MASTER

FUEL PLANTATION RESEARCH
Quarterly Progress Report
August 1, 1977 - November 30, 1977

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FUEL PLANTATION RESEARCH

Progress Report

The following report covers the period from August 1, 1977 through November 30, 1977. Previous accomplishments are summarized in our progress report of August 1977 (SR0-0903-3). We have used the tasks given in our Statement of Work as the basic organization for this report.

Task I: Paraquat Treatment of Test Plot:

The establishment of plots is completed except for continued periodic inspections for insect and disease attack, and any associated control measures that may be required. Our last paraquat treatment for a large-scale test (in cooperation with Union Camp Corporation) was completed on July 18, 1977. A summary of direct costs of the various treatments is given in table 1.

Table 1.--Cost Comparisons of Five Paraquat Treatment Methods

Treatment	Costs in Dollars				
	Paraquat	Paraquat	Insecticide	Insecticide	Total
Method	Application	Application	Application	Application	
- per 100 cubic feet of wood -					
(per tree in parenthesis)					
Chipper (5% paraquat)	0.12 (0.018)	1.32 (0.21)	0.15 (0.02)	1.38 (0.21)	2.97 (0.46)
Drill hole (5% paraquat)	0.12 (0.018)	2.88 (0.41)	0.16 (0.02)	1.40 (0.21)	4.56 (0.66)
Injection (2% paraquat)	0.11 (0.011)	1.62 (0.16)	5.76 (0.56)	1.88 (0.18)	9.37 (0.91)
Single dowel	1.45 (0.210)	2.55 (0.37)	0.16 (0.02)	1.40 (0.21)	5.56 (0.81)
Double dowel	2.16 (0.340)	4.59 (0.73)	0.15 (0.02)	1.31 (0.21)	8.21 (1.30)

Results in table 1 are presented on the basis of cubic feet of wood because it is the one measurement of wood volume least subject to variation. A cord, for instance, may vary in actual solid wood content from 70 cubic feet to nearly 100 cubic feet. Data are also given on a per tree basis, however, because tree size enters into costs based on volume. The chipper method, wherein horizontal 1/3 circumference wounds were made with a power tool and then sprayed with paraquat solution, would appear to be the least expensive method. However, the per tree data show that the injector method could be somewhat less expensive; this treatment as applied was quite costly because we used diesel oil for the insecticide carrier. If water were used as in the other treatments, and if trees of comparable size to those treated with a chipper were used (slash pines of the injection treatment are smaller than the loblolly used in chipper experiments), the cost of treating 100 cubic feet would be about \$2.65 as compared to \$2.97 for the chipper method.

We used diesel fuel in our injector treatment, which is in cooperation with Union Camp Corporation, in order to complement both earlier and ongoing small scale studies that they have conducted on their lands in cooperation with us. Of our two dozen cooperators, they have had least problems with insect pests, and they alone of the cooperators have used diesel oil as an insecticide carrier. Although this could well be fortuitous, our large-scale test at SRP gave an opportunity for a thorough test of diesel oil. In a comparison with trees of equivalent size, total treatment costs using diesel oil are about twice as expensive as injection or chipper treatments using water.

The drill hole method is considerably more expensive in paraquat application than either the injection or chipper methods, and it shows no advantage

in oleoresin production (see table 3). Concerning the double dowel treatments, we have not yet received the wood sample analysis data to determine its oleoresin yield (see Task II below), although preliminary indications are that it will be high. If this is true, the additional cost of a double dowel treatment might well be a good investment if it were not for another crucial factor -- losses from insect attack. We recorded insect attack incidence before treating stands, and have periodically inspected them thereafter. Results of those insect surveys for individual experiments are given in table 2. Ips beetles are the principal insect pests and account for virtually all of the insect-caused tree mortality. Turpentine beetles are also present, and may well contribute to mortality by weakening trees and allowing subsequent successful attack by Ips beetles. Ambrosia beetles and other secondary insects are also present. This class of insects seldom, if ever, cause mortality as is implicit in the definition of "secondary insects".

Table 2.--Bark Beetle Incidence Before Paraquat Treatment, As It Currently
Exists After Treatment, And Associated Tree Mortality.

Experiments	: Beetle Incidence	: Treatment	: Current Beetle	: Mortality
	: Before Treatment	: Duration	: Incidence	
- Percent of trees involved -				
<u>Westvaco</u>				
Chipper	4.2	12 months	12.0	0.8
Drill hole	5.7	12 months	11.3	6.5
Single dowel	2.8	12 months	11.0	29.0
Control	4.1	12 months	6.4	0.3
<u>Reichhold</u>				
Double dowel	6.7	11 months	90.0	84.1
<u>Continental</u>				
Chipper	4.8	11 months	11.9	2.0
<u>Union Camp</u>				
Injection	1.5	5 months	4.0	2.2

As shown in table 2, mortality data for dowel treatments forcefully indicate that these treatments are unacceptable in spite of any oleoresin accumulations they may attain. The Reichhold experiment has been virtually wiped out. This double dowel treatment was initially chosen for two reasons:

- 1) As a wood naval stores industry, Reichhold must have wood much richer in oleoresin than can be used simply as pulpwood. We knew that higher paraquat dosage was correlated with higher oleoresin yield, and two dowels per tree amounts to about six times as much paraquat as would be given in a chipper treatment using a 5% paraquat solution.
- 2) We have treated trees in Florida with as many as four dowels, and they remain in a healthy condition. The rationale was that there was slow release of paraquat from the dowel, which allowed the trees to tolerate such an otherwise very high dosage. These Reichhold trees were treated in December 1976 and January 1977, and it was May 1977 before there was evidence of serious insect attack. This is contrary to our previous experience in Florida and throughout the south; in general, if attacks occur they happen within six to eight weeks after treatment. The spring and summer were very dry here at the Savannah River Plant, and it is exceedingly probable that this contributed greatly to successful insect attack and subsequent mortality of these already weakened trees.

Although the Reichhold experiment has been ruined as far as the principal objective -- a trial run at a wood extraction plant -- it has been highly useful and productive in these ways:

- 1) If this type of treatment with loblolly pine is too hazardous, now is the time to discover this and not after the wood naval stores industries have treated large volumes of timber; if there had been a wet spring and this caused mortality to remain tolerable, this in the longer view would have been a catastrophe.
- 2) These high populations of

insects per tree presented an opportunity for intensive collection of useful bark samples, to determine larvae to adult emergence ratios. This has been done. The degree of insect brood success in paraquat treated trees is a highly important question; our industrial cooperators are quite apprehensive about this and as such it may be the greatest single stumbling block to prompt commercialization of the lightwood induction discovery. Industry envisions a situation where trees are treated on a large scale on their lands, this act starting an insect epidemic that spreads to adjacent lands of other owners, and then there are resulting law suits. Except for data collected in this study and in our other insect research plots here at SRP, there are virtually no hard data regarding this insect emergence question. 3) These dowel treatments, and immediately surrounding treated stands which have all of the treatments we have used except injection, furnish highly useful data pertaining to the correlations of insect attack and tree mortality to the absolute amount of paraquat given per tree. These results are useful as an actual and rather dramatic demonstration, through slides and photos for use in presenting papers and to illustrate publications.

Aside from the dowel treatments, insect infestation and associated tree mortality show no cause for concern in these studies. Incidence of attack has increased over stand conditions before treatment, but mortality is actually somewhat less than may be expected in untreated but otherwise equivalent stands; it is within the range of normal random variation.

Task II: Determination of Oleoresin Yields

There seems to be some confusion over the number of wood samples that were to be analysed since our original cooperation with DOE (then ERDA). This probably stems from the initial talks (April 1975) and first proposal,

a preliminary 189, in which funds were requested to cover costs of analyzing 10,000 samples then on hand at our laboratory in Olustee, Florida. After our contract was signed in October 1975, much time and effort was spent in attempting to set up an arrangement with DuPont Savannah River Laboratory for analysis of these samples, which was not successful because of the high costs per analysis they were obliged to charge. We had to look elsewhere for a contractor, and a contract to analyze 4000 samples was put out for bid and finally let with FY-76 funds. By the time this contractor (Briggs Engineering, Norwell, Mass.) was ready to receive samples, the original 10,000 samples had been reduced to 719 by our Olustee laboratory, through compositing and increasing analysis production. These 719 samples were sent for analysis under the 4000 sample contract paid for with DOE (ERDA) funds. Consequently, 10,000 samples from Olustee never were involved, but rather 719. All of the remaining 3281 samples of this contract were sent from our studies here at the Savannah River Plant.

We have analysis data from the contractor for the 719 Olustee samples. They are part of a cooperative study with Reichhold, located at Blountstown, Florida, which is not yet closed and thus has not yet been published.

The 3281 samples were taken exclusively from the Westvaco and Reichhold experiments. Of these samples, 2158 were collected from the Westvaco plots 6 months following treatment, 43 were from Westvaco 9 months following treatment and the remaining 1080 samples were from the Reichhold experiment 9 months following treatment.

Thus far, 1170 samples from Continental at 6 and 9 months following treatment, and 810 samples from Union Camp at 6 months following treatment have also been collected. These samples are being sent for analysis to our laboratory at Olustee, Florida as are the remaining 2117 nine month

samples from Westvaco. All future samples from our four large-scale experiments will also be sent there.

Review of analysis costs in dealing with a contractor, with the logistical and other problems encountered, led us to examine the costs and problems of performing analyses within our own organization. We found that for \$60,000 (the cost of 4000 samples analyzed by a contractor not including transportation and storage costs), we could store, transport and analyze all the 6795 samples we have scheduled to collect this fiscal year. We have expanded our laboratory analysis facilities at Olustee and hired two GS-3 biological aids on temporary term appointments. An additional aid is working under the YACC program at no cost to us.

At Olustee we have worked out a computer program, using our computer located there, for the statistical analysis of these data. As oleoresin analysis data become available they are added to the data storage bank for this program. A second program is being set up to combine tree volume data with respective oleoresin sample data so that actual oleoresin production can be given on a whole tree basis; i.e. on the total merchantable volume in cubic feet for each tree. From these data will be constructed a yield table of oleoresin yields over time for each paraquat treatment.

Table 3 summarizes oleoresin yields by treatment for Westvaco data, all loblolly pine, and also gives results of the analysis of variance. A similar table (table 4) divides these data into the constituents of oleoresin, which are resin acid (rosin) and turpentine. As mentioned earlier, considerable analysis data from the other experiments (and for nine month sampling dates) are in hand, but are not complete enough for statistical analysis at this time.

Table 3.--Oleoresin Content by Tree Section Six Months
after Treatment with Paraquat.

Treatment	Tree Section		
	1st 5 feet	2nd 5 feet	10 feet to 4 inch top
- percent oleoresin, dry wood basis -			
Chipper	6.39 ^{1/} a	4.39 a	3.43 a
Drill hole	5.75 a b	4.24 a	3.49 a
Single dowel	5.38 b	5.02 a	4.42 a
Control	3.84 c	3.69 a	3.16 a

^{1/} Means within a column not followed by the same letter are
significantly different at the 5% level.

Table 4.--Resin Acid and Turpentine Content by Tree Section
Six Months after Treatment with Paraquat.

Treatment	Resin Acid			Turpentine		
	1st	2nd	10 ft.	1st	2nd	10 ft.
	: 5 feet	: 5 feet	: to top	: 5 feet	: 5 feet	: to top
- percent, dry wood basis -						
Chipper	5.39 ^{1/} a	3.89 a	3.09 a	1.00 a	0.50 a	0.34 a
Drill hole	5.01 a b	3.80 a	3.20 a	0.75 b	0.43 a	0.29 a
Single dowel	4.67 b	4.42 a	3.99 a	0.71 b	0.60 a	0.43 a
Control	3.50 c	3.41 a	2.90 a	0.35 c	0.29 a	0.26 a

^{1/} Means within a column not followed by the same letter are significantly different at the 5% level.

At this stage of six months after treatment the chipper method appears to be somewhat better than the drill hole method (table 3), but on a whole-tree basis the single dowel method is somewhat better than either (computations involving this are not presented). We also note that the single dowel method may well be having more affect farther up the tree bole, although comparisons of the means beyond 5 feet are not significant. It is interesting to note that untreated loblolly pines here at the Savannah River Plant have approximately twice the oleoresin content, on the average, as does loblolly pine in general throughout the south. These are all planted trees and the seed source is unknown; however, a genotypic explanation seems most likely to account for the high "natural" oleoresin content.

From the data of table 4 it is clearly evident that paraquat treatment increases turpentine production relatively more than resin acid production. The oleoresin of control trees is about 9 percent turpentine, while turpentine in treated trees is about 14 percent. We have previously found that treated slash and longleaf pines also produce a relatively higher turpentine yield. From a financial point of view this is desirable because turpentine is more valuable than rosin, but in terms of energy content on a weight to weight basis there is virtually no difference.

On two occasions we have supplied paraquat treated wood samples to our mutual cooperator, Dr. Dan O'Neil and his associates at the Georgia Tech Research Institute. We have also tried to assist them in other ways, especially general information in lightwood induction and aspects of wood sample analysis for oleoresins.

Task III: Evaluation of Mill Trials

Most of the preparatory work for the Continental Forest Industries trial, to take place at their pulp mill at Port Wentworth, Georgia, has been accomplished. The research contract between DOE(SRP) and Continental is nearing final form. Two of the three blocks in the study have received final 100 percent inventory, for use in obtaining present standing wood volume and also to determine growth since treatment. All three blocks will be sampled for oleoresin data just prior to logging, which is scheduled to begin on January 25, 1978. The pulp mill will begin using paraquat treated wood from this study in the second week of February 1978.

Task IV: Exploratory and Complimentary Studies

In compliance with instructions from Solar Energy WO just before this fiscal year began, and due to man power and fiscal constraints in the prior year, no studies pertaining to this task have been installed on the Savannah River Plant. Research in these lines, however, is being vigorously pursued by our team at Olustee.

Our SRP team has a study plan draft for an exploratory experiment in treating young small pines with paraquat; as envisioned now we would treat pines circa. 5 inches in diameter. Dan O'Neil, our cooperator and DOE's contractor of the Georgia Tech Research Institute, was and is very interested in such a study.

Other Topics

Cooperation.--Our work with the Georgia Tech Research Institute is mentioned above under Task II. We also have had several discussion sessions with Dr. Robert Inman of Mitre Corporation regarding a wide range of problems and questions relating to their plan for an energy plantation, as contracted by Solar Energy, DOE, WO.

As ex officio members of the Lightwood Research Coordinating Council Executive Committee, our Olustee Team Leader Dr. Donald Roberts and I attended the planning session for the January 1978 LRCC meeting. At a later date the Chairperson of the LRCC, Mr. Barry Malac of Union Camp, Don Roberts and I put together the actual program, which among other items involved contacting several dozen researchers for papers to be presented.

Research Dissemination.--The author has given three talks concerning lightwood induction in general and our research efforts with DOE: 1) To the Edisto Chapter (South Carolina) of the Society of American Foresters; 2) To the Florida Division of this society; 3) To the Society of Chemical Engineers, Charleston, S. C.; a group predominantly composed of pulp and paper company employees. Several other less formal talks and show-me trips have also been given.

The following papers will be presented at the January 1978 Lightwood Research Coordinating Council annual meeting, and these will be published in the proceedings:

- Moore, Gordon E. 1978. Emergence of Ips and black turpentine beetles from paraquat treated trees during three seasons of a year.
- Peters, William J. 1978. Ethrel-diquat-paraquat interaction in lightwood formation.

Roberts, Donald R. 1978. A new tool for paraquat application.

_____. 1978. Southwide paraquat inducement of light-wood -- 2nd LRCC standard experiment.

Stubbs, Jack. 1978. Large scale field testing of paraquat application techniques.

_____. 1978. Production of wood chemicals -- a status report.

We have many requests for publication reprints and other paraquat research information in both our SRP and Olustee offices.

Activities Scheduled For The Next Quarter

(December 1977 - February 1978)

During the next quarter, 1290 wood samples will be collected. This includes final sampling of the Continental and Westvaco experiments. Oleo-resin analysis results from the Reichhold 9-month sampling will be in hand, and statistical analysis completed. Our Olustee laboratory is currently working on analyses of the 9-month Westvaco samples, should have them completed before April, and will begin work on the Continental and Union Camp samples.

Final inventory of the third and last block of the Continental experiment will be completed, also final inventory of the Westvaco experiment. Insect and mortality surveys will be conducted at the same time. Preparations for harvest of both Continental and Westvaco studies will be completed, and logging will be accomplished under our supervision. Analysis of growth data to determine if paraquat treatments affected wood volume growth should be completed by April 1978.