Effects of Viterra® Root Dips and Benomyl on Root Growth Potential and Survival of Longleaf Pine Seedlings

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ABSTRACT. *A mixture of clay and benomyl is registered for use on longleaf pine* (Pinus palustris *Mill.) to control diseases and increase outplanting survival. However, for one sandy site in Alabama, treating roots with a gel slurry of Viterra containing benomyl reduced survival of stored seedlings when compared to a clay slurry containing benomyl (2.5% active ingredient). Root growth potential for January-lifted seedlings was also reduced by adding benomyl to a Viterra gel. For this study, seedlings planted in January and mid-February had better survival than seedlings planted in December or March. Poor survival in December resulted when seedlings were planted 2 wk prior to a hard freeze. South. J. Appl. For. 18(1):19–23.*

Longleaf pine (*Pinus palustris* Mill.) is highly susceptible to brown-spot needle blight (*Mycosphaerella dearnessii* Barr). In some regions, this disease can be a serious obstacle to the success of artificial regeneration. The disease reduces the photosynthetic area and can result in prolonging the "grass" stage of longleaf pine. A mixture of benomyl and clay (applied to the roots as either a dry mixture or a wet slurry) can be very effective in controlling brown-spot after outplanting (Kais and Barnett 1984, Kais et al. 1986, Cordell et al. 1985, Barnett et al. 1988). Consequently, a supplemental label was approved to allow nursery managers to treat longleaf pine roots with clay containing 5% active ingredient (ai.) of benomyl.

In addition to disease control, treating roots with a mixture of clay and benomyl has resulted in impressive increases in seedling survival (Table 1). Increases in survival of stored seedlings have occurred even when brown-spot is not a problem (Barnett et al. 1988). Apparently the fungicide is effective in suppressing the growth of other disease organisms while seedlings are in cool storage. Therefore, some recommend the use of benomyl root dips for all bareroot stock of longleaf pine (Barnett et al. 1990) while others recommend its use for sites where brown-spot disease is likely to be a problem (Snow et al. 1990).

Some nursery managers use a clay slurry for packing pine seedlings (Gramling 1988, Pryor 1988) while others use a slurry made with an absorbent gel such as Ag-Sorbent®, Hydro-Gel®, Liqua Gel®, Terra-Sorb®, Viterra®, or other similar products (Bryan 1988, Huff 1988, Sparkman 1988). The cost of treating roots with an absorbent gel can be as low as 4 cents per thousand seedlings (Huff 1988). This is a relatively inexpensive treatment when compared to other, more expensive ways of increasing outplanting survival (Echols et al. 1990). In Texas (Kroll et al. 1985), survival of loblolly pine (*Pinus taeda* L.) seedlings treated with a Terra-Sorb (50.8%) was better than seedlings treated with a clay-slurry (31.9%). When average survival of loblolly pine is greater than 70%, others have observed no differences between a clay slurry and a Terra-Sorb gel (Goodwin 1982, Stangle and Venator 1984). However, the best root treatment will likely depend on which brand and formulation of gel is used (Venator and Brissette 1983).

Although the supplemental benomyl labels refer only to mixing benomyl with clay, some nurseries have incorporated benomyl along with an absorbent gel. Some nurseries have used this treatment on an operational basis even though only a few studies have reported results from incorporating benomyl with an absorbent gel (Cordell et al. 1985, Filer and Nelson 1987). The purpose of this study was to test the effects of benomyl on storability and root growth potential (RGP) of longleaf pine seedlings when seedlings were packaged using a Viterra root dip.

NOTE: The authors are most grateful to the Union Camp Nursery for providing the seedlings and to the Union Camp Corporation for providing the outplanting site Funding for this research was provided by the Auburn University Southern Forest Nursery Management Cooperative. This paper is Journal Series No. 9-923363 of the Alabama Agricultural Experiment Station. Use of trade, firm or corporation names is for the reader's information and convenience. Such use does not constitute official endorsement by Auburn University of any product or service to the exclusion of others that may be suitable. Discussion of pesticides in this paper does not constitute recommendation of their use.

Table 1. Effect of adding benomyl to clay on survival of longleaf pine seedlings.

Study	Location	Weeks of storage	Application[1]	Clay only	Clay + benomyl	Difference
				(Survival %)		
Cordell et al. 1985	MS	0	slurry 10% a.i.	80	73	-7
	MS	3	slurry 10% a.i.	80	58	-22
Kais et al. 1981	MS	0	dry 10% a.i.	75	87	12
	MS	0	dry 10% a.i.	64	82	18
Kais and Griggs 1986	MS	0	dry 10% a.i.	56	83	27
Kais et al. 1986	LA	0	dry 5% a.i.	59	80	21
	MS	0	dry 5% a.i.	60	81	21
	AL	0	dry 5% a.i.	39	48	9
	GA	0	dry 5% a.i.	34	32	-2
	FL	0	dry 5% a.i.	42	28	-14
Kais and Barnett 1984	LA	0	dry 5% a.i.	99	96	-3
	MS	0	dry 5% a.i.	47	62	15
Barnett et al. 1988	LA	1	slurry 5% a.i.	67	79	12
	LA	1	slurry 5% a.i.	81	84	3
	LA	1	slurry 5% a.i.	46	64	18
	LA	3	slurry 5% a.i.	8	75	67
	LA	3	slurry 5% a.i.	30	83	53
	LA	3	slurry 5% a.i.	28	61	33

[1] Dry treatment involves applying a dry benomyl/clay mixture to moist roots. Slurry treatment involves dipping roots in a slurry of benomyl/clay and water.

Materials and Methods

In 1989, longleaf pine seedlings (seed lot # 331) were grown at the Union Camp Nursery at Union Spring, AL. Approximately 3,000 seedlings were hand-lifted on December 12, 1989, January 15, 1990, and February 12, 1990. After transportation to Auburn, AL, seedlings less than 7.5 mm at the root collar were removed, and the roots of the remaining seedlings were rinsed to remove soil.

Seedlings were treated with one of four root treatments. One treatment involved treating the roots with an absorbent slurry (2 g Viterra per liter of water). Two gel/benomyl treatments involved the same Viterra slurry with an addition of either 10 g (0.5% treatment) or 20 g (1.0% treatment) of Benlate® 50WP. An additional treatment involved dipping roots into a clay slurry plus benomyl (380 g kaolinite + 20 g Benlate® 50WP per liter of water). It should be noted that differences occur when calculating the percent active ingredient for root treatments. When using an absorbent gel, the amount of water used is included in the numerator to determine the percent active ingredient. In contrast, when using a clay slurry, the amount of water used is ignored (Cordell et al. 1985, Barnett et al. 1988). Therefore, the clay plus benomyl treatment in this study is a 2.5% treatment (10 g benomyl/380 g clay and 20 g Benlate® fungicide) instead of a 0.7% treatment (10 g benomyl/380 g clay, 20 g Benlate® and 1000 g water).

In this study, a liter of the Viterra slurry was sufficient to treat 250 seedlings. Therefore, for the 1% ai. treatment, each seedling was theoretically treated with 40 mg of benomyl. In contrast, a liter of the clay-benomyl slurry treated approximately 300 seedlings. This equates to treating each seedling with about 33 mg of benomyl.

For the January lifting, seedlings within each treatment were divided into six groups (three groups for outplanting and three for an RGP study). The taproots of seedlings used for the RGP test were pruned to a length of approximately 14 cm. Few seedlings had any new white root tips at potting. Seedlings were potted into coarse sand using 1 liter milk cartons and placed on a rooting bed in a greenhouse (under natural photoperiod) for 28–30 days. Seedlings were watered every day or every other day to keep the sand moist. Twenty seedlings were used per treatment/replication. After removal from the containers, the following measurements were obtained for each seedling: root collar diameter, taproot length, root dry weight, shoot dry weight, and number of white root tips ($\geq$0.5 cm). The study was a completely randomized design with two replications. The General Linear Models procedure of the Statistical Analysis System (SAS Institute Inc. 1985) was used to test treatment differences. In addition, correlation analyses were used to examine the potential relationships between RGP and seedling diameter.

Seedlings designated for outplanting were placed in Kraft-

Polyethylene bags and kept in cool storage (3°C ± 1°C) for up to 48 hr or for 1 or 3 wk. After storage, seedlings were hand-planted in four randomized complete blocks on a Troup soil in Autauga County, AL. Site preparation consisted of chopping and burning, followed by disking. Twenty-five seedlings per replicate plot were hand-planted on a 1.8 by 3.0 m spacing. Each plot (5 rows of 5 trees/row) was considered an experimental unit. First-year survival was recorded in April 1991.

Results

Survival

A hard freeze occurred on December 23, 1989, and temperatures reached –18°C and did not rise above –9°C until the next day (Figure 1). This freeze reduced survival of the first planting (December 13) and second planting (December 20) to 25% and 22% respectively. Survival of seedlings from the December lift was much greater when stored and planted on January 2 after the hard freeze (Figure 2). Therefore, the freeze damage resulted in a significant lift by storage interaction (Table 2). Seedlings lifted in December and stored for 3 wk had the best survival for the three storage treatments, while the opposite occurred for the January and February lift dates (seedlings stored for 3 wk had the worst survival). Overall survival for freshly lifted seedlings was 83% for January and February lifts, but storage for 1 or 3 wk reduced survival to 70% and 55%, respectively. Rainfall was average during the month of December (142 mm) and above average during January (278 mm), February (221 mm), and March (270 mm).

The clay-benomyl slurry was consistently the best root treatment in terms of survival (Figure 2). This treatment averaged 71% survival in comparison to an average of 60% survival for the Viterra treatment with no benomyl. This finding is similar to the report by Cordell et al. (1985) who compared clay-benomyl slurry with a Terra-Sorb-benomyl slurry. They found that regardless of benomyl treatment, seedlings treated with a clay slurry had better survival than seedlings treated with Terra-Sorb.

There was a significant interaction between storage treatment and root treatment. If seedlings were not stored, adding benomyl to the Viterra treatment appeared to have little affect on survival (Figure 2). However, adding benomyl to the Viterra generally decreased survival when seedlings were stored for 3 wk.

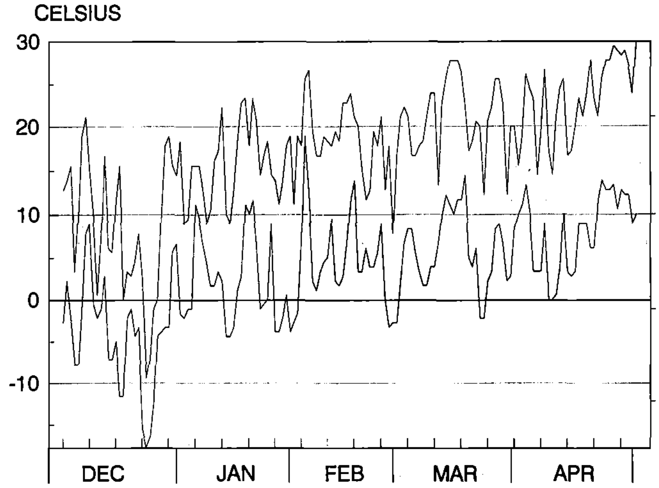

Figure 1. Maximum and minimum temperatures, at Thorsby, AL, during the 1989–1990 planting season.

For this study, the best time to plant was during January and the first part of February. The hard freeze caused problems for December plantings. Planting stored seedlings after February 12 was also not very successful. Poor survival after mid-February may be due to insufficient time for root growth to occur before the onset of hot summer weather. Poor survival can be expected when bareroot longleaf pine seedlings are planted in March just prior to spring droughts (Boyer 1989). In years with a severe spring drought, a December planting may be more favorable than planting in February or March (Barnett 1991). Although planting container-grown longleaf pine from mid-September to mid-November is a common practice in Alabama, early fall planting of bareroot longleaf pine has not been tested since 1937 (Wakeley 1954).

Root Growth Potential

Adding benomyl to the Viterra treatment greatly reduced RGP (Figure 3). Even the 0.5% rate of benomyl reduced RGP

Table 2. Analysis of variance table for first-year survival and root growth potential (RGP) of longleaf pine seedlings.

	Survival			January RGP		
Factor	df	F value	PR > F	df	F value	PR > F
Block	3	2.25	0.0864	1	0.61	0.4510
Lift date	2	157.23	0.0001			
Storage	2	8.47	0.0004	2	36.44	0.0001
Treatment	3	21.33	0.0001	3	61.05	0.0001
Lift*storage	4	60.63	0.0001			
Storage*treatment	6	4.33	0.0006	6	6.98	0.0029
Lift*treatment	6	3.04	0.0088			
Lift*storage*treatment	12	1.43	0.1625			
Error	105	(137.5)		11	(8.5)	

NOTE: Numbers in parentheses represent the mean square error.

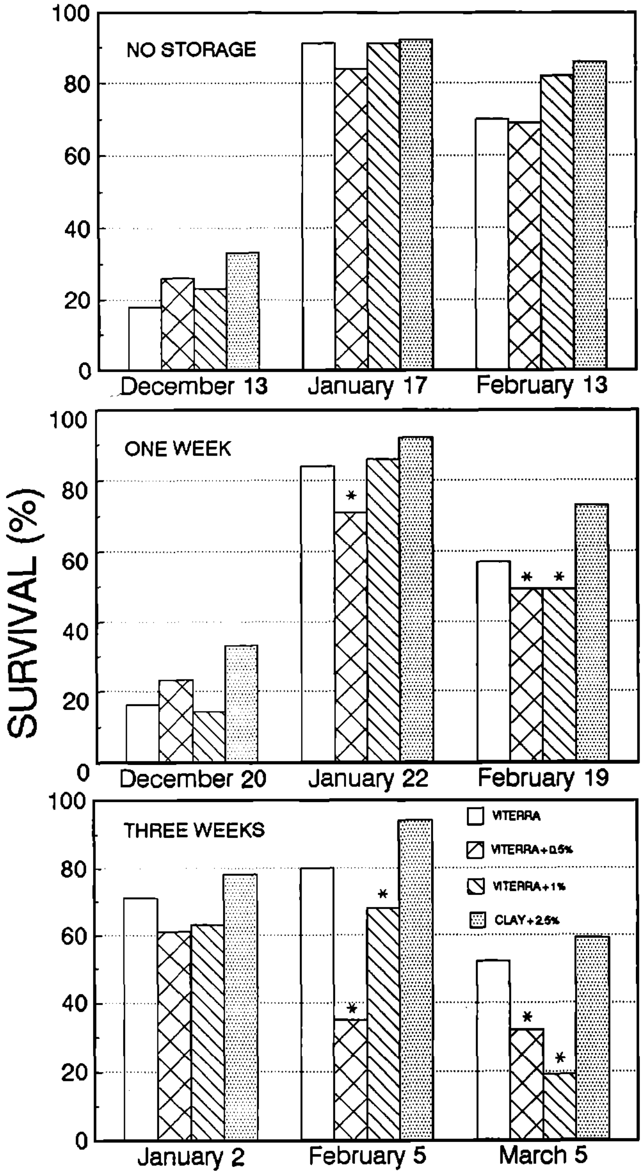

Figure 2. First-year survival of longleaf pine seedlings by planting date and storage length. Within each planting date, a significant (5% level of probability) difference from the clay/benomyl control is indicated by an asterisk (*) as determined by Duncan's new multiple range test. Each bar represents a mean of 100 seedlings.

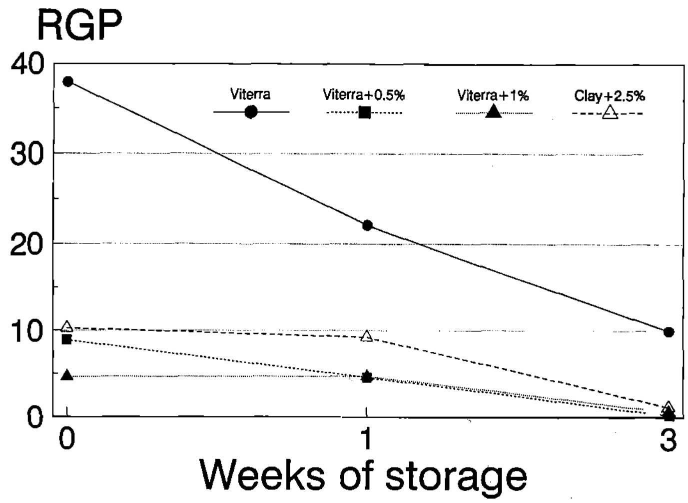

Figure 3. Effects of storage and root treatments on root growth potential (no. of new roots > 0.5 cm) of longleaf pine seedlings lifted on January 15, 1990. Each point represents a mean of 40 seedlings.

of unstored seedlings by 76%. The clay-benomyl treatment had about twice as many new roots as the 1% benomyl in Viterra. An unpublished study with the USDA Forest Service also showed benomyl to decrease RGP of longleaf pine. For freshly lifted seedlings, the RGP was reduced by 89% with the addition of benomyl (5% ai.) to a clay slurry root dip (pers. comm. J. P. Barnett 1990). Barnett et al. (1988) also observed a 65% reduction in RGP of loblolly pine seedlings when roots were dipped in a benomyl (5% ai.) clay slurry.

In this study, seedling storage decreased RGP for January-lifted seedlings. For seedlings treated with Viterra only, 1 and 3 wk of storage decreased RGP by 42% and 74%, respectively. The dramatic decline in RGP with storage helps to explain why cool storage of some sources of longleaf pine has not been very successful. In contrast, other sources of longleaf pine may show little or no reduction in RGP when January lifted seedlings are stored (Brissette and Barnett 1988).

For seedlings not stored and not treated with benomyl, RGP was related to seedling size (Table 3). There was a positive correlation between RGP and seedling diameter (RGP = –42.1 + 8.3 × diameter; r^2 =0.15; $P > F = 0.02$; $n = 36$). For this data set, a 12 mm seedling might have an RGP value of 57, while an 8 mm seedling might have a value of 24 This could help explain why longleaf pine seedlings with 12 mm diameters survive better than seedlings with diameters less than 10 mm (White 1981, Lauer 1987).

There was no significant correlation between RGP and survival for seedlings lifted in January (% survival = 74.9 + 0.6 × RGP; $r^2 = 0.14$; P > F = 0.22; $n = 12$]. The lack of a statistically significant correlation was due in part to a high survival (92%+) of seedlings treated with clay-benomyl slurry. Similar results have been observed in Louisiana. When seedlings were stored for 3 wk, RGP of longleaf pine was reduced by 90% by a clay-slurry with benomyl, but the treatment increased seedling survival by 19 percentage points

Table 3. Mean values and ranges for various seedling attributes and Pearson Correlation Coefficients between RGP and various morphological measurements. Data for freshly lifted seedlings treated with Viterra only (*N* = 36).

	Diameter	Root wt.	Shoot wt.	Taproot length	RGP
Mean value	9.6 mm	2.3 g	4.4 g	12.9 cm	38.0
Range	7.2 - 12.9	1.0 - 5.4	1.4 - 12.3	10.5 - 17.0	0 - 112
r value	0.388	0.413	0.418	-0.003	—
P> *r* value	0.019	0.012	0.011	0.984	—

(Pers comm., J.P Barnett 1990). This phenomenon may help to explain the treatment by site interaction in Table 1. In situations where water is limiting and good initial root growth is necessary for survival, the addition of benomyl could result in a reduction in survival (e.g., sites in Florida and Mississippi). However, when soil moisture is adequate during establishment, a reduction in initial root growth may not be enough to reduce survival. As a result, the long-term benefit of the fungicide eventually results in an increase in survival.

Conclusions

In this study, a benomyl-Viterra root dip decreased survival of stored longleaf pine seedlings. In view of this and other reports (Cordell et al. 1985), researchers should not recommend that nursery managers treat longleaf pine with a benomyl root dip regardless of the packing medium used. Although a clay slurry containing benomyl has proven beneficial, data are not available to show that adding benomyl to a Viterra or Terra-Sorb slurry is safe for use on longleaf pine. Further research with differing gel formulations and differing benomyl concentrations will be required before a gel/benomyl slurry can be recommended for operational use.

One to three weeks of cool storage can reduce the RGP of some sources of longleaf pine. To help ensure high outplanting survival, these seed sources should be planted soon after lifting. Poor survival can result when seedlings are planted just prior to a hard freeze. Low survival can also be expected when seedlings are planted in late February or early March prior to a spring drought. However, more research is needed to determine the optimal time for transplanting longleaf pine.

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