EFFECTS OF WATER LEVEL AND FERTILIZER COMBINATIONS ON LOBLOLLY AND SLASH PINE SEEDLINGS

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This study reports interacting influences of three fertilization levels and four controlled water regimes for loblolly pine *(Pinus taeda)* and slash pine *(P. elliottii)* in the Southeastern tidewater zone.

Summary

If water was ponded on the surface, seedlings had poorer survival when fertilized than when not fertilized; each fertilizer application increased mortality. This was the only effect of fertilization on survival. Height growth was stimulated through the second growing season by nutritional supplements under all water conditions, except for loblolly pine permanently inundated to 4 inches. Needle lengths and foliar nitrogen, phosphorus, and potassium increased with drainage and fertilization, particularly early in the season. In England, Prof. E. R. C. Reynolds found that fertilization partially alleviated the detrimental]

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effects of waterlogging. It was decided that the plastic Bladen clay loam soils of the coastal areas should be rained to depths of 4 inches, and that, for significantly proved growth during the first 2 years of plantation establishment, 1,000 pounds per acre of 8-8-8 plus 100 pounds per acre of a trace element mixture must be applied.

The Study

The Bladen series is a poorly drained "flatwoods" soil formed from thick beds of acid clay. It is characterized by highly reduced iron oxides. Mottling occurs in the heavy soil at depths as shallow as 2 inches. Forests cover 75 percent of this soil, which is on much of the tidewater area. Loblolly pine is the principal species; it reproduces quickly and grows well where drainage is adequate. Slash pine is frequently planted and grows well on moist sites to the west of the Georgia tidewater area.

Twenty-five seedlings of each species were planted in 12- by 24-foot diked and ditched plots at 2- by 2foot spacing in January 1959. Species were assigned at random to one-half of each plot. Water was supplied by an artesian source. Treatments were initiated on June 1, when seedlings were firmly established and had begun to grow. Fertilization treatments were randomly superimposed on the water-control treatments, and all treatment combinations were repeated three times. The treatments were

+4: Water maintained at 4 inches above mean plot elevation.
±0: Water maintained at mean plot elevation.
-4: Water maintained at 4 inches below mean plot elevation.
ck : Uncontrolled natural conditions.
0 : Fertilizer.
1 : Initial fertilizer: 1,000 pounds per acre of 8-8-8 plus 100 pounds per acre of a mixture of trace elements (Es-Min-EI) broadcast in mid-April, 6 weeks before water treatments began.
1 + S : Same as 1, plus 400 pounds per acre of diammonium phosphate applied in mid-July, 6 weeks after water treatments began.

Survival and height measurements were made annually for the 2 years since the first report; these data were statistically tested by analysis of variance using the arc sin transformation of survival percentages.

Results

Survival.-After 3 years, water impoundment still affected survival more than did fertilizer application. For both species, survival was adequate only if water was maintained at 4 inches below ground level, regardless of fertility level. When water was ponded, survival decreased radically. This was most notable with the higher rate of applied fertilizer (table 1). Statistically, third-year effects were similar to those of the first 2 years; results differed significantly among species and treatments. The slash pine stock used in these trials was generally superior to loblolly pine.

Before the end of the fourth growing season, a few more trees were lost in most treatment plots. Still, survival was adequate if surface water was drained. Four-year trends, however, indicated that species' survival varied; slash pine was superior, but only at the 5 percent level of confidence (table 1). For this period, trees in the untreated plots reacted similarly to those in the areas drained to a depth of 4 inches.

TABLE 1.—*Seedling survival of slash and loblolly pine at four water levels and three fertilization rates*

Treatment		Years since start of treatment			
		3		4	
Water	Fertilizer	Slash pine	Loblolly pine	Slash pine	Loblolly pine
		Percent	*Percent*	*Percent*	*Percent*
Check	0	89	91	88	84
	1	92	91	87	87
	1+S	96	88	95	81
−4″	0	92	88	89	84
	1	95	84	92	83
	1+S	92	84	87	84
±0″	0	63	44	35	31
	1	55	19	43	16
	1+S	47	27	41	24
±	0	37	8	15	1
	1	15	0	5	0
	1+S	0	0	0	0
Statistical Significance					
Source					
Replicates		NS		NS	
Treatments		**		**	
Species		**		**	
Species X treatment interaction		NS		NS	

Growth.-Treatments affected growth through the third and fourth years. Fertilization for both levels of application resulted in taller trees (table 2). Draining free water to a 4-inch depth also improved growth. Third- and fourth-year data differ from those of the first 2 years because the interacting influences of species and treatment only become important during the third and fourth years. Slash pine is more responsive to treatment than loblolly pine (table 2).

TABLE 2.—*Growth of surviving slash and loblolly pine seedlings at four water levels and three fertilizer rates*

Treatment		Years since start of treatment			
		3		4	
Water	Fertilizer	Slash pine	Loblolly pine	Slash pine	Loblolly pine
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
Check.....	0	32.7	23.6	60.1	39.5
	1	34.8	34.0	61.4	53.2
	1+S	36.5	38.2	63.2	59.6
−4''.....	0	29.3	22.4	49.7	34.2
	1	33.7	36.9	56.2	54.1
	1+S	35.6	42.6	63.5	64.8
±0''.....	0	6.2	4.2	8.1	7.8
	1	11.6	7.6	16.9	10.4
	1+S	11.8	14.0	20.9	20.8
+4''.....	0	5.1	1.6	3.9	3.0
	1	8.8	.....	3.6	.....
	1+S	.....	.....	.....	.....

Statistical Significance Source		
Replicates	NS	NS
Treatments	**	**
Species	*	*
Sp. X treatment interaction	*	*

Discussion

Trees in plots under 4 inches of water alive after 4 years had few terminal needles. These were usually chlorotic. Many seedlings in the inundated plots which had only two or three needles at the end of the first year (and therefore were practically dead) were transplanted to a moderately well-drained site. Survival was excellent, and after 4 years they were 3 to 6 feet tall.

A high salt concentration may limit absorption of water by plants. Perhaps the mineral salts in the treatments which combined fertilizers and inundation resulted in a reduced diffusion-pressure gradient from soil to root and this, in turn, limited water uptake. The trees then died.

Early in the study, it was apparent that shrubs, principally gallberry *(Ilex coriacea),* were stimulated by fertilization where water was not controlled in the check plots. Thus, gallberry shrubs were taller than the pines during the 4 years of observation.

Chlorosis of pines was prevalent in ±0, 0 plots. Other vegetation encroaching in unfertilized flooded plots included cord grass *(Spartina* spp.), black rush *(Sporobolus* spp.), Bermuda grass *(Cynodon dactylon),* love grass *(Eragrostis* spp.), and cattail *(Typha* spp.). With water at ground level, surviving trees appeared healthiest when fertilized; however, the luxurious grass probably consumed appreciable nutrient elements.

The species X treatment interaction significance for growth shows that the effect of a fertilizer treatment depends upon the water treatment with which it is applied. Thus, fertilization in the presence of adequate, but not excessive, moisture results in improved survival and growth.