Auburn University Southern Forest Nursery Management Cooperative

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SYNTHETIC BED STABILIZERS COST EFFECTIVELY INCREASE SEED EFFICIENCY

by

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INTRODUCTION

To insure that most pine seed sown will germinate and produce bareroot seedlings of acceptable and uniform size, seed must be prepared to germinate quickly and sown at precise seedbed spacings and depth (Boyer and South 1988). To maximize germination speed and seedling emergence, seed are sown just below the soil surface (Barnett 1986) which, unfortunately, predisposes seed to the effects of severe rains. In fact, heavy rains after sowing probably cause more seedling loss than any other factor (Boyer and South 1984). Synthetic soil stabilizers can greatly reduce seed loss from heavy rains and are now used at most nurseries with satisfactory results (Carey 2004). Although many nurseries have continued to refine their use of bed stabilizer, there are few public reports on efficacy since usage was adopted in the late 1980's. Since rain-caused losses are still occasionally excessive, and it has been several years since a comprehensive assessment of stabilizer use was made, Coop members agreed to assess current use patterns and levels of satisfaction. That survey indicated interest in reassessing stabilizer efficacy through planned studies to evaluate the economic returns of application.

HISTORY

Chemical seed-treatments to prevent bird damage were proved effective in direct seeding operations in the mid-fifties (Mann and Derr 1955). Before that, seed and seedbeds needed physical protection from both birds and rain. The barriers available to prevent bird damage had to be so thick that they required removal after germination to allow seedling growth. Wakeley (1954) referred to such treatments as "seedbed surface covers" and described their function as "to protect seed from birds and from displacement by rain, and particularly to keep seed and soil continuously moist" through germination. These surface covers had to be inexpensive, and quick and easy to apply and remove. Wakeley (1954) preferred burlap and/or pine straw and, with the mechanization then available, burlap was the cheaper of the two materials to apply and remove. However, once chemical seed-treatments could prevent bird damage, plant products like pine straw, grain straw and sawdust could then be applied thinly enough to remain on beds after germination. These became cheaper to use than woven materials and additionally contributed to the soil organic matter. Minimally processed plant materials such as pine straw, sawdust and other mulches are still used to reduce rain damage but by the mid-eighties processed wood-fiber treatments (e.g. Hydromulch) that could be sprayed on beds were being adopted at some nurseries (Vanderveer1986). These had advantages over raw mulches (Horton 1986) but were used for only a few years before being replaced by fully synthetic soil stabilizers, such as Geotech® (Stringfield 1988).

In the South, the first studies of synthetic stabilizer (Geotech®) began in the mid-1980's (Carlson et al 1987) with most industry and some State nurseries evaluating and adopting Geotech® within a few years (Chapman 1988, Stringfield 1988, Sharp 1988, Stauder 1988). Most managers adopted the use of approximately 55 gal/ac Geotech® in 800 gal water and some modified applicators to treat bed shoulders more heavily than middles without changing the total volume per acre (Sharp 1988).

The thickness of the soil layer bound by a volume of stabilizer varies with the amount of water in the application and with that water in the soil at time of treatment. The usual target is for most of the applied stabilizer to dry, or cure, within the top 1/8th to 1/4th inch of surface soil (South 1987). The amount of water applied is varied by the manager based on experience and assessment of soil moisture and weather conditions. However, in the field, both soil moisture and any water added through irrigation are difficult to determine precisely and both quantities can be large compared to the 500 to 800 gallons of water typically applied with the treatment. Many irrigation systems apply more than 6,000 gal/hr (0.25") and many nursery managers report irrigating for 20 to 40 minutes before applying stabilizer. With each minute of irrigation adding about 100 gal/ac and each percent of soil moisture equal to about 2,000 gal/ac furrow slice, the difficulty of producing repeatable curing conditions is clear.

In this study, the variable of concern is stabilizer effect on seed efficiency (the conversion of seed into sellable seedlings). Treatment results were expected to vary with the severity of rains and especially those rains before seedling establishment which would move seed and recent germinates out of drills. In addition, losses associated with the erosion of bed shoulders can occur throughout the season. Therefore, we compared seed efficiency between treated and control plots and between inside and outside drills expecting treatment response to differ with rain severity among nurseries.

MATERIALS AND METHODS

Treatment: Stabilizer studies were installed at Weyerhaeuser's Pine Hill Nursery near Camden, AL, Smurfit-Stone Container Corporation's Rock Creek Nursery near Brewton, AL and Plum Creek Timber Company's Pearl River Nursery near Hazelhurst, MS. Each nursery used a different brand of stabilizer but we assume that efficacies are similar on a pound to pound basis. Three-bed-wide spray booms applied stabilizer at each nursery so three adjoining beds were always treated together. Treatments were applied as a randomized complete block (RCB) by dividing each three-bed-unit, across its long axis, into four equal blocks (of 80 to 120 feet depending on total bed length), and randomly assigning each of three stabilizer rates to one third length section. The three treatments were 1) a non-treated control, 2) the nursery's standard rate of stabilizer and 3) twice the standard rate. The same RCB layout was used at each study site. One RCB was installed at Rock Creek, one at Pearl River and three, each in a separate field, at Pine Hill Nursery.

Cultural Practices: Beds receiving stabilizer plots had recently been sown by management without altering schedule or practice for this study. Other cultural practices were not affected by the stabilizer study and, although these practices were similar at all three nurseries, their order varied. Within 24 hours of sowing, all beds received a pre-emergence herbicide treatment (either 0.5 lb ai/ac oxyfluorfen (Goal®) alone or in combination with 0.5 lb ai/ac fomesafen (Reflex®)). At Pine Hill, sown beds were first treated with herbicide, then stabilizer was applied (47 gal/ac product in 600 gal water) and allowed to cure for several hours before irrigation. At Pearl River, sown beds were moistened until the top quarter inch of soil (usually 30 minutes of irrigation varying with soil moisture and weather) was wet before stabilizer was applied (50 gal/ac product in 350 gal water) and herbicide was applied within 24 hours. At Rock Creek, sown beds were first treated with herbicide and then irrigated (usually for 30 minutes) before stabilizer was applied (37 gal stabilizer in 260 gal water per acre). Studies were applied in two fields at Pine Hill on April 9th and in a third field on April 19 and to one field at Pearl River on April 21 and one at Rock Creek on April 22, 2004.

Seedling Data: Seedlings were counted approximately 30 days after sowing (in May) at each nursery and in November before harvest. A one-foot-wide counting frame was placed across the middle bed of each three-bed-wide plot near the middle of each treatment plot and the numbers of seedlings per linear foot of drill were recorded for each drill. An unplanned assessment of seedling size was included due to herbicide injury among recently emerged seedlings in control (no stabilizer) plots of two fields at Pine Hill Nursery. To determine if stunting was associated with the herbicide injury, the seedlings within each counting frame plot in one affected field (field 1) were harvested. Twenty-five seedlings were randomly taken from each plot sample and measured to determine root collar diameter (RCD) then dried to determine root and shoot masses. The distribution of seedling grades (size classes) was determined from those RCD's and frame counts were used to convert mean seedling data into data per square foot of bed.

Weed Counts: After herbicide injury was observed in two fields at Pine Hill, weed counts were made by treatment plot on May 3rd to assess the impact of stabilizer on herbicide efficacy. All emerged weeds (grass and broad leaved) were counted in all three beds at both affected fields. Numbers of weeds were compared to numbers of seedlings using SAS Correlation.

Soil Analysis: Soil samples were collected from each study site in May with a 1" diameter soil core. Samples were mixed together by treatment plot in plastic bags until a minimum of 7oz (200 gm) of soil was collected. In Auburn, the samples were bulked by field for soil texture analysis. For texture analysis, a measured weight of dry soil was throughly mixed and suspended in 1L of water in a glass cylinder and measured volumes of this suspension were removed after 40 seconds and after 2 hours. The water was dried-off and the soil left behind weighed to determine the percentages of silt, clay and sand based on sedimentation rates (the pipette method of Olmstead et al 1930). Names of soil series were obtained from nursery management.

Rain Data: Daily rainfall totals between sowing and harvest were compiled by each nursery. From these, all days with at least 0.3 inches of rain were graphed by day after sowing (Figure 1).

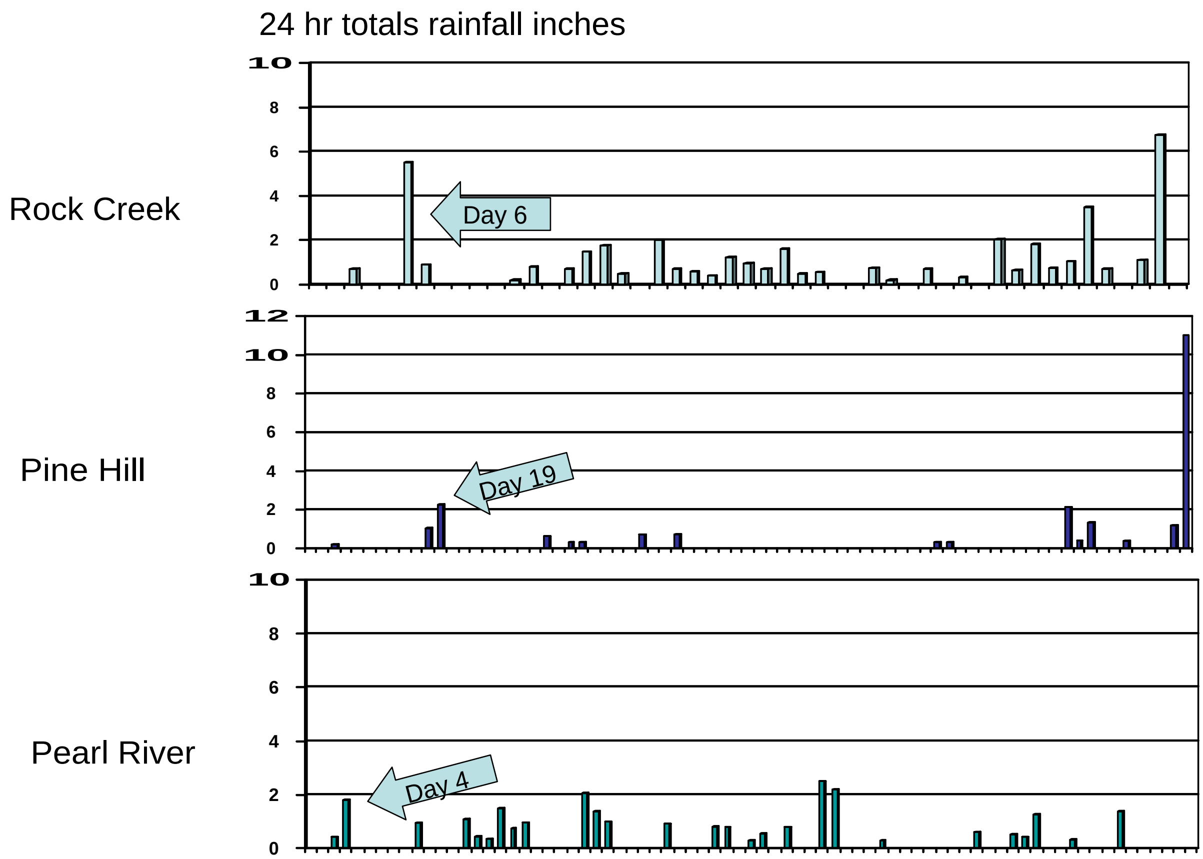

Figure 1. Twenty-four hour rainfall totals for days with at least 0.3 inches rain by day after sowing.

RESULTS AND DISCUSSION

The parent soil series at Pine Hill is Lucedale (a fine-loamy, siliceous, subactive, thermic Rhodic Paleudults) but surface soils in the three fields with stabilizer trials differed in color and apparent texture roughly in proportion to the clay fractions recorded in Table 1. However, field 3 seemed more different in color (gray rather than red) and sandier compared to fields 1 and 2 than the 2% to 4% more sand indicated by textural analyses. In the two finer textured Pine Hill fields (fields 1 and 2) visible herbicide injury occurred. At Rock Creek, the soil series is Orangeburg (fine-loamy, kaolinitic, thermic Typic Kandiudults) which in the studied field had a surface texture of a loamy sand. The Pearl River soil series is Latonia loamy sand (coarse-loamy, siliceous, thermic Typic Hapludults) and the surface soil of the study area was by texture a sandy clay loam.

Table 1. Soil texture analyses for fields with stabilizer studies.

Location	Soil Series	Sand %	Silt %	Clay %	Class
Pine Hill field 1	Lucedale	68	9	23	Sandy Loam
Pine Hill field 2	Lucedale	70	8	22	Sandy Loam
Pine Hill field 3	Lucedale	72	7	21	Sandy Loam
Rock Creek	Orangeburg	84	5	11	Loamy Sand
Pearl River	Latonia	60	7	33	Sandy Clay Loam

Rain damage to nursery beds and seedlings is more directly associated with rates of precipitation than with total accumulations. However, rate records are hard to get so we will infer what we can about precipitation rates from 24 hour accumulations. There are potential problems with this inference. For example, potentially damaging rains can produce a total accumulation of only half an inch or could be absent for an accumulation of two inches or more. Nevertheless, greater accumulations are positively correlated with periods of intense rain such that given two 24 hr accumulations, one of 2 inches and one of 0.5 inches, there is probably a more intense period of rain associated with the greater total accumulation. Along that line, it seems reasonable to assume that periods of intense rain occurred within the 11" and 7" totals, respectively, at Pine Hill and at Rock Creek that was associated with Hurricane Ivan in Figure 1. Similarly, the 6" accumulated at Rock Creek on the sixth day after sowing should contain some severe rain. This is indicated by a reduction in May seedlings in outside compared to inside drills and the differences among treatments in Table 3. Days with accumulations of two inches often contain periods of rain intense enough to damage recently sown seedbeds, especially those without stabilizer. However, a recorded rain (minimum 0.3 inches) on the day preceding that 2" rain at Pearl River could indicate the 2" accumulated over several hours and no seedbed damage was indicated by inspection or from the distribution of seedlings among drills or treatments.

For all five study sites, there were six more seedlings/ft^2 in stabilizer than in control plots ($pr > F < 0.01$). However, much of this difference is attributable to herbicide-caused seedling mortality in control plots at Pine Hill. Because herbicide effects were not part of the study plan and because these appear important only on some fine textured soils, plots with herbicide injury were analyzed separately and compared to the number of May weeds per plot in Table 2. The herbicide injury was due to the pre-emergence oxyfluorfen. This was the only herbicide applied before the symptoms developed and these were typical of that compound. Weed abundance correlated with seedling numbers and the fewest weeds and seedlings were in plots without stabilizer ($p = 0.01$). There were 15 fewer pine seedlings/ft^2 in control plots than in stabilizer plots in May. Between May and November, seedling counts changed (α 0.05) only for the 2X treatment and the mean difference between stabilizer and control plots was 13 seedlings/ft^2. There was little additional mortality after May and no apparent growth differences resulted from that herbicide injury.

Table 2. Weeds and seedlings by stabilizer treatment from fields with herbicide damage at Pine Hill.

Stabilizer Rate	Weed/ft^2 May	Pines/ft^2 May	Pines/ft^2 Nov	RCD	Mean Stem (gms)	Stem / bed ft^2 (gms)
0X	0.00 a	18.3 a	16.9 a	5.9 a	6.0 a	117.0 a
1X	0.04 b	31.7 b	30.7 b	5.2 b	5.1 b	160.3 b
2X	0.07 b	34.2 b	30.0 b	5.4 ab	5.3 ab	161.4 b
lsd	*0.03*	*3.0*	*2.9*	*0.6*	*0.8*	*25.7*

Separating fields with visible herbicide injury (see Table 2) from the analyses for stabilizer effects left one site at each nursery to evaluate soil stabilizers. The analyses for these sites had a significant interaction between site and treatment. Therefore, analyses by nursery are presented in Table 3 as main effects of treatment by site. The source of the interaction is apparent in Table 3. That is, at Pine Hill the fewest seedlings were among 2X stabilizer plots. Also at Pine Hill, there were significant block effects and, counter intuitively, more seedlings in outside drills. Although this “strange” variability does not disqualify those data, it indicates that factors other than treatment significantly influenced survival and it increases concern for the importance of random sources of variation not related to treatment. There was no interaction for site for the combined data of Pearl River and Rock Creek and for that analysis one application of stabilizer (the standard rate) increased production by 1.5 seedlings/ft^2 (43,000 seedlings/ac) compared to no treatment. A second application increased production another 0.64 seedlings/ft^2 (18,000/ac). Although at each nursery the numbers of seedlings in treatments and in controls project positive cost benefit analyses, only at Rock Creek (or if that nursery is combined with Pearl River) is the null hypothesis, that treatments do not affect seed efficiency, rejected with statistical confidence. The greater positive effect of stabilizer at Rock Creek seems attributed to a more severe rain there before seedling establishment (Figure 1).

Hurricanes and Seedbeds: Hurricane Ivan passed over the Rock Creek and Pine Hill nurseries on September 16th and 17th, respectively, 147 days and 160 days after sowing study. Rainfall records for those days (Figure 1) indicate approximately 8" of rain for Rock Creek and 12" for Pine Hill and both nurseries experienced winds of 100 mph or greater. Not surprisingly, nursery structures and surrounding plantations were damaged at both locations. However, when these nurseries were visited within two weeks of the storm there was little apparent damage to pine seedling production at either location and data in Table 3 indicates little difference in seedbed densities between May and November counts. This indicates that once seedlings are well established they are resistant to the effects of wind and rain and protect their seedbeds integrity. Comparing the differences among treatments at Rock Creek in May to the differences between May and November by treatment indicates the relative importance of soil stabilization before or after seeding establishment.

Table 3. Seedlings per linear foot of drill by nursery, stabilizer treatment and bed position.

Nursery	Variable	Level	Stems / drill foot May	Stems / drill foot November
Rock Creek	Stabilizer	0	11.4 a	11.2 a
		1	12.9 b	12.3 ab
		2	13.0 b	12.8 b
		lsd	*1.3*	*1.1*
	Drill Position	Outside	11.8 a	10.9 a
		Inside	13.1 b	13.3 b
		lsd	*1.1*	*0.9*
Pearl River	Stabilizer	0	12.5	11.7
		1	12.5	12.2
		2	12.0	12.3
		lsd	*1.5*	*1.0*
	Drill Position	Outside	12.5	12.3
		Inside	12.2	11.9
		lsd	*1.2*	*0.8*
Pine Hill	Stabilizer	0	12.7	12.4 ab
		1	14.6	13.5 a
		2	12.6	11.1 b
		lsd	*2.2*	*1.9*
	Drill Position	Outside	12.7	11.7
		Inside	13.9	12.9
		lsd	*1.8*	*1.5*

MANAGEMENT IMPLICATIONS

In 1987, a standard application of stabilizer cost about $190/ac which was the approximated value of 8,000 seedlings/ac (South 1987). Currently, those costs are about $220/ac and compared to seedlings equal the value of about 5,500 seedlings/ac. The seedling production required to equal stabilizer application has declined from about 0.3 seedling / ft^2 in 1987 to 0.2 seedlings / ft^2 currently. Increased seedling production in stabilized plots at Rock Creek or at Pearl River were more than ten times the estimated cost of materials for treatment. Even where rainfall caused no apparent bed erosion (at Pearl River) increased survival made application economical.

A brief review of nursery studies in past Cooperative Research Reports demonstrates that in studies with moderate replication (4 to5 replicate plots), treatments must differ by about 10% of the mean value to be significant (α 5%). For example, where stem weights average 100 gms in control plots, treatments that differ by less than 10 gms are seldom significantly different. In Table 3, stems per unit area, as usual, would have to differ by about 10% to be statistically significant. With values for an acre of seedlings so much greater than the cost of treatment, there is a large gap between statistically significant and economically important.

Severe rains in early 1991 were estimated to have destroyed about 80 million pine and three million hardwood seedlings across the South (Carey 1991) and 2003 was a bad year in several nurseries. Little attention seems to be paid to rain-caused losses in average years, and some of us assume stabilizer protection is less important in years in which rain damage is less obvious. However, rains after sowing often cause seedling loss (Boyer and South 1984) and this study indicates that, although stabilizer is most beneficial when rain damage occurred in control plots, enough seedling loss was prevented to be cost effective even where there was no visible bed deterioration.

As Wakeley reported, the kind of seedbed surface protection (stabilizer, mulch, etc.) chosen by a nursery manager results from many factors including experience (comfort), availability and cost of substitutes and labor, and the values placed on seed efficiency and production. Synthetic stabilizers have been the preferred choice at most industry nurseries since the mid-1980's and are probably more cost effective than in the past. Where seed efficiency is valued, the non-significant improvement in stabilized plots (as at Pearl River) pays for application in years with moderate rain and the return is increased in those years where erosion would occur in non-stabilized beds (as at Rock Creek).

LITERATURE CITED

Barnett, James P. 1986. Principles of sowing southern pines. In Proceedings of the Southern Forest Nursery Association. July 22-24, 1986. Pensacola, FL. Pg. 22-31.

Barnett, James P. 1989. Seed, cultural practices, and seedling uniformity. Forestry Supplement 62:95-105.

Brooks, Rhett, K. Pine straw - A conversion back to nature's mulch. In Proceedings of the Southern Forest Nursery Association. July 22-24, 1986. Pensacola, FL. Pg. 44-53.

Boyer, James N. and David B. South. 1984. Forest nursery practices in the South. S.J.A.F. 8(2):67-75.

Boyer, James N. and David B. South. 1988. Date of sowing and emergence timing affect growth and development of loblolly pine seedlings. New Forests 2:231 -246.

Carey, Bill. 1991. Survey of rain related seedling loss at southern nurseries. Auburn University Southern Forest Nursery Management Cooperative. Fall 1991. Pg 2.

Carey, Bill. 2004. Survey shows synthetic bed stabilizers generally satisfactory to nursery managers. Auburn University Southern Forest Nursery Management Cooperative. Spring 2004. Pg 5-6.

Carlson, W.C., J. G. Anthony and R. P. Pyler. 1987. Polymeric nursery bed stabilization to reduce seed losses in forest nurseries. SJAF 11:116-119.

Chapman, Walt. 1988. Geotech application technique used at MBI nursery 1986-1988. In Proceedings of the Southern Forest Nursery Association. July 25-28, 1988. Charleston, SC. Pg. 61-62.

Horton, Rick D. 1986. Hydromulch use at International Paper Company nurseries. In Proceedings of the Southern Forest Nursery Association. July 22-24, 1986. Pensacola, FL. Pg. 58-59.

Mann, W. F. Jr. and H. J. Derr. 1955. Not for the birds. Tree Planters' Notes. 20:3-6.

Olmstead, L. B., L. T. Alexander, and H.E. Middleton. 1930. A pipette method of mechanical analysis of soils based on improved dispersion procedure, U.S. Dept. Agr. Tech Bull. 170.

South, David B. 1987. Soil stabilizers. Auburn University Southern Forest Nursery Management Cooperative. Spring 1987. Pg 5-6.

Stringfield, Donald A. 1988. Geotech at Westvaco. In Proceedings of the Southern Forest Nursery Association. July 25-28, 1988. Charleston, SC. Pg. 61-62.

Sharp, Doug. 1988. Use of Geotech at the JSC/CCA Rock Creek Nursery. In Proceedings of the Southern Forest Nursery Association. July 25-28, 1988. Charleston, SC. Pg. 61-62.

Stauder, Albert F. III 1988. Geotech application at the Indian Mound Nursery. In Proceedings of the Southern Forest Nursery Association. July 25-28, 1988. Charleston, SC. Pg. 61-62.

Vanderveer, Harry L. 1986. Seedbed mulching - Some alternatives. In Proceedings of the Southern Forest Nursery Association. July 22-24, 1986. Pensacola, FL. Pg. 44-53.

Wakeley, Philip C. 1954. Planting the southern pines. U.S.D.A. Forest Service. Agriculture Monograph No. 18. 233 p.