

FERTILIZERS AND ORGANIC ADDITIVES IN PINE NURSERY SEEDBEDS: EFFECTS ON FIELD SURVIVAL, FIELD GROWTH, AND CHEMICAL CONTENT OF FOLIAGE

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Numerous studies of fertilizers and organic additives have been made; the results and conclusions have often been conflicting. Climate, soil, or fertilizer rates may have been factors in this. Therefore, if the maximum number of quality seedlings are to be grown in a particular nursery, studies should be conducted in that nursery, using the reported studies as guides.

This paper reports such a study at the Union State Tree Nursery, Jonesboro, Ill., made in 1960 and 1961 using loblolly, shortleaf, white, and Scotch pines. Details are given so the reader may compare them with other studies.

One season prior to planting the pine seed, soil treatments were applied and cover crops of soybeans and sudan grass were grown. The cover crop was disked under before it reached maturity, and the entire area was treated in the fall with 1-1/2 pounds of methyl bromide per 100 square feet. Composite soil samples were taken at the time pine seed were planted and again when the seedlings were lifted. Additional nitrogen was supplied to the growing seedlings with rates depending upon size and color of seedlings in each plot. Seedlings

Methods

The soil in our nursery beds is a silt loam derived from loess, transported by rain or wind from adjacent hills. The waterholding capacity of the soil is 20 percent at field capacity and 6 percent at wilting point.

Nine soil treatments were replicated three times for each species in 4- by 100-foot plots as follows:

¹ Department of Forestry, University of Illinois and Union State Tree Nursery, respectively.

<u>Organic matter</u> <u>(cu. yds. per acre)</u>	<u>Fertilizer</u>		
	<u>Nitrogen</u> <u>(lbs.</u> <u>per acre)</u>	<u>Phosphorus</u> <u>(lbs.</u> <u>per acre)</u>	<u>Potassium</u> <u>(lbs.</u> <u>per acre)</u>
Sawdust:			
200.....	300	132	100
200.....	100	44	33
100.....	300	66	50
100.....	100	22	17
Peat:			
52.....	120	53	75
52.....	40	18	24
26.....	60	26	37
26.....	20	9	12
Control:			
None.....	100	44	33

growing in plots with high rates of organic additives received more nitrogen than seedlings on other plots.

In March 1961, loblolly, shortleaf, and Scotch pine were lifted as 1-0 seedlings; in March 1962, white pine was lifted at 2-0 seedlings. From the randomly lifted samples, we determined the percent plantable, the shoot/root ratio on oven-dry weight basis, and the number of seedlings per square foot. We also used 25 seedlings for chemical analysis and 50 seedlings for field planting.

Foliar nitrogen was determined by the micro-Kjeldahl method, soil and foliar phosphorus by the phosphomolybdic acid method, soil potassium by the cobaltinitrite method, and foliar potassium by the flame photometer method,

Total height and survival were measured at the end of the second growing season after the seedlings were field planted.

The following variables were analyzed for each species to determine if the differences between these variables could be attributed to the seedbed treatment and also to determine the relationship of one variable to another:

1. Foliar nitrogen (N)
2. Foliar phosphorus (P)
3. Foliar potassium (K)
4. Shoot/root ratio
5. Nursery bed density
6. Preseeding nursery soil pH
7. Preseeding nursery soil phosphorus (P)
8. Preseeding nursery soil potassium (K)
9. Preseeding nursery soil organic matter (O.M.)
10. Increase in organic matter during study
11. Field height at end of 2 years
12. Field survival at end of 2 years

Results

The results of the study are given for each species according to (1) the effects of seedbed treatments, and (2) the relationship between variables. Only the most important effects and relationships are given for each species.

Loblolly pine (table 1):

- (1) Foliar potassium was lower in the control seedlings.
- (2) Foliar nitrogen was related to the nursery seedbed density; foliar potassium to foliar phosphorus and height.

Shortleaf pine (table 2):

- (1) Foliar potassium was lower in the control seedlings and number of plantable seedlings was less in treatments receiving the higher

applications of sawdust and peat.

- (2) Foliar nitrogen, shoot/root ratio, number of plantable seedlings, and seedbed density were related to each other; foliar phosphorus to foliar nitrogen; and soil phosphorus to the number of plantable seedlings and the seedbed density.

White pine (table 3):

- (1) Foliar phosphorus was lower in the peat and control plots than in the sawdust plots. The shoot/root ratios were larger in control plots and in plots receiving the lesser amounts of sawdust and fertilizers. Plots receiving the most organic material grew less seedlings per square foot of nursery bed than other plots. Peat plots grew the least number of plantable seedlings. Heights of the white pine were not measured.
- (2) Seedbed density was related to foliar nitrogen and foliar phosphorus; foliar potassium to shoot/root ratio and soil potassium; number of plantable seedlings to organic matter; and soil phosphorus to shoot/root ratio and seedbed density.

Scotch pine (table 4):

- (1) In plots that received large applications of organic material, foliar potassium was higher, but the shoot/root ratio and seedbed density were lower.

TABLE 1.--The effects of organic additives and fertilizers¹ on loblolly pine

Organic (cubic yard per acre)	Fertilizer per acre			Foliage			Shoot/ root ratio	Nursery bed density per square foot	Plant- able seed- lings	Total height	Surv- ival
	N	P	K	N	P	K					
Sawdust:	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>	<i>Per- cent</i>	<i>Per- cent</i>		<i>Number</i>	<i>Percent</i>	<i>Inches</i>	<i>Percent</i>
200....	300	132	100	1.94	0.13	20.27	4.54	33	52	30	90
200....	100	44	33	1.64	.13	.25	5.43	43	61	29	88
100....	300	66	50	2.02	.11	.29	5.42	39	58	31	88
100....	100	22	17	1.99	.12	.28	6.60	43	52	31	87
Peat:											
52....	120	53	75	1.91	.12	.24	5.85	42	58	30	85
52....	40	18	24	1.86	.13	.26	6.31	40	60	29	84
26....	60	26	37	1.94	.12	.21	7.46	40	55	30	66
26....	20	9	12	2.02	.12	.25	7.78	35	53	30	66
Control:											
None...	100	44	33	1.82	.08	.18	7.31	43	59	28	84

¹ N = nitrogen, P = phosphorus, K = potassium.

² Significant differences between treatments at the 1 percent level.

TABLE 2.--The effects of organic additives and fertilizers¹ on shortleaf pine

Organic (cubic yard per acre)	Fertilizer per acre			Foliage ²			Shoot/ root ratio	Nursery bed density per square foot	Plant- able seed- lings	Total height	Surv- ival
	N	P	K	N	P	K					
Sawdust:	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>		<i>Number</i>	<i>Percent</i>	<i>Inches</i>	<i>Percent</i>
200....	300	132	100	1.82	0.11	0.31	3.83	48	52	26	89
200....	100	44	33	1.78	.12	.33	3.87	52	47	26	92
100....	300	66	50	1.84	.11	.28	3.38	23	80	29	90
100....	100	22	17	1.97	.13	.32	3.84	32	70	26	89
Peat:											
52....	120	53	75	1.94	.10	.30	3.42	45	44	26	95
52....	40	18	24	1.82	.11	.32	4.18	42	54	26	93
26....	60	26	37	1.92	.12	.30	3.86	18	86	28	95
26....	20	9	12	1.88	.13	.27	4.24	20	75	30	87
Control:											
None...	100	44	33	1.80	.10	.25	3.54	46	42	24	95

¹ N = nitrogen, P = phosphorus, K = potassium.

² Significant differences between treatments at the 1 percent level.

TABLE 3.--The effects of organic additives and fertilizers¹ on white pine

Organic (cubic yard per acre)	Fertilizer per acre			Foliage			Shoot/ root ratio	Nursery bed density per square foot	Plant- able seed- lings	Total height	Survi- val
	N	P	K	N	P	K					
Sawdust:	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>		<i>Number</i>	<i>Percent</i>	<i>Inches</i>	<i>Percent</i>
200....	300	132	100	1.72	20.15	0.19	³ 5.06	216	278	16	91
200....	100	44	33	1.64	.13	.16	5.26	24	83	15	85
100....	300	66	50	1.63	.13	.18	5.22	39	75	14	81
100....	100	22	17	1.56	.14	.20	9.29	36	80	16	83
Peat:											
52....	120	53	75	1.55	.11	.20	5.16	38	66	17	91
52....	40	18	24	1.51	.12	.19	7.18	37	73	15	76
26....	60	26	37	1.55	.09	.21	6.32	46	80	16	89
26....	20	9	12	1.58	.11	.19	5.14	37	71	16	84
Control: None...	100	44	33	1.46	.12	.21	9.55	44	75	17	85

¹ N = nitrogen, P = phosphorus, K = potassium.

² Significant differences between treatments at the 5 percent level.

³ Significant differences between treatments at the 1 percent level.

TABLE 4.--The effects of organic additives and fertilizers on Scotch pine

Organic (cubic yard per acre)	Fertilizer per acre			Foliage ²			Shoot/ root ratio ²	Nursery bed density per square foot ²	Plant- able seed- lings	Total height	Survi- val
	N	P	K	N	P	K					
Sawdust:	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>		<i>Number</i>	<i>Percent</i>	<i>Inches</i>	<i>Percent</i>
200....	300	132	100	2.15	0.12	0.28	3.10	40	67	18	99
200....	100	44	33	2.21	.12	.26	3.01	36	63	17	98
100....	300	66	50	2.07	.13	.25	3.91	49	70	18	99
100....	100	22	17	2.07	.10	.25	3.24	44	63	16	95
Peat:											
52....	120	53	75	2.01	.12	.24	3.38	39	66	19	92
52....	40	18	24	1.97	.10	.26	3.80	41	74	18	95
26....	60	26	37	1.99	.11	.23	4.13	50	73	18	97
26....	20	9	12	1.99	.10	.24	4.81	50	67	18	96
Control: None...	100	44	33	2.08	.11	.25	3.54	34	56	18	99

¹ N = nitrogen, P = phosphorus, K = potassium.

² Significant differences between treatments at the 1 percent level.

(2) Foliar nitrogen was related to shoot/root ratio and seedbed density.

Upon examination of the first four tables, one might conclude that seedbed treatments affected foliar potassium in all pines except white pine and that foliar phosphorus was affected by treatments only in white pine. The probable explanation lies in the age of the needles of the four species. All needles were 1-year-old with the exception of white pine which were 2-0 seedlings and thus had land 2-year-old needles. Phosphorus and potassium are highly mobile in plants and internal redistribution of these elements occur readily. Old leaves frequently lose these elements to the growing regions of the plant. Thus, if only 1-year-old needles of white pine had been analyzed, probably potassium and not phosphorus would have been the element that correlated with the seedbed treatments.

The shoot/root ratio of all seedlings is much higher than is normally thought of as ideal for seedlings of good quality. Assigning an acceptable range of shoot/root ratios for plantable seedlings can be misleading. It is possible to have a combination of thick, thin, short, and tall stems, succulent or woody tissue, with fibrous or single root systems. If the shoot/root ratio is computed by volume instead of by weight, wide differences in the ratios might be found. Also in this study the ovendry weight of the entire plant of both plantable and nonplantable seedlings was used to determine shoot/root ratio.

The high seedbed densities can be attributed more to sowing rates than to seedbed treatments. The seedbeds should have been thinned to the desired density early in the growing season.

The important result shown in the first four tables is that seedbed treatments did not affect height or survival of plantable seedlings. This leads to the conclusion that the soil fertility levels of the experiment are adequate to produce quality seedlings.

Soil analyses were made at the time the seed were planted and when the seedlings were lifted (table 5). Values at seeding time are for composite soil samples from each treatment area before the area was divided into subareas for the various species. Values at lifting time are of composite soil samples taken from specific plots according to treatment and species. Differences in variables between treatments reflect soil treatment of the area prior to the time the seed were sown.

Statistical analysis showed that regardless of species grown, soil pH was related to soil phosphorus, soil potassium to increase in organic matter, and soil organic matter to

increase in organic matter.

The amount of ovendry material removed per acre is given in table 6. The pounds of ovendry material is about half of that reported by other workers for southern pine. The difference might be ascribed to the spindly seedlings in this study because of the high seedbed density.

Nitrogen, phosphorus, and potassium removed from the soil by the harvested seedlings are given in table 7. Amounts of fertilizers removed by the seedlings could be misleading if the values in the table are taken by themselves. The fertilizer consumption could have been expressed in elements used per 100 pounds of seedlings lifted. The following values would be obtained per 100 pounds of seedlings:

	<u>Nitrogen</u> <u>(pounds)</u>	<u>Phosphorus</u> <u>(pounds)</u>	<u>Potassium</u> <u>(pounds)</u>
Loblolly pine	1.900	0.114	0.252
Shortleaf pine	1.870	.113	.292
White pine.....	1.580	.113	.186
Scotch pine.....	2.060	.104	.249

If a nurseryman wants to know the amount of fertilizer removed by his harvested seedlings, table 7 would be correct. If he wants to compare fertilizer removal by one species with another, he should put the two species on the same unit base, as was done above.

The end result of seedling production is how seedlings perform after they are outplanted in the field. If they survive and make acceptable growth, the nurseryman has produced quality seedlings. If not, he should examine all phases of his nursery management and make the necessary corrections. This study showed that quality seedlings can be produced at various soil fertility levels and that these fertility levels encompass a wide range of conditions.

TABLE 5.--Nursery soil pH, phosphorus, potassium, and organic matter at seeding time; increase in organic matter due to organic additive; and soil phosphorus and potassium at seedling lifting time¹

Organic (cubic yard per acre)	Fertilizer per acre ²			Soil at seeding time				In- crease O.M. ²	Soil at seedling lifting time							
	N	P	K	pH	P per acre	K per acre	O.M.		Phosphorus per acre				Potassium per acre			
									L	S	W	Sc ³	L	S	W	Sc ³
Sawdust:	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>		<i>Lbs.</i>	<i>Lbs.</i>	<i>Per- cent</i>	<i>Per- cent</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
200...	300	132	100	5.97	188	232	2.65	1.34	188	181	196	171	249	232	292	200
200...	100	44	33	6.08	132	227	2.66	1.18	120	149	126	125	238	215	263	228
100...	300	66	50	5.93	137	232	2.14	.71	144	117	147	114	206	173	210	173
100...	100	22	17	6.27	98	192	2.14	.61	118	70	135	100	165	152	201	176
Peat:																
52...	120	53	75	6.10	144	211	1.65	.33	114	111	129	144	193	196	211	224
52...	40	18	24	6.48	124	179	1.76	.47	106	106	133	155	168	183	201	205
26...	60	26	37	6.23	119	177	1.85	.23	135	142	160	157	185	150	196	183
26...	20	9	12	6.33	93	148	2.01	.28	121	131	132	134	166	164	191	178
Control:																
None..	100	44	33	6.12	127	197	1.40	.00	139	126	140	161	217	212	227	227

¹ Significant differences between treatments for all variables at the 1 percent level.

² N = nitrogen, P = phosphorus, K = potassium, O.M. = organic matter.

³ Increase in soil organic content at seeding time due to organic additive applied the previous spring.

⁴ L = loblolly pine, S = shortleaf pine, W = white pine, Sc = Scotch pine.

TABLE 6.--Weight of oven-dry plant material removed by treatment and species

Organic (cubic yard per acre)	Loblolly	Shortleaf	White	Scotch
	<i>Pounds per acre</i>	<i>Pounds per acre</i>	<i>Pounds per acre</i>	<i>Pounds per acre</i>
Sawdust:				
200.....	3,186	5,921	1,703	2,616
200.....	3,925	5,487	1,855	1,830
100.....	4,773	4,712	3,158	2,934
100.....	4,645	4,915	2,732	2,090
Peat:				
52.....	4,601	4,930	3,323	2,145
52.....	4,816	4,354	2,680	2,179
26.....	4,562	3,417	3,984	3,497
26.....	3,958	3,479	2,697	2,692
Control:				
None.....	5,530	4,214	2,936	1,920

TABLE 7.--Fertilizer elements removed per acre from nursery seedbed by harvested seedlings according to soil treatments¹ and tree species²

Organic (cubic yard per acre)	Fertilizer			Nitrogen				Phosphorus				Potassium			
	N	P	K	L	S	W	Sc	L	S	W	Sc	L	S	W	Sc
Sawdust:	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
200.....	300	132	100	62	108	29	56	4	7	2	3	9	19	3	7
200.....	100	44	33	64	98	30	40	5	7	2	2	10	17	3	5
100.....	300	66	50	96	87	51	61	5	5	4	4	14	13	6	7
100.....	100	22	17	92	97	43	43	5	6	4	2	13	16	5	5
Peat:															
52.....	120	53	75	88	96	52	43	5	5	4	2	11	15	7	5
52.....	40	18	24	90	79	40	43	6	5	3	2	13	13	5	6
26.....	60	26	37	88	66	62	70	6	4	3	4	10	10	8	8
26.....	20	9	12	80	65	43	54	5	4	3	2	10	9	5	6
Control:															
None....	100	44	33	101	76	43	40	4	4	3	2	10	10	6	5

¹ N = nitrogen, P = phosphorus, K = potassium.

² L = loblolly pine, S = shortleaf pine, W = white pine, Sc = scotch pine.