more tolerant than southern sources (Table 1). All but three of the 18 more northern sources had better than average tolerance. Many of the clones from the northern sources had ratings of 5 or less; many of the clones from the southern sources had ratings of 8 or greater.

A geographic pattern for tolerance to leaf beetle defoliation is not surprising, since this same group of clones displayed geographic trends for Septoria leaf spot resistance (Cooper and Filer 1976) and Melampsora rust resistance (Cooper and Filer 1977). The collective indication is that cottonwood along the lower Mississippi River is not a single freely intermating population in equilibrium. It may be that trees growing along the crumbling banks of the northern portions of the Mississippi River or some of its tributaries have floated down the river during spring floods and deposited seed of resistant genotypes, causing differences in tolerance observed among clones from the different geographic locations.

Heritability for tolerance to the leaf beetle was low (0.18) and standard errors were high, probably because of erratic distribution of insects in the 30-acre experimental area. Analysis of variance revealed significant differences among clones (.05 level of probability) in only 15 of 36 sources, and Friedman's Ranked Sign Test revealed significance in 13 of 36 sources.

This study will continue with a selection scheme designed to retain a moderate amount of genetic diversity. Choosing the best 9 of 36 sources should result in a 3.5 percent genotypic gain in leaf beetle tolerance. Considering only the 9 best sources, selection of the 10 best clones per source should give 11.6 percent additional improvement. This group of 90 clones should have 15.1 percent more tolerance to the leaf beetle than the general population. More observations per clone would have permitted additional gain, but this would have been impractical with such a large number of clones.

Table 1.--Incidence of cottonwood leaf beetle damage to clones of different geographic origin.

Source	Latitude (N)	Mean score[1/]		Number of clones			
				Most resistant		Least resistant	
				≤4	≤5	≥8	≥9
1	34°57'	5.41	d-e	6	16	2	1
2	34°45'	6.68	a-e	0	4	5	1
3	34°43'	6.02	a-e	1	9	2	1
4	33°57'	6.04	a-e	1	8	2	1
5	33°57'	7.46	a-b	0	1	16	7
6	33°57'	7.29	a-c	1	4	17	3
7	33°46'	6.37	a-e	1	7	5	0
8	33°45'	6.19	a-e	3	11	5	1
9	33°35'	6.33	a-e	2	8	4	1
10	33°30'	6.17	a-e	1	8	3	1
11	33°06'	6.41	a-e	2	5	4	1
12	33°02'	4.98	e	12	21	1	1
13	32°52'	5.92	a-e	3	10	1	1
14	32°51'	6.03	a-e	1	7	4	0
15	32°45'	5.75	c-e	6	13	2	1
16	32°38'	6.49	a-e	0	5	6	1
17	32°16'	6.03	a-e	1	10	3	0
18	32°07'	6.29	a-e	5	9	6	3
19	32°05'	7.01	a-d	0	2	7	0
20	32°03'	6.65	a-e	0	4	6	3
21	31°59'	7.58	a	0	0	15	5
22	31°56'	7.22	a-c	0	1	11	1
23	31°52'	7.34	a-c	0	2	14	4
24	31°44'	6.55	a-e	1	5	5	1
25	31°40'	7.42	a-e	1	2	20	5
26	31°37'	6.86	a-d	1	3	5	1
27	31°31'	6.67	a-e	0	3	5	0
28	31°11'	7.21	a-c	0	2	13	2
29	31°10'	5.83	b-c	2	12	6	0
30	31°05'	6.40	a-e	1	8	5	2
31	31°01'	7.09	a-d	0	3	13	1
32	30°59'	6.99	a-d	0	4	10	5
33	30°37'	7.31	a-c	0	6	13	11
34	30°37'	6.56	a-e	0	4	5	1
35	30°36'	7.19	a-c	0	3	8	5
36	30°31'	6.57	a-e	0	2	4	2
Total				52	222	253	74
Mean		6.56					

1/ Sources not sharing a common letter are different at the 5-percent level, Duncan's new multiple range test.

Since cottonwood can be easily asexually propagated, and leaf beetle damage can be scored during the first growing season, repeated cycles of testing are practical. The selected clones will be tested in 1977 and subsequent years to identify clones with consistently high tolerance to the cottonwood leaf beetle.

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