AN ASSESSMENT OF COTTONWOOD TWIG-BORER ATTACKS 1/

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Commercial production of eastern cottonwood (Populus deltoides Bartr.) in plantations on agricultural soils in Brazos and Burleson Counties, Texas, is economically prohibitive because of severe attacks by cottonwood insects. The stunting and deformation of young trees caused by the cottonwood twig-borer (Gypsonoma haimbachiana Kft.) is especially serious. Morris (1967) rates this as the most destructive of the insects that damage young cottonwood. The degree of damage currently being sustained in Brazos River bottom non-irrigated plantations confirms the destructive ability of this insect.

This investigation was undertaken to determine (1) whether any of the clones currently under test have a low incidence of twig-borer attack, (2) what relationship there is between clonal form and incidence of twig-borer attack, and (3) what relationship there is between clonal volume production and incidence of twig-borer attack.

In addition, the high rates of attack found in plantations prompted sampling of naturally regenerated trees of the Brazos and Colorado river bottoms to determine whether natural stands sustained the same high levels of attack.

METHODS

Four cottonwood plantations and six naturally regenerated areas were utilized in this study. The intensity of twig-borer attacks was determined during the dormant season in three non-irrigated clonal test plantations on the Brazos River bottom. Two of these were one-year-old plantations established near the city of Mumford, in Brazos County, on contrasting soil types--one on the more productive soil for cottonwood, a Norwood clay loam, and one on the lesser productive soil, a Miller clay. The third was a two-year-old plantation on a Norwood clay loam soil on the Texas A&M University farm in Burleson County, Texas.

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In order to rate the intensity of attack in the three plantations, the sampling procedure consisted of removing the leader of a randomly chosen ramet of each of 36 eastern cottonwood clonal selections and of one hybrid, NE-316 P. cv. Charkowiensis X P. cv. Robusta, in two replications in each of the three plantations during the dormant season. The terminal 14 inches of each of the 222 leaders was scored for the number of twig-borer attacks. In sampling from the naturally regenerated areas, five 14-inch leaders were collected at each of three sub-sample points on both the Brazos and Colorado River bottoms.

The counts of the twig-borer attacks were analyzed by transforming the counts to the square root of the original value plus 1, X= /X+1. The transformed counts were then subjected to an analysis of variance. A nested analysis (Table 1) with equal sample, subsample, and specimen numbers was used to compare the Colorado and Brazos natural areas with the three Brazos clonal plantations. Samples in this study were Brazos River plantations, Brazos River natural stands, and Colorado River natural stands. In order to have only five terminals per plantation, five random samples were chosen from among the 74 terminals collected per plantation. Sub-sample areas on the Brazos River were areas near the cities of Mumford and Bryan and an area near the Texas AO University farm. Sub-sample areas on the Colorado River were near the cities of Bastrop, LaGrange and Smithville.

Table 1.--Nested analysis of variance for number of twig-borer attacks per 14-inch terminal

Source	df	ss	ms	F 1/
Samples 2/	2	30.00	15.00	14.4**
Sub-samples within samples	6	6.24	1.04	5.2**
Trees within sub-samples	36	7.40	.20	

1/ *Statistically significant at the .01 level.

2/ Samples were Brazos River plantations, Brazos River natural stands, and Colorado River natural stands.

A factorial analysis was used for the clonal data. The counts of the clones in the plantation were analyzed separately by plantations and then combined over plantations, since the error terms were found to be homogeneous.

Data on form was obtained only in the two-year-old University farm plantation. Four ramets of each clone were subjectively rated on a scale from 0 to 5; a 0 indicated no apparent damage and a 5 many dead tips and multiple leaders.

Volume production was obtained for eight clones growing in a four-year-old irrigated plantation on the Texas AO University farm in the Brazos River bottom.

RESULTS AND DISCUSSION

Plantations versus Natural Stands

Comparison of the sample means by the Duncan test indicated the Colorado River samples to have a significantly lower level of attack than either the Brazos plantations or the Brazos natural stands (Table 1). The mean number of attacks per leader (Table 2) for the three Brazos River plantations was 12. It differed by little from the value of 10 for the three Brazos Rivernatural stands. However, the attack on the Colorado River bottom was much lower, with the mean for the three Colorado River stands at only 2 attacks per terminal.

Table 2. Mean number of twig-borer attacks per 14-inch leader for the three samples

	Mean number of attacks per 14-inch terminal [1/]
Brazos River Plantations	12
Brazos River Natural Stands	10
Colorado River Natural Stands	2

[1/] Means not connected by the same vertical line differ significantly at the .01 level by the Duncan test.

The current explanation offered for the discrepancy between the attack levels is that the high level of agricultural pesticides used in the Brazos Bottom keeps the twig-borer predator population at a low level. This explanation needs to be checked experimentally.

Significant differences (Table 1) also existed among sub-samples within samples in the Colorado River natural stands and the Brazos plantations. The mean attack of 5 for the LaGrange sub-sample from the Colorado River (Table 3) was significantly greater than the mean of one for the other two sub-samples. The mean of 9 for the Mumford Miller clay plantations was significantly lower than the mean of 15 for the Mumford Norwood clay loam. There is at present no factual explanation for the differences found among the sub-samples.

Table 3. --Mean number of twig-borer attacks per 14-inch leader for each sub-sample

	Mean number of attacks per 14-inch terminal 1/
Brazos River Plantations	
Mumford Norwood soil	15 |
University farm Norwood soil	13
Mumford Miller soil	9
Brazos River Natural Stands	
Mumford Norwood soil	12
University farm Norwood soil	11
Bryan Norwood soil	8
Colorado River Natural Stands	
LaGrange	5
Bastrop	
Smithville	

1/ Means not connected by the same vertical line differ significantly at the .01 level by the Duncan test.

Clonal Differences in Number of Attacks

Significant differences among clones were indicated for number of attacks (Table 4). The range in mean number of attacks per terminal was from 1.5 to 16. The frequency of clones having various levels of attack is given in Table 5. Only one of the 37 clones has less than two attacks per terminal. Comparing the means by the Duncan test, only the hybrid NE-316 with a mean of 1.5 is found to have a lower incidence of attack than the other clones.

Table 4.--Clonal analysis of variance combined over plantations for mean numbers of twig-borer attacks per 1 -inc terminal

Source	df	ss	ms	F 1/
Plantations	2	23.21	11.61	1161.0**
Replications in plantations	3	.03	.01	
Clones	36	38.25	1.06	3.3**
Clones X Plantations	72	23.16	.32	2.5**
Pooled error	108	13.63	.13	

1/ ** Statistically significant at the .01 level

Unfortunately, NE-316 does not outgrow native cottonwood of Texas origin. In the four-year-old irrigated plantation used for data on volume production, native nursery-run cottonwood averaged 40.0 fee: in total height, NE-316 only 35 feet (Woessner, 1970). Maisenhelder (1970) also finds that eastern cottonwood selections are outgrowing hybrids on southern sites. He points out that these hybrids originated and were originally selected and tested in more northern latitudes than where they are now being grown. This could be one reason why native selections outgrow them.

Table 5.--Frequency table of nearest whole number of twig-borer attacks combined over plantations •ei:-W-rnT-} termina for the 37 clones

Number of attacks	Clonal frequency	Relative Frequency
2	1	3
9	1	3
10	3	8
11		11
12	9	24
13	5	13
14	7	19
15	6	16
16	1	3
	37	100

Maisenhelder (1970) also reported native cottonwood to be more resistant to pests than the hybrids he tested. However, one clone of Mississippi delta origin which he tested, Rosedale 8, was also included in this study, and it averaged 11 attacks per terminal in these tests as opposed to the 1.5 for the hybrid NE-316.

A significant clone-by-plantation interaction is also indicated by the analysis of variance results (Table 4). A statistically significant interaction could be detected by the analysis of variance when a true interaction, i.e., changing of clonal ranking from plantation to plantation, does not really exist. Robertson (1959) pointed out that an interaction could arise for two reasons, one being a changing of ranking and the other being that the clonal components of variance are different in the different environments. In this instance, the largest and smallest clonal components do differ by about 40 percent. Also, come changing of rank of the clones from plantation to plantation does take place. However, this could be due to too few samples per clone per plantation rather than indicative of a true interaction. Until further investigations can confirm or disclaim the interaction, it should be suspect.

Of most practical significance is the fact that the hybrid NE-316, the only clone significantly less attacked by the twig-borer, does not change ranks and remains relatively stable across the environments. The lowest level of attack, .5 per ramet, occurred on the Mumford Miller clay. The highest, 3.0 attacks per ramet, was on the Mumford Norwood soil planting.

Relationship between Form, Volume Productivity, and Number of Attacks

Obvious differences in form and in volume production show up among the 36 native eastern cottonwood clones. NE-316 was not included in these investigations because of the low level of attack. Since twig-borer attacks stunt and deform trees, it would not be unreasonable to expect that well-formed, high-volume producers would have a low intensity of attack.

An investigation of the relationship between form and intensity of attack was carried out in the two-year-old planting on the University farm. The trees were scored subjectively for form on a scale from 1 to 5, 5 being the poorest form. Two of the better formed clones of above average growth, S7C1 and S13C13, are shown in Figures 1 and 2. Clones of much poorer form, but also of above average growth, S7C8 and S13C21, are shown in Figures 3 and 4. The intensity of attack for these clones is given in Table 6. For these four clones, there is an inverse relationship between form and intensity of attack--the better the form, the higher the level of attack. A simple linear correlation between the mean form score for the 36 clones and the mean number of attacks failed to bear out any statistically significant relationship, either positive or negative. The simple linear correlation was extremely low--.03.

Table 6. Mean number of twig-borer attacks per 14-inch terminal for two well-formed and two poorly-formed clones

	Mean number of attacks per 14-inch terminal [1/]
S13C13	12.3
S13C21	8.7
S7C1	16.3
S7C8	12.5

[1/] Six terminals per clone; 3 plantations, 1 ramet in each of 2 replications per plantation.

The relationship between volume production and intensity of attack was investigated for eight of the native cottonwood clones, utilizing the mean number of attacks for the three one- and Vivo-year-old plantations and the clonal volume production at age 4 in the Texas A&M University farm irrigated plantation. The simple linear correlation was fairly high, .60, but still insignificant. At any rate, S7C1, the clone with the highest average rate of attack in the three younger non-irrigated plantations is producing the greatest volume in the four-year-old irrigated plantation.

Figure 1. Clone S7C1

Figure 2. Clone S13C13

Clones S7C1 and S13C13 maintain excellent apical dominance in an area subject to heavy twig-borer infestations.

Figure 3. Clone S7C8

Figure 4. Clone S13C21

Clones S7C8 and S13C21 were badly deformed when grown in an area subject to heavy twig-borer infestations.

The results obtained for the form and volume investigations turned out somewhat differently than originally hypothesized. Among the clones tested, an inverse relationship between form, volume production and intensity of attack does not exist. Apparently, some clones if growing fast enough have reasonable form and produce high volumes in spite of the twig borer.

SUMMARY AND CONCLUSIONS

An investigation of intensity of cottonwood twig-borer attack in three sample areas, Brazos River bottom natural stands, Brazos River bottom plantations, and Colorado River natural stands, indicated there to be essentially no difference in attack levels in the Brazos. Brazos natural stands averaged 10 attacks per terminal as opposed to 12 for the plantations. The attack level in the Colorado was significantly lower, being only 2 attacks per terminal. An appealing but as yet unproved hypothesis is that the high twig-borer population in the Brazos is tied in with land-use patterns. The Brazos bottom is intensely farmed, and agricultural pesticides are in wide use. It could be that pesticides have more effect on twig-borer predators than on the twig-borers and thus have led to an epidemic-like situation in the portions of the Brazos River bottom studied.

The investigation of differences in intensity of attack among the clones indicates that all 36 eastern cottonwood clones are heavily attacked. The native material ranged from 9 to 16 attacks per 14-inch terminal. These differences among the native clones could not be shown to be statistically significant. NE-316, a hybrid with an average of 1.5 attacks per terminal, was significantly less attacked than all of the native cottonwood.

An investigation of the relationship between tree form and intensity of attack with the native cottonwood clones indicated certain clones were able to maintain a reasonable timber form even though sustaining high levels of twig-borer attack. An investigation of the relationship between volume production under irrigated conditions and intensity of attack under non-irrigated conditions indicated native clones having above average rates of attack under non-irrigated conditions are capable of high volume production when grown under irrigated conditions.

Possibly, native cottonwood can be found that will be relatively resistant to borer attack and thus capable of maintaining economical growth on non-irrigated sites. If not, species hybridization as suggested by Schreiner (1970), with native cottonwood as one of the parents, may well be the most reasonable approach if cottonwood is to be grown commercially and economically in Texas. All hybrids so far tested in Texas, including NE-316, grow slower than the better native cottonwood. However, this is not an indication of the true potential of hybridization, because currently available Populus hybrids were not selected for their performance in the south. A slower growth rate could certainly be tolerated in insect resistant hybrids capable of growing without irrigation. The savings in irrigation costs and insect protection would more than offset the loss in growth.

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