Combinations of Fungicide and Cultural Practices Influence the Incidence and Impact of Fusiform Rust in Slash Pine Plantations

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ABSTRACT. *Slash pine was grown in central Louisiana under four levels of culture with or without repeated sprayings of the systemic fungicide triadimefon for protection against fusiform rust. The eight treatment combinations were: (1) no fungicide, weed control, or fertilizer; (2) weeded; (3) weeded, applied inorganic fertilizer, and bedded before planting; (4) weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); (5) applied fungicide but no weed control or fertilizer; (6) applied fungicide and weeded; (7) applied fungicide plus treatment 3; and (8) applied fungicide plus treatment 4. Fungicide applications greatly reduced fusiform rust impact in 10-yr-old slash pine stands. Fungicide treatments resulted in higher survival, fewer trees with stem galls, fewer trees with galls encircling 76%-100% of the stem circumference, greater total volume/ac, and less volume/ac among infected trees. The fungicide-treated trees had fewer stem galls below 5 ft of tree height compared with untreated trees, indicating that the fungicide treatment protected planted seedlings through several growing seasons. Weed control increased fusiform rust incidence. The fungicide-treated plots receiving delayed fertilization yielded the most volume (3,018 ft^3/ac) after 10 growing seasons because of high stocking and accelerated growth following fertilization. South. J. Appl. For. (2):53–59.*

Fusiform rust, caused by *Cronartium quercuum* (Berk.) Miyabe ex Shirai f. sp. *fusiforme*, is the most destructive disease of slash pine (*Pinus elliottii* Engelm. var. *elliottii*), frequently causing mortality and reducing the value of surviving infected trees for sawtimber (Busby and Haines 1988, Webb and Patterson 1983). The incidence of the disease increases when certain cultural practices and fertilizers are used to increase seedling growth (Burton et al. 1985, Dinus and Schmidtling 1971, Froelich et al. 1983, Miller 1972, Rowan 1978). The incidence of fusiform rust is increasing in slash pine plantations in the West Gulf Coastal Plain (Hunt and Lenhart 1986).

The systemic fungicide triadimefon (Bayleton®)[1] is effective against several plant diseases including fusiform rust (Snow et al. 1979). Triadimefon is translocated in plants from foliar sprays. Because the control of fusiform rust in slash pine stands would be beneficial, we applied triadimefon fungicide to measure the effects of fusiform rust incidence and severity on the survival, growth, and yield of planted slash pine growing under several other cultural practices.

NOTE: The authors wish to acknowledge the many contributions James D. Burton and Eugene Shoulders made toward this research and the study of fusiform rust.

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Materials and Methods

Study Area

The study area was cutover forestland in central Louisiana. The longleaf pine (*P. palustris* Mill.) sawtimber was harvested in the 1920s, and the land was grazed as open or fenced range until 1967 when livestock was excluded. In 1978, the natural pine-hardwood growth was cleared, debris or standing residual trees greater than 2 in. dbh were removed, and smaller trees were cut and left in place.

The soil is a Beauregard-Caddo silt loam association. Slopes range from 1% to 3% with a consistent western aspect. These soils are slowly permeable, low in organic matter and plant nutrients, droughty in summer (Burton et al. 1985), and intermittently water-logged in winter (Haywood et al. 1990).

Chemical analyses were run on the surface 6 in. of soil collected from 10 random locations in the study area. Available phosphorus was very low averaging 0.9 ppm. Total nitrogen was 0.09% and soil organic matter was 5%. Cation exchange capacity was 7.1 meq/100 g of soil and the pH was 4.8. Soil phosphorus was extracted by shaking the soil with 0.3M NH_4F + 0.1M HCl for 15 min. (Bray and Kurtz 1945). Total nitrogen was determined by macro-Kjeldahl (Bremner

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1965), and organic matter content was assayed by wet oxidation without external heat (Jackson 1958). Cation exchange capacity was measured by saturation with 1N ammonium acetate and replacement with 1N Magnesium acetate (Chapman 1965). Soil pH was determined with a glass electrode using 1:2 soil:water (Jackson 1958).

Treatments

Three blocks of eight treatments each were established in a randomized complete block design. Blocking was based on the general drainage condition of the site. Each of the 24 plots (3 blocks × 8 treatments) were 96 by 84 ft (0.185 ac), and contained 12 rows of pines spaced 8 ft between rows, and seedlings were planted 6 ft apart within rows (168 trees/plot or 908 trees/ac).

The eight treatments/block represent four levels of culture with or without repeated sprayings of a systemic fungicide (Table 1). The eight treatment combinations were:

C = No fungicide, weed control, or fertilizer

W = Weeded

WI = Weeded, applied inorganic fertilizer, and bedded before planting

WDI = Weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization)

FC = Applied fungicide but no weed control or fertilizer

FW = Applied fungicide and weeded

FWI = Applied fungicide and weeded, applied inorganic fertilizer, and bedded before planting

FWDI = Applied fungicide and weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization)

In October 1978, 6 months before planting, the WI and FWI plots received 96 lb/ac of phosphorus as a broadcast application of 0-46-0 triple superphosphate, the W and FW plots were flat-disked, and the WI, WDI, FWI, and FWDI plots were bedded. The beds were 8 ft apart on the centerlines, and bedding mixed the fertilizer into the soil on the WI and FWI plots. In July 1979, 3 months after planting, nitrogen as ammonium nitrate (NH_4NO_3) pellets was applied on the WI and FWI plots in a circle 1 ft in radius around each seedling at a rate of 200 lb/ac within these circles.

Unimproved slash pine seed was collected in Mississippi in 1973. Seedlings were grown for 14 wk in styrofoam containers with 4 in^3 cavities until outplanted in April 1979.

The weeded plots (W, WI, WDI, FW, FWI, and FWDI) were sprayed for the first 4 yr with several herbicides: dalapon (6 lb active ingredient (ai)/ac) mixed with simazine (3 lb ai/ac) applied in April and glyphosate (5.5 lb ai/ac) applied in late July. These sprays were accompanied by periodic manual hoeing to maintain an essentially weedless condition. Competing vegetation on C and FC plots, in order of importance, was bluestem grasses (*Andropogon* spp. and *Schizachyrium* spp.), blackberry (*Rubus* spp.), southern bayberry (*Myrica cerifera* L.), and greenbrier (*Smilax* spp.). The competing vegetation overtopped the planted pines on the two C treatments during the first two growing seasons.

The systemic fungicide spray was prepared by mixing 6 g Bayleton® 50 WP with 6.3 ml Agridex®, a surfactant, in 1 gal of water. Fungicide was applied to the seedlings the day before planting and then four times at 0.05 lb ai/ac at 2-wk intervals after planting. Five sprays, each at 0.2 lb ai/ac, were applied the second year. Four sprays were applied at 1.9 lb ai/ac the third year, and three sprays at 1.0 lb ai/ac the fourth year. Application rates/ac increased with tree size each year, except the fourth year when only the growing tips were sprayed instead of the entire tree as in previous years.

Hand-pumped backpack sprayers were used to drench the shoots in the first and second years. A high-volume power sprayer was used in the third and fourth years. Fungicide

Table 1. The eight treatment combinations and coefficients for the orthogonal contrasts.

	Treatments[1]							
	No fungicide				Fungicide			
Orthogonal contrasts	C	W	WI	WDI	FC	FW	FWI	FWDI
Main effect comparisons								
Cultural treatment effects								
Check vs. weeded	+3	-1	-1	-1	+3	-1	-1	-1
Weeded vs. weeded + fertilizer	0	+2	-1	-1	0	+2	-1	-1
Fertilization at planting vs. delayed fertilization	0	0	+1	-1	0	0	+1	-1
Fungicide treatment effect								
No fungicide vs. fungicide	+1	+1	+1	+1	-1	-1	-1	-1
Interactions between cultural and fungicide effects								
Check vs. weeded × fungicide vs. no fungicide	+3	-1	-1	-1	-3	+1	+1	+1
Weeded vs. weeded + fertilizer × fungicide vs. no fungicide	0	+2	-1	-1	0	-2	+1	+1
Fertilization at planting vs. delayed fertilization × fungicide vs. no fungicide	0	0	+1	-1	0	0	-1	+1

[1] C = no fungicide, weed control, or fertilizer; W = weeded; WI = weeded, applied inorganic fertilizer, and bedded before planting; WDI = weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); FC = applied fungicide but no weed control or fertilizer; FW = fungicide and weeded; FWI = fungicide plus WI; and FWDI = fungicide plus WDI.

applications began the first week of April and ended the first week in June. These dates spanned the period when basidiospore dissemination usually occurred.

Since bedding the two WDI treatments did not increase pine growth after 5 growing seasons compared with the two W treatments, we decided to compare fertilization at planting (WI and FWI) to delaying fertilization until the pines were established (WDI and FWDI). Delayed fertilization is a recommended rust management practice in high rust hazard areas (Schmidt and Klapproth 1982). The two WDI treatments were fertilized in April 1984 by broadcasting 96 lb/ac of phosphorus as 0-46-0 triple superphosphate and 200 lb/ac of nitrogen as NH_4NO_3.

Measurements and Analysis

Measurements were made on 48 trees (6 rows of 8 trees) in the center of each plot. Tree survival counts and total height measurements were made beginning at the end of the second growing season, and diameters (dbh) were measured yearly beginning at the end of the third growing season for trees greater than 4.5 ft tall. Total outside bark stem volume was calculated using the formula developed by Lohrey (1985).

Fusiform rust galls were tabulated yearly. After the tenth growing season, the height to the center of each stem gall on living trees was measured to the nearest 0.1 ft, and the severity of galls was evaluated. Gall severity was defined as the percentage of the stem circumference occupied by the gall. The data for the most severe stem gall on infected trees were divided into four classes: mild (1–25%), moderate (26–50%), serious (51–75%), and severe (76–100%) encirclement.

Survival counts, height, diameter, and volume data for all trees, for rust-infected trees, and for each of the gall severity classes were analyzed by analysis of variance and orthogonal contrasts ($P \leq 0.05$) (Table 1). The main effect contrasts were: (1) Check vs. weeded (C+FC vs. W+WI+WDI+FW+FWI+FWDI), (2) Weeded vs. weeded plus application of inorganic fertilizer (W+FW vs. WI+WDI+FWI+FWDI), (3) Fertilized at planting vs. delayed fertilizaton (WI+FWI vs. WDI+FWDI), and (4) fungicide vs. no fungicide (C+W+WI+WDI vs. FC+FW+FWI+FWDI). The interaction contrasts were: (5) Check vs. weeded × fungicide vs. no fungicide, (6) Weeded vs. weeded plus application of inorganic fertilizer × fungicide vs. no fungicide, and (7) Fertilization at planting vs. delayed fertilization × fungicide vs. no fungicide.

Results

Survival and Fusiform Rust Infection

Fungicide treatment significantly increased pine survival; there were 178 more living pines/ac on the fungicide treatments compared with the no fungicide treatments after 10 growing seasons (Table 2). Thirty-four percent and 53% of

Table 2. Total and fusiform rust infected trees/ac and contrast probabilities for living and dead slash pines 10 yr after planting.

Treatments[1]	Trees living after 10 yr		Trees dead after 10 yr	
	Total	With at least 1 stem gall	Total	Infected at death
	(trees/ac)			
No fungicide				
C	737	284	170	132
W	700	422	208	195
WI	637	372	271	208
WDI	637	353	271	252
Mean	678	358	230	197
Fungicide				
FC	857	170	50	0
FW	870	384	38	6
FWI	826	353	82	38
FWDI	870	252	38	19
Mean	856	290	52	16
	(probability > F-value)			
Contrasts				
Main effect comparisons				
Check vs. weeded	0.0470	0.0002	0.0470	0.0001
Weeded vs. weeded + fertilizer	0.0511	0.0195	0.0511	0.0146
Fertilization at planting vs. delayed fertilization	0.3545	0.0743	0.3545	0.3019
Fungicide vs. no fungicide	0.0001	0.0081	0.0001	0.0001
Interactions				
Check vs. weeded × fungicide vs. no fungicide	0.0578	0.2494	0.0578	0.0044
Weeded vs. weeded + fertilizer × fungicide vs. no fungicide	0.3219	0.6879	0.3219	0.5460
Fertilization at planting vs. delayed fertilization × fungicide vs. no fungicide	0.3545	0.2082	0.3545	0.0180

[1] C = no fungicide, weed control, or fertilizer; W = weeded; WI = weeded, applied inorganic fertilizer, and bedded before planting; WDI = weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); FC = applied fungicide but no weed control or fertilizer; FW = fungicide and weeded; FWI = fungicide plus WI; and FWDI = fungicide plus WDI.

the living pines had stem galls on the fungicide-treated and untreated plots, respectively, after 10 growing seasons. Plots with no cultivation (C and FC) had fewer trees with stem galls than did the six weeded treatments, and the fertilized plots (WI, WDI, FWI, and FWDI) also averaged fewer infected trees than did the weeded without fertilization (W and FW) plots.

Fungicide treatment significantly reduced the numbers of trees infected with fusiform rust at death (rust-associated mortality). On fungicide-treated plots, only 2% of the 908 planted trees/ac died with stem infections, but on untreated plots, 22% of the planted trees died with stem infections during the first 10 growing seasons (Table 2).

Weeding (with or without fertilization) significantly increased rust-associated mortality. When fungicide was not used, 132 trees/ac died with stem infections on the C plots compared to an average of 218 trees/ac on the three weeded treatments (W, WI, and WDI) (Table 2). When fungicide was used, no trees died with stem infections on the FC plots compared to an average of 21 trees/ac that died with stem infections on the three weeded treatments (FW, FWI, and FWDI).

Fertilization (with or without fungicide) also increased the number of trees with rust-associated mortality. When fungicide was not used, 195 trees/ac on the unfertilized, weeded plots died with stem infections compared with an average of 230 trees/ac on the two weeded–fertilized treatments (WI and WDI) (Table 2). When fungicide was used, 6 trees/ac on the unfertilized, weeded plots died with stem infections compared with an average of 29 trees/ac on the two weeded-fertilized treatments (FWI and FWDI).

The ANOVA revealed a significant interaction between the fertilization at planting vs. delayed fertilization and fungicide vs. no fungicide main effects when comparing among number of trees with rust-associated mortality (Table 2). When fungicide was not used, delayed fertilization (WDI) increased rust-associated mortality by 44 trees/ac compared to the fertilized at planting treatment (WI), but on plots receiving fungicide, delayed fertilization (FWDI) reduced rust-associated mortality by 9 trees/ac compared to the fertilized at planting treatment (FWI). However, the magnitude of the difference in number of trees/ac that died with stem infections between the fertilized, fungicide-treated plots (an average of 29 trees/ac for FWI and FWDI) and the fertilized without fungicide plots (an average of 230 trees/ac for WI and WDI) was far greater than the magnitude of this interaction.

The fungicide-treated plots averaged 129 fewer living trees/ac with severe stem galls than the plots without fungicide treatment after 10 growing seasons (Table 3). Without fungicide, 132 trees/ac on the C plots had severe stem galls compared to an average of 246 trees/ac on the three weeded

Table 3. Number of trees/ac by fusiform rust gall severity class and fungicide/cultural treatment, as well as the contrast probabilities, among living slash pine trees after 10 growing seasons.

Treatments[1]	Gall severity class[2]			
	Mild	Moderate	Serious	Severe
	(trees/ac)			
No fungicide				
C	63	51	38	132
W	32	25	50	315
WI	38	63	82	189
WDI	19	57	44	233
Mean	38	49	54	217
Fungicide				
FC	25	50	32	63
FW	44	132	101	107
FWI	50	126	82	95
FWDI	32	63	69	88
Mean	38	93	71	88
Contrasts	(probability > F-value)			
Main effect comparisons				
Check vs. weeded	0.9024	0.0462	0.0655	0.0042
Weeded vs. weeded + fertilizer	0.6224	0.5289	0.8853	0.0201
Fertilization at planting vs. delayed fertilization	0.0428	0.0566	0.3882	0.4853
Fungicide vs. no fungicide	0.8951	0.0059	0.4727	0.0001
Interactions				
Check vs. weeded × fungicide vs. no fungicide	0.0645	0.0744	0.2569	0.0850
Weeded vs. weeded + fertilizer × fungicide vs. no fungicide	0.9123	0.1005	0.1798	0.0740
Fertilization at planting vs. delayed fertilization × fungicide vs. no fungicide	0.8611	0.1107	0.8112	0.3554

[1] C = no fungicide, weed control, or fertilizer; W = weeded; WI = weeded, applied inorganic fertilizer, and bedded before planting; WDI = weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); FC = applied fungicide but no weed control or fertilizer; FW = fungicide and weeded; FWI = fungicide plus WI; and FWDI = fungicide plus WDI.

[2] Gall severity was defined as the percentage of the stem circumference occupied by the gall. The severity data for the most severe stem gall on infected trees were divided into four classes: mild (1–25%), moderate (26–50%), serious (51–75%), and severe (76–100%) encirclement.

treatments (W, WI, and WDI). However, when fungicide was used, 63 trees/ac on the FC plots had severe stem galls compared to an average of 97 trees/ac on the three weeded treatments (FW, FWI, and FWDI).

Without fungicide, the trees had more stem galls at a height of 4 ft or less than when fungicide was used (Figure 1). At 1 ft high, 34% of the surviving 10-yr-old slash pines were predicted to have stem galls if a fungicide was not used, but only 9% of the fungicide-treated pines were predicted to have stem galls. At 4 ft high, 9% of the pines were predicted to have stem galls if a fungicide was not used, but only 2% of the fungicide-treated pines were predicted to have stem galls. At over 4 ft high, the percentage of stems with galls by height where the gall occurred was not evidently influenced by fungicide treatment, although galls were still evident at a height of 23 ft.

Growth and Yield

Fungicide and cultural treatments significantly affected pine growth and yield. Fungicide effectiveness ceased once the pines were over 4 ft tall (Figure 1), and pines on the FW, FWI, and FWDI plots averaged over 4 ft tall in the third growing season (Figure 2). Pines on the FC plots did not average over 4 ft tall until the fourth growing season. Through 10 yr, surviving pines on the six weeded treatments (W, WI, WDI, FW, FWI, and FWDI) remained significantly taller with larger dbh and greater volume/tree than pines on C and FC treatments (Table 4). Also, individual pines on the fertilized treatments (WI, WDI, FWI, and FWDI) were significantly larger than pines on the W and FW treatments.

In treatments with no fungicide, individual pines were significantly larger if fertilized before planting (WI) than if fertilization was delayed until the sixth growing season (WDI) (Figure 2, Table 4). When fungicide was used, there were no significant individual tree-size differences between the two fertilization treatments (FWI vs. FWDI).

Total volume/ac was significantly greater when fungicide was used (Table 4), because of better stocking on fungicide-treated plots (Table 2). The difference in total volume/ac between the fungicide-treated and untreated plots was 122 ft^3 for C vs. FC, 700 ft^3 for W vs. FW, 150 ft^3 for WI vs. FWI, and 847 ft^3 for WDI vs.. FWDI treatments.

Weed control was more important when fungicide was used (Table 4). In treatments with no fungicide, weeded plots (W, WI, and WDI) averaged 1,220 ft^3/ac more total volume than the C plots, but with fungicide treatment, weeded plots (FW, FWI, and FWDI) averaged 1,664 ft^3/ac more total volume than the FC plots.

In treatments with no fungicide, fertilization before planting (WI) yielded more volume/ac than fertilization delayed until the sixth growing season (WDI) (Table 4). However, when fungicide was used, there were no significant volume/ac differences between the fertilization treatments (FWI vs. FWDI).

Among pines with stem galls, fungicide-treated trees were larger on average than trees not treated with fungicide (Table 4). However, because of differences in the numbers of infected trees/ac between the fungicide-treated and untreated treatments (Table 2), the trees with stem galls averaged similar yields/ac whether or not fungicide was used (Table 4). Other differences in growth among stem-infected pines followed the same pattern as those for the entire population.

Discussion

The use of fungicide for several growing seasons after outplanting significantly reduced the number of fusiform rust galls that formed on the lower 4 ft of the tree stem. The protection of young trees, and therefore the lower stem, with a fungicide greatly improved conditions within plots of slash pine in terms of better stocking, fewer trees with stem galls, and reduced severity of disease among infected trees. Fungi-

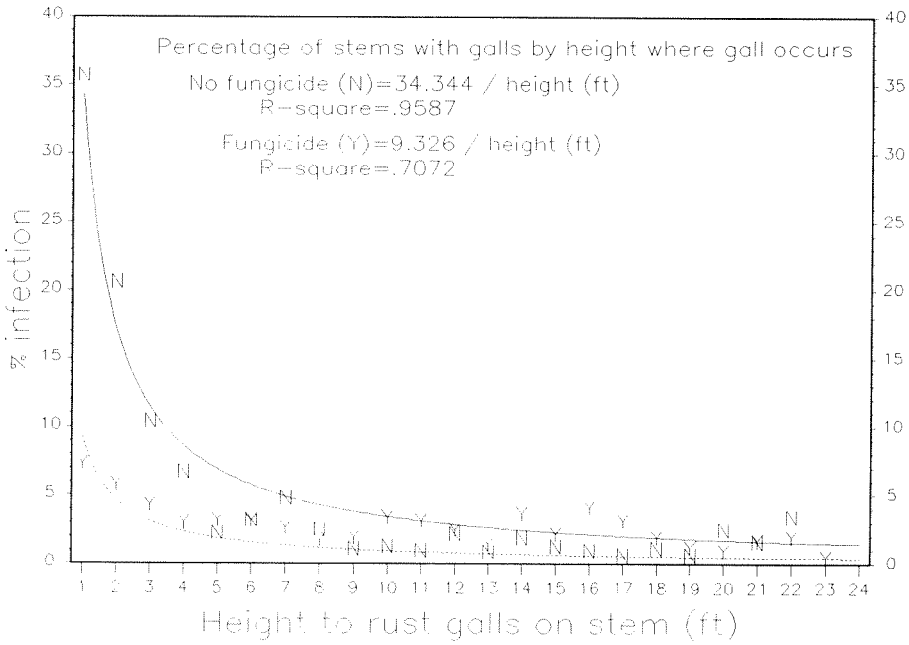

Figure 1. Incidence of fusiform rust galls (% infection) on the main stem of 10-yr-old slash pines by height classes.

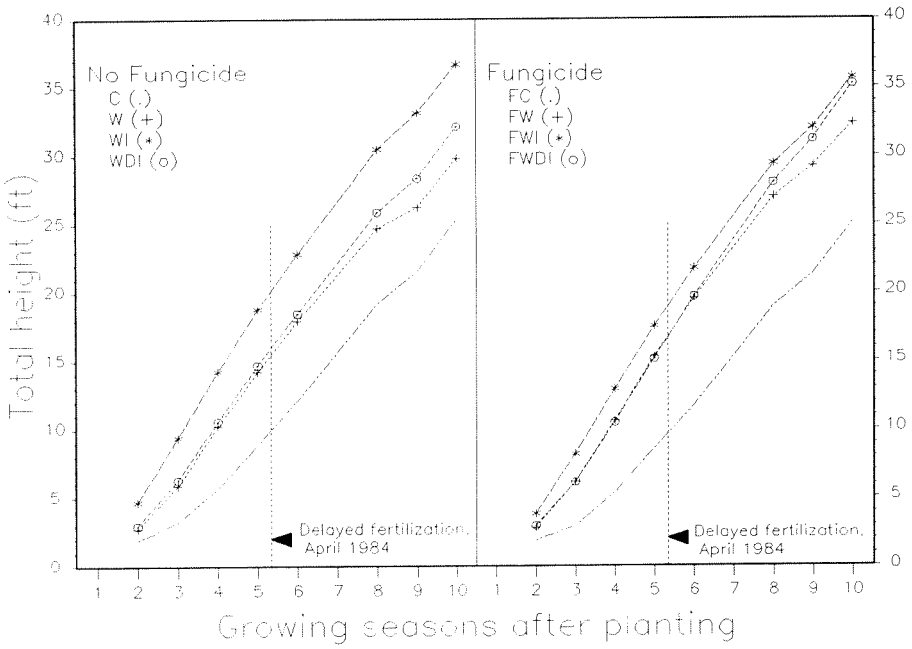

Figure 2. Cumulative height through 10 growing seasons for slash pines receiving different cultural treatments. The treatment codes used are: C = no fungicide, weed control, or fertilizer; W = weeded; WI = weeded, applied inorganic fertilizer, and bedded before planting; WDI = weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); FC = applied fungicide but no weed control or fertilizer; FW = fungicide and weeded; FWI = fungicide plus WI; and FWDI = fungicide plus WDI.

cide did not increase individual tree size because competition among pines on the better stocked fungicide-treated plots suppressed individual tree development. However, total volume/ac and volume/ac of non-infected trees were greater when fungicide was used because of higher stocking and less rust incidence. The high yields on the fungicide-treated delayed fertilization plots resulted from a combination of better stocking and accelerated growth following fertilization.

Clearly, fungicide was beneficial, but fungicide use might only be economical under certain specific, and limited, managment conditions—such as protecting outplantings at campgrounds. However, rust-resistant families of slash pine might be at least as successful as our fungicide-treated trees in reducing the number and severity of fusiform rust galls.

For example, first-generation selections of rust-resistant families have shown about a 30–35% reduction in rust incidence compared to unimproved seedlings, and even greater improvements are expected from later generations (Hodge et al. 1990, Hollis et al. 1977, Schmidt et al. 1981). We showed a 45% reduction in rust incidence with fungicide treatment if both rust-associated mortality and 10-yr-old trees with rust galls are included in the comparison. If only surviving 10-yr-old trees are compared, we showed a 19% reduction in rust incidence from fungicide treatment. In either case, our data suggest that forest managers might expect total yields to be increased by 6% to 43% in pole-size stands of rust-resistant families, due solely to a reduction in gall incidence and severity (Table 4)—an important justification for planting rust-resistant stock.

However, the ability of slash pine families to resist fusiform rust infection can vary among locations (Walkinshaw and Roland 1990). A variation in rust resistance caused by such a family/location interaction would reduce the overall gains in volume/ac expected from the use of rust-resistant planting stock across a wide geographic area.

Fertilization and weed control generally increased tree height, dbh, and corresponding volume production, but were associated with a greater incidence of fusiform rust, as normally occurs when unimproved slash pines are outplanted and intensively cultured (Hollis et al. 1977). Pines not receiving weed control had the lowest incidence of fusiform rust, possibly because competing vegetation shielded the seedlings for 2 growing seasons after outplanting and because of slower initial growth rates (less new tissue exposed) than the intensive-culture treatments (Figure 2).

Managers should limit weed control after outplanting to low rust hazard areas. If rust-resistant planting stock is available, fertilizer applications, a capital expense, might be delayed without a reduction in future stand yields or a subsequent increase in rust infections, findings supported by earlier recommendations (Hollis et al. 1977, Powers et al. 1981, Powers et al. 1993, Schmidt and Klapproth 1982).

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Table 4. Growth and yield statistics by fungicide/cultural treatment and contrast probabilities for all surviving 10-yr-old slash pines and those infected with fusiform rust.

Treatments [1]	All surviving trees				Trees with stem galls			
	Total height (ft)	dbh (in.)	Volume/ tree (ft^3)	Volume/ ac (ft^3)	Total height (ft)	dbh (in.)	Volume/ tree (ft^3)	Volume/ ac (ft^3)
No fungicide								
C	25	4.0	1.27	941	24	3.7	1.08	309
W	30	4.8	2.30	1,611	29	4.5	1.92	808
WI	37	6.1	4.23	2,701	35	5.7	3.65	1,393
WDI	32	5.6	3.42	2,171	31	5.2	2.72	962
Mean	31	5.1	2.81	1,856	30	4.8	2.34	868
Fungicide								
FC	25	4.0	1.23	1,063	24	3.9	1.13	191
FW	32	5.2	2.66	2,311	32	5.1	2.59	992
FWI	36	5.6	3.45	2,851	36	5.6	3.43	1,213
FWDI	35	5.6	3.47	3,018	34	5.4	3.12	791
Mean	32	5.1	2.70	2,311	32	5.0	2.57	797
Contrasts	(probability > F-value)							
Main effect comparisons								
Check vs. weeded	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Weeded vs. weeded + fertilizer	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0790
Fertilization at planting vs. delayed fertilization	0.0009	0.0265	0.0038	0.1624	0.0013	0.0003	0.0001	0.0024
Fungicide vs. no fungicide	0.0168	0.6948	0.2302	0.0001	0.0005	0.0010	0.0123	0.3992
Interactions								
Check vs. weeded × fungicide vs. no fungicide	0.0666	0.8265	0.6526	0.0441	0.0337	0.4691	0.2256	0.7479
Weeded vs. weeded + fertilizer × fungicide vs. no fungicide	0.1797	0.0006	0.0026	0.3595	0.1988	0.0015	0.0102	0.0941
Fertilization at planting vs. delayed fertilization × fungicide vs. no fungicide	0.0048	0.0103	0.0026	0.0137	0.0354	0.0433	0.0134	0.9704

[1] C = no fungicide, weed control, or fertilizer; W = weeded; WI = weeded, applied inorganic fertilizer, and bedded before planting; WDI = weeded, bedded, and applied inorganic fertilizer in the sixth growing season (delayed fertilization); FC = applied fungicide but no weed control or fertilizer; FW = fungicide and weeded; FWI = fungicide plus WI; and FWDI = fungicide plus WDI.

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