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Electromagnetic Treatment of Loblolly Pine Seeds

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SUMMARY

Loblolly pine (*Pinus taeda* L.) seeds were exposed to an electromagnetic radiation treatment (Energy Transfer Process®, marketed by the Energy Transfer Corporation), and the effects of the treatments on seed germination, seedling development, disease resistance, and field performance of seedlings were evaluated. None of the evaluated variables showed any improvement over untreated controls.

Keywords: Energy Transfer Process, germination speed, germination value, Gray Process, *Pinus taeda*, seed dormancy, seedling survival and growth.

INTRODUCTION

Loblolly pine (*Pinus taeda* L.) is the species most frequently used for reforestation in the Southern United States; in fact, over 1 billion loblolly pine seedlings are produced each year for planting (McDonald and Krugman 1985). This has lead to a great deal of interest in any treatment that may have a potential to improve the survival and -early growth of this tree species.

In the early 1970's Sam Gray, Ph.D., patented an electromagnetic radiation seed treatment process (called the Gray Process) that claimed to speed seed germination, markedly hasten seedling growth, and provide disease control. Gray's Energy Transfer Corporation (ETC) marketed the seed treatment as the Energy Transfer Process® and promoted it across the South as a technique that would revolutionize agriculture. Some of the claimed results of using this process were (Helm 1976):

1. Yield of treated corn was increased by 161 percent, and in one variety the increase was reported to be 1,200 percent.
2. Soybeans showed a 300-percent increase in yield after treatment.
3. A crop of peanuts grown from treated seeds was 177 percent greater than one grown from untreated seeds.
4. Seedlings from treated loblolly pine seeds grown in a nursery had no disease or insect problems either in the nursery or in the field.
5. Treated loblolly pine seeds germinated in 3 days compared to 7 days for untreated seeds.
6. Loblolly pine seedlings grown from treated seeds showed increased growth; height and diameter growth was from 11 to 75 percent greater than seedlings grown from untreated seeds.

An evaluation of seedlings grown from loblolly pine seeds treated with the Energy Transfer Process was conducted in 1978 (Hughes 1978). An increase in seedling survival and growth was reported after 2 years in the field. A few major forest industries made long-term arrangements to have large quantities of seeds treated (Runge 1975). However, controversy over the effectiveness of the process developed. Controls used in Hughes' 1978 evaluation had not come from the same seedlot as those that had received the treatment. A test of a sample of seeds from the same lots Hughes had used showed no positive response from ETC treatments when tested by the USDA Forest Service in Pineville, LA. However, another study (Nelson and others 1980) reported that certain electrical treatments could influence germination rates. In 1979 the Forest Service agreed to conduct an impartial evaluation of the ETC seed treatment process. Testing was conducted by the Alexandria Forestry Center (AFC) in Pineville, Louisiana.

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METHODS

Loblolly pine seeds were selected from Rapides Parish, Louisiana. A 20-pound seedlot was chosen. It was divided into two 7 1/2-pound sublots for two ETC treatments and two 2 1/2-pound sublots for controls. One control was shipped with the seeds to be treated, but received no exposure to the treatment. This provided for an evaluation of any effects caused by the shipment of the seeds. The other control was kept at Pineville.

The sublots sent to ETC for treatment were supposed to be given different treatments; however, due to a misunderstanding, one of the sublots was given a duplicate treatment. Another seedlot was then selected and sent for the ETC treatment. The sublots and their treatments are listed below:

Seed Lot	*Treatment*
Lot 1	Control (retained at AFC)
Lot 1	Control (sent to ETC)
Lot 1	Treated with 60° AT (sublot 1)
Lot 1	Treated with 60° AT (sublot 2)
Lot 2	Control (retained at AFC)
Lot 2	Control (sent to ETC)
Lot 2	Treated with 70° AT

It is not possible to provide a clear description of the ETC treatment. Close associates of Gray that are familiar with the treatment have stated that no one but the inventor could make the patented process work (Runge 1975). When asked to describe his patented seed treatment process, Gray stated that: "The seeds are placed on a conveyor belt and passed under an electromagnetic energy field that rearranges the molecules and causes genetic changes" (Helm 1976). The information provided as to the treatments given to the seedlots sent for processing was as follows:

> The 60" AT treatment began with a seed temperature of 57° F and a moisture content of 8.38 percent; a coolant gas was used at 40" F, and seeds were run through the process for 20 seconds at 740 milliamps until the seed temperature reached 60" F. Seeds were held under a vacuum at 10 inches of mercury for 7 minutes. At the end of the treatment process the seed moisture content was 8.30 percent. The 70" AT treatment was similar, but with an initial seed temperature of 56 °F and moisture content of 10.95 percent. The coolant gas was at 49 °F and the seed exposure was for 22 seconds at 740 milliamps until 70 °F was reached. The seeds were held under vacuum as with the 60" AT treatment, and the final moisture content was 10.90 percent.

On completion of the ETC treatments, the treated sublots were returned to Pineville, where they were further divided into four subsets (replications) for the testing. Germination tests were run on both unstratified seeds and seeds stratified for 28 days to evaluate any immediate effects on seed quality. To evaluate for the presence of microorganisms, two 25-seed samples from each of the four subsets were plated on malt-agar media and assessed after 2 days.

The effects of the treatments on speed and completeness of germination (Czabator 1962) were tested on both unstratified and stratified seeds; testing followed Association of Official Seed Analysts (1980) rules. Three 100-seed samples were tested for each of the four subsets. Testing was done after 1 year of storage at 72 °F and after 1, 3, and 5 years of storage at 34 °F.

Measurements of initial seedling development were made using containerized seedlings following the greenhouse growing period. Seedlings grown for the 1980 test were measured at 17 weeks; those grown in 1981 were measured at 14 weeks.

Seedlings were grown in containers and bare-root nurseries for evaluation of seedling development and field performance. The container seedlings were grown in Styroblock-4® containers for 14 weeks at the Alexandria Forestry Center. Standard cultural techniques (Barnett and Brissette 1986) were used to grow the seedlings. Bare-root nursery seedlings were grown at the AFC Nursery and at the W. W. Ashe Nursery in southern Mississippi. Seeds from each treatment replication were sown in a randomized manner in the nurseries and lifted for immediate outplanting in January.

The initial field portion of the study was begun in the spring of 1980. However, one of the most severe droughts on record occurred during the summer and fall of 1980. Field survival of the container seedlings was lower than desired, and seeds sown late in the spring (for the bare-root seedling portion of the study) did not develop into plantable stock. The field portions of the study were rerun in 1981-82 from a new crop of seedlings. Container-grown stock was outplanted May 7, 1981, and bare-root stock was planted January 20, 1982.

To evaluate survival and growth, 121 seedling plots of each of the four treatment replications of container and Ashe Nursery bare-root stock were outplanted on the Palustris Experimental Forest on a moderately drained, sandy-loam soil. Seedlings were planted at 6-foot intervals in rows 6 feet apart. This close spacing was used to minimize soil variation and facilitate remeasurements. Survival was determined 2 months after planting, and survival and heights were measured in the fall dormant season. Additional measurements of survival and height were made 2 and 3 years after planting.

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A completely randomized design was used throughout the evaluations. Analyses of variance were used to test for significant (α = 0.05) differences among treatments.

The nursery seedlings grown for the 1980 test at the AFC Nursery had been evaluated for incidence of fusiform rust (*Conartium quercum*, f. sp. *fusiforme*) cankers. This evaluation of the AFC seedlings was made to determine if ETC treatments affected development of stem cankers. The seedlings grown at the AFC Nursery were used because they had not been given preventive fungicide treatments.

RESULTS AND DISCUSSION

Seed Germination

Initial Tests. -The primary differences in germination were between the two seedlots (table 1). Lot 1 appeared to be less dormant than lot 2. Unstratified seeds of lot 1 had higher germination than those of lot 2. There were no differences that could be attributed to treatment in the germination of unstratified seeds. Germination values (Czabator 1962) of unstratified seeds, which reflect both speed and completeness of germination, followed the same pattern. Values for lot 2 seeds were lower than for lot 1 seeds. There were no biologically meaningful differences among ETC treatments.

With stratification, germination of both seedlots was essentially the same, averaging 96 percent (table 1). Seeds of lot 1 held at AFC (control) had significantly higher germination values than some of the other treatments, but the differences were too small to be of practical importance.

Viability After Storage. -Storage at 34 °F for 1 year had no adverse effect on viability. Overall germination was slightly higher than the before-storage values, primarily due to a 2-percent increase in germination of unstratified seeds (table 2). Again, the primary differences in viability were between seedlots, not between untreated and ETC treated seeds.

Even at 72 °F, viability dropped only about 6 percent after 1 year of storage. In no instance did ETC treatments improve seed storability as measured by either speed or completeness of germination (table 2).

Additional germination tests were conducted after 3 and 5 years of storage at 34 “F. The ETC treated seeds did not show any increase in germination or germination value after storage (table 3). There was never more than a 3-percent difference in germination of stratified seeds, regardless of treatment. However, overall germination of unstratified seeds did drop about 6 percent over the 5 years of storage. Differences among treatments also developed in the unstratified seedlots after 5 years. Generally, unstratified seeds from lot 2 were more dormant, had lower total germination and germination values, and the control retained at AFC appeared to be more dormant than the control that had been sent to ETC.

Seedcoat Sterility

A malt-agar medium test for seedcoat microorganisms indicated that there were no differences among treatments. All seeds averaged a 98-percent or greater microorganism infestation.

Initial Seedling Development

Seedlings grown for the 1980 test were measured at 17 weeks of age; those grown in 1981 were measured at 14 weeks. Statistical analyses of the 1980 data showed that only top dry weights differed significantly among treatments (table 1). When the study was rerun in 1981, there were no differences in initial seedling characteristics with treatment (table 4).

Nursery seedlings grown in the 1980 test at AFC were evaluated for incidence of fusiform rust cankers. Less than 1 percent of all seedlings (control and treated) had fusiform rust galls; this may have been due to the early and severe drought of 1980. Normally 30 percent of seedlings develop cankers when no fungicide treatments are employed.

Field Performance

Two-month field survival for the containerized seedlings in the 1980 test averaged a fairly low 78 percent (table 1), and there was marked variation within and among the replications. There were no statistically significant differences among treatments.

Survival was excellent for both container- and nursery-grown bare-root seedlings in the 1981 test. Containerized seedling survival averaged 99 percent after 10 months in the field; nursery seedling survival averaged 98 percent after 3 months (table 5). Seedling heights of the container seedlings planted May 7, 1981, were also measured after 10 months. The seedlings averaged 0.93 feet in height. Seed treatment showed no influence on either survival or height of these seedlings.

Measurements of survival and height of both containerized and nursery grown seedlings were made in January 1983 and 1984; there were no differences among treatments. In early 1984, heights of container stock averaged 6.8 feet compared to 2.8 feet for bare-root stock (table 6). However, it should be noted that the container seedlings had been planted about 8 months prior to the bare-root material.

CONCLUSIONS

The results from this evaluation of the Energy Transfer Corporation's electromagnetic radiation treatment of loblolly pine seeds indicate no significant improvement in either seed germination or disease resistance, development, and field performance of seedlings grown from treated seeds.

Table 1.-*Summary of germination, initial seedling development, and 2-month survival of loblolly pine seeds and seedlings grown in containers (1980 test)*

Seed stratification	Treatment*	Seedlot	Seed properties: Germination	Seed properties: Germ. value	Initial seedling characteristics†: Ht.	Initial seedling characteristics†: Stem diam.	Initial seedling characteristics†: Top wt.	Initial seedling characteristics†: Root wt.	2-month field survival
			Percent		.... *mm*		.... *mg*		*Percent*
Unstratified	Control (AFC)	1	95.4 ab‡	22.6 d		....	......	....	
	Control (ETC)	1	95.6 ab	22.8 d	.....	....	.....	....	....
	60" AT (sublot 1)	1	95.6 ab	23.0 d	.....	....	....	....	....
	60" AT (sublot 2)	1	97.2 ab	23.3 d	.....	....	....	....	....
	Control (AFC)	2	83.2 c	11.8 f	.....	....	....	....	
	Control (ETC)	2	89.1 c	16.1 e	.....	....	....	....	
	70" AT	2	78.8 c	10.4 f	.....	....	....	....	
Stratified§	Control (AFC)	1	97.4 a	42.6 a	214a	2.9 a	1263 ab	210 a	84a
	Control (ETC)	1	95.8 ab	40.2 b	213a	3.0 a	1306 a	226 a	81 a
	60° AT (sublot 1)	1	95.8 ab	39.1 b	200a	2.9 a	1139 bc	220 a	81 a
	60° AT (sublot 2)	1	94.9 b	37.5 bc	204 a	2.7 a	1077 c	175 a	73 a
	Control (AFC)	2	96.8 ab	37.8 bc	223a	3.0 a	1232 ab	225 a	75 a
	Control (ETC)	2	96.0 ab	38.0 bc	206 a	2.8 a	1142 bc	203 a	79 a
	70° ΔT	2	96.2 ab	37.5 c	224a	2.8 a	1195 abc	222 a	76 a
Mean square error			4.62	2.73	165.54	.0199	8079.12	1,135.35	151.49

*See text for explanation of sublot treatments.

†Weights are dry weights; no seedlings were grown from unstratified seeds. Values are presented in metric measurements because this is the way they are measured; to convert to English measurements: divide mm by 25.4 mm/inch and mg by 28,349.53 mg/oz to obtain inches and ounces.

‡Treatment means, within columns, followed by the same letter are not significantly different at the 0.05 level. Duncan's Multiple Range Test was used to array treatment means.

§Seeds were stratified for 28 days.

Table P.-Germination percentages and values of *loblolly* pine seeds *after* 1 year of storage at either 34 or 72 °F*

Seed stratification	Treatment†	Seedlot	Stored at 34 °F Germ.	Stored at 34 °F Germ. value	Stored at 72 °F Germ.	Stored at 72 °F Germ. value
			Percent		*Percent*	
Unstratified	Control (AFC)	1	96.4 bc	21.4 d	66.4 cd	14.7 c
	Control (ETC)	1	95.4 cd	20.5 de	88.3 cd	14.7 c
	60" AT (sublot 1)	1	94.6 cd	19.3 de	87.2 cde	14.4 c
	60" AT (sublot 2)	1	95.6 cd	19.1 e	86.1 cde	13.9 c
	Control (AFC)	2	89.9 e	13.9 f	83.8 ef	11.1 d
	Control (ETC)	2	90.7 e	14.3 f	84.3 de	12.1 d
	70" AT	2	89.1 e	13.2 f	79.8 f	9.8 d
Stratified	Control (AFC)	1	96.4 bc	33.2 ab	88.4 cd	22.8 b
	Control (ETC)	1	94.3 cd	30.0 c	80.4 bc	23.7 b
	60" AT (sublot 1)	1	94.6 cd	31.2 bc	87.3 cde	22.6 b
	60" AT (sublot 2)	1	93.8 d	30.7 c	86.6 cde	22.2 b
	Control (AFC)	2	97.6 ab	33.9 a	97.4 a	29.6 a
	Control (ETC)	2	97.4 ab	33.5 a	92.2 b	23.9 b
	70" AT	2	98.5 a	32.6 ab	97.5 a	27.7 a
Mean source error			3.67	2.03	4.61	1.20

*Treatment means within columns, followed by the same letter, are not significantly different at the 0.05 level.
†See text for explanation of sublot treatments.

Table 3.-Germination percentages and values of *loblolly* pine seeds *after* 3 and 5 years of storage at 34 °F*

Seed stratification	Treatment†	Seedlot	Stored 3 years Germ.	Stored 3 years Germ. value	Stored 5 years Germ.	Stored 5 years Germ. value
			Percent		*Percent*	
Unstratified	Control (AFC)	1	95.0 b	20.6 b	86.2 cd	15.7 c
	Control (ETC)	1	94.8 b	19.6 b	86.8 cd	15.0 cd
	60" AT (sublot 1)	1	92.6 b	19.4 b	90.2 d	16.9 d
	80" AT (sublot 2)	1	94.9 b	20.5 b	82.8 bcd	13.3 c
	Control (AFC)	2	82.1 a	12.0 a	58.2 a	5.0 a
	Control (ETC)	2	88.4 a	14.3 a	73.5 b	9.0 b
	70" AT	2	84.4 a	12.2 a	78.9 bc	8.8 b
Stratified	Control (AFC)	1	94.5 abc	35.2 bc	91.2 a	29.4 c
	Control (ETC)	1	93.0 a	31.0 a	90.4 a	27.5 abc
	60" AT (sublot 1)	1	94.6 abc	35.9 c	91.1 a	28.4 bc
	60" AT (sublot 2)	1	94.2 ab	32.3 ab	89.2 a	27.7 bc
	Control (AFC)	2	97.5 cd	32.5 ab	91.1 a	25.1 ab
	Control (ETC)	2	96.5 bcd	33.2 abc	92.1 a	26.7 abc
	70" AT	2	97.6 d	33.3 abc	88.4 a	24.1 a
Mean source error			8.28	3.19	25.46	4.48

*Treatment means within columns, followed by the same letter, are not significantly different at the 0.05 level.
†See text for explanation of sublot treatments.

Table 4.—*Summary of initial seedling development of loblolly seedlings grown in containers, 1981 test**

Treatment†	Seedlot	Initial seedling characteristics*			
		Height	Stem dia.	Top wt.	Root wt.
		------- *mm* -------		-------- *mg* --------	
Control (AFC)	1	207	2.6	860	160
Control (ETC)	1	205	2.6	600	136
60" AT lot (1)	1	216	2.6	605	169
60" AT lot (2)	1	206	2.6	615	160
Control (AFC)	2	214	2.6	604	154
Control (ETC)	2	206	2.5	622	165
70" AT	2	202	2.6	880	166
Mean square error		255.67	.0060	3,175.68	576.35

'There were no significant differences in means across treatments for any seedling characteristics at the 0.05 level.

†See text for expl'anation of seedlot treatments.

*Values are presented in metric measurements because this is the way they are measured; divide mm by 25.4 mm/inch and mg by 26349.53 mg/oz to obtain inches and ounces.

Table 5.—*Summary of early field performance of container- and nursery-grown loblolly pine seedlings, 1981 test'*

Treatment†	Seedlot	Container grown			Nursery grown
		2-mo. survival	10-mo. survival	10-mo. height	3-mo. survival
		------------*percent*------------		— *Feet* ---	---*Percent*---
Control (AFC)	1	100	99	0.84	96
Control (ETC)	1	99	99	.93	99
60° AT (sublot 1)	1	100	99	.94	99
60° AT (sublot 2)	1	99	99	.92	96
Control (AFC)	2	100	99	1.00	99
Control (ETC)	2	99	99	.92	97
70° AT	2	100	96	.86	98
Mean square error		15.87	23.03	.0053	17.48

*There were no significant differences in means across treatments for any seedling characteristic at the 0.05 level.

†See text for explanation of sublot treatments.

Table B.-Summary of second- and third-year *field performance* of container- and nursery-grown (bare-root) *loblolly* pine seedlings, 7981 test*

Treatment+	Seedlot	Container grown				Nursery grown			
		Survival		Height		Survival		Height	
		1983	1984	1963	1964	1963	1984	1983	1964
		---Percent----		-_-_- Feet ----		--- Percent ---		---- Feet -----	
Control (AFC)	1	99	99	3.4	6.7	69	88	1.3	2.9
Control (ETC)	1	96	96	3.4	6.8	92	92	1.3	2.9
60° AT (sublot 1)	1	99	99	3.4	6.7	89	86	1.3	2.9
60" AT (sublot 2)	1	99	99	3.4	6.7	83	62	1.3	2.6
Control (AFC)	2	100	100	3.7	7.2	91	90	1.2	2.9
Control (ETC)	2	99	98	3.5	7.0	90	90	1.2	2.7
70" AT	2	96	96	3.2	6.4	69	90	1.3	2.7
Meansquare error		27.28	26.53	.0878	.2167	65.73	68.04	.0212	.1894

'There were no significant differences in means across treatments for any seedling characteristic at the 0.05 level.
†See text for explanation of sublot treatments.

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