RESPONSE OF DOUGLAS-FIR & PONDEROSA PINE TO PHOSPHORUS FERTILIZATION AT THE J. HERBERT STONE NURSERY

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ABSTRACT

Twelve combinations of nitrogen and phosphorus fertilizers were applied in the first growing season to Douglas-fir and ponderosa pine seedlings. Soil analysis was done prior to sowing and after the second growing season. Foliar analysis was done at the end of the first growing season. Seedling height, caliper and shoot and root dry weight measurements were made at the end of the first and second growing seasons. Results indicated seedlings responded more to increased levels of phosphorus fertilization than to increased levels of nitrogen fertilization.

INTRODUCTION

Generally, soil scientists have recommended many soil phosphorus levels for forest nurseries ranging from 200 pounds P205 per acre (Wilde) to 575 pounds P_2O_5 per acre (Leaf). Variations in climatic conditions and soil types lead to site-specific soil nutrient requirements for nurseries in different locations. Variations in nutrient requirements for the major species produced should also be considered.

In the spring of 1980, the J. Herbert Stone Nursery started an administrative study to test several fertilization rates of phosphorus and nitrogen. The objective of the study was to discover the rate of fertilization required to produce seedlings with large caliper and low shoot to root ratios. This was accomplished by analyzing soil and foliar nutrient levels and relating them to applied fertilizer rates.

MATERIALS AND METHODS

One seed lot each of Douglas-fir and ponderosa pine were selected for the study. Three levels of nitrogen and four levels of phosphorus (twelve combinations) were applied during the seedlings' first growing season. Standard nursery practice has been to avoid fertilizer application during the second growing season in these species. This practice was followed during this study. Table I summarizes the nutrient levels applied to the 1-0 seedlings. Nitrogen fertilizer was applied in the form of ammonium sulfate and the application dates were based on a modified degree-day schedule (application every two weeks beginning in late May). The applications were made by hand to the plots and followed by two hours of irrigation. A total of

three applications were made to plots receiving nitrogen. The phosphorus fertilizer was applied in the form of superphosphate incorporated into formed beds by hand raking.

TABLE I

FERTILIZER LEVEL BY TREATMENT.

Treatment Number	Fertilizer Level
1	N_o P_o
2	N_o P_1
3	N_o P_2
4	N_o P_3
5	N_1 P_o
6	N_1 P_1
7	N_1 P_2
8	N_1 P_3
9	N_2 P_o
10	N_2 P_1
11	N_2 P_2
12	N_2 P_3

N_o = Ammonium sulfate not applied

N_1 = 100 pounds/acre 21-0-0-24 (0.06#/piot)

N_2 = 200 pounds/acre 21-0-0-24 (0.12#/plot)

P_0 =Superphosphate not applied

P_1 = 240 pounds/acre $P_2 0_5$ (0.22 # 0-20-0/plot)
(400#/ac product)

P_2 = 860 pounds/acre $P_2 0_5$ (0.78 # 0-20-0/plot)
(1400#/ac product)

P_3 = 1450 pounds/acre $P_2 0_5$ (1.32 # 0-20-0/plot)
(2400#/ac 0-20-0)

The study employed a randomized complete block design. The blocks were replicated five times within each species. Both species were being grown for 2-0 reforestation stock. The ponderosa pine was a Winema National Forest seed source and the Douglas-fir was a Rogue River lot. Table II summarizes the plot layout by block and treatment number. Each treatment plot within the blocks was 6' x 4' with a 4' x 4' buffer area separating the plots.

STUDY LAYOUT TREATMENT PLOTS WITHIN BLOCKS WITHIN REPLICATION WITHIN SPECIES.

Douglas-fir

Block 1	Block 2	Block 3	Block 4	Block 5
Plots	Plots	Plots	Plots	Plots
5	12	9	7	6
10	1	12	4	1
11	3	1	2	2
7	5	8	9	9
2	9	11	1	8
4	6	2	8	3
8	11	3	11	10
9	2	10	3	5
12	8	5	5	11
6	7	7	6	7
3	4	6	10	4
1	10	4	12	12

Ponderosa pine

Block 1	Block 2	Block 3	Block 4	Block 5
Plots	Plots	Plots	Plots	Plots
3	8	9	1	10
1	12	4	4	7
4	7	5	3	5
5	5	2	7	11
8	4	8	6	4
10	9	1	12	12
11	6	12	5	6
9	2	3	8	1
7	3	10	11	2
6	11	11	10	8
2	10	6	2	3
12	1	7	9	9

Three composite soil samples consisting of 20-6" cores were taken from the area prior to the installation of the study. Soil was sampled again at the end of the second growing season. One composite sample per treatment per species was taken. Foliar samples were taken and correlated to the soil sample areas.

Twenty seedlings from each treatment plot were destructively sampled at the end of each growing season. Top height and caliper were measured. Shoot to root ratio was determined by the dry weight method.

RESULTS AND DISCUSSION

Table III summarizes soil nutrient contents before and after the two year seedling rotation. Total nitrogen in the soil over the nursery growing period showed a slight decrease in both the unfertilized plots (N_O) and the 100 pounds per acre plots (N1). The plots receiving 200 pounds per acre (N2) nitrogen fertilizer actually showed an increase in total nitrogen in three of four areas with no change in the fourth. This would indicate the N2 level supplied more nitrogen than the plants actually needed.

TABLE III

RESULTS OF COMPOSITE SOIL SAMPLES
TAKEN 11/79 (pre-sowing) AND 11/81.

	Pre-Sowing		After 2nd Growing Season	
	TN	PPM P	TN	PPM P
N_oP_o	.088	45	.05	17
N_oP_1	.094	25	.10	14
N_oP_2	.094	19	.08	16
N_oP_3	.103	55	.09	18
N_1P_o	.091	17	.08	14
N_1P_1	.091	44	.07	17
N_1P_2	.094	80	.07	28
N_1P_3	.088	24	.09	19
N_2P_o	.088	28	.11	12
N_2P_1	.091	19	.09	17
N_2P_2	.088	48	.15	24
N_2P_3	.088	39	.12	20

In all cases soil phosphorus levels were depleted over the 2 year rotation. First inclinations are to conclude that even 1450 pounds per acre (P3) are not enough to supply the needs of the plants for two years. Other nursery experiences however raise the theory that some of the applied phosphorus fertilizer is being tied up on soil clay particles. This possibility will be explored in the near future.

Table IV shows the result of foliar analysis done at the end of the first growing season. It is interesting to note that all seedlings showed an adequate level of nitrogen at all levels of nitrogen fertilization. This indicates that the plants managed to extract sufficient quantities of nitrogen from the soil even when no nitrogen fertilizer was applied. Phosphorus tissue levels were similar at all levels. Apparently, adequate supplies were present in all cases.

RESULTS OF FOLIAR ANALYSIS DONE 11/80.
ALL NUTRIENTS ARE REPORTED IN PER CENT.

Douglas-fir

	N	P
N_oP_o	2.17	.14
N_oP_1	1.69	.26
N_oP_2	1.60	.19
N_oP_3	2.47	.24
N_1P_o	2.59	.12
N_1P_1	2.03	.24
N_1P_2	2.18	.22
N_1P_3	2.49	.16
N_2P_o	2.43	.15
N_2P_1	2.02	.16
N_2P_2	2.21	.17
N_2P_3	2.59	.16

Ponderosa pine

	N	P
N_oP_o	1.97	.23
N_oP_1	2.02	.30
N_oP_2	2.07	.31
N_oP_3	2.17	.32
N_1P_o	2.26	.24
N_1P_1	2.25	.24
N_1P_2	2.33	.28
N_1P_3	1.97	.35
N_2P_0	2.25	.21
N_2P_1	2.25	.24
N_2P_2	2.31	.27
N_2P_3	2.23	.33

Analysis of seedling growth characteristics showed surprising differences related to phosphorus fertilization. Table V summarizes seedlings growth performance at the end of both the 1U and 2-0 years. Table VI shows increasing nitrogen fertilization made no significant contribution to seedling size in either species. However, as the phosphorus fertilization levels increased so did seedling size. In both species, each higher level of phosphorus significantly increased the seedling height over the seedlings at the level below. The first (P_1) level of phosphorus fertilization significantly increased Douglas-fir seedlings caliper over the control (P0) level. Caliper continued to increase (although not at significant levels) as phosphorus fertilization increased. This same general trend held with the ponderosa pine seedling diameter growth although a significant increase was not reached until the increase from Pl to Y2.

TABLE V

RESULTS OF DESTRUCTIVE SAMPLING DONE 11/80

(after 1-0 growing season) & 11/81 (after 2-0 growing season).

	1-0 Douglas-fir					2-0 Douglas-fir				
	(in CM)	(in MM)	Dry Weight (in grams)			(in CM)	(in MM)	Dry Weight (in grams)		
	Ht.	Cal.	Top	Root	S/R	Ht.	Cal.	Top	Root	S/
N_oP_o	8.4	2.1	8.8	6.7	1.3	28.9	3.6	65.5	22.0	3.
N_oP_1	10.5	2.3	14.2	9.5	1.5	32.8	4.4	82.1	29.5	2.8
N_oP_2	13.1	2.8	21.2	13.4	1.6	33.6	4.5	99.9	39.9	2.5
N_oP_3	14.5	2.9	26.6	14.4	1.8	34.9	4.6	112.1	41.6	2.3
N_1P_o	8.7	2.0	9.3	7.1	1.3	29.7	3.9	92.2	27.9	3.3
N_1P_1	10.3	2.3	13.5	10.0	1.3	29.1	3.8	74.2	27.3	2.7
N_1P_2	12.1	2.7	19.7	12.8	1.5	31.0	4.2	95.5	31.2	3.1
N_1P_3	14.2	3.0	25.9	16.0	1.6	32.4	4.4	109.0	41.7	2.6
N_2P_o	8.7	2.0	9.5	6.6	1.4	30.9	3.7	71.4	23.0	3.1
N_2P_1	10.6	2.3	13.4	9.4	1.4	30.9	4.5	88.5	33.5	2.6
N_2P_2	12.8	2.5	21.2	13.2	1.6	33.9	4.7	94.5	39.2	2.4
N_2P_3	14.2	2.9	29.7	18.0	1.6	34.3	4.9	117.4	44.0	2.7
1-0 Ponderosa pine						2-0 Ponderosa pine				
N_oP_o	5.9	2.4	10.4	11.2	0.9	12.1	3.7	56.7	26.3	2.2
N_oP_1	6.0	2.6	12.3	12.7	1.0	11.7	3.4	55.0	23.0	2.4
N_oP_2	6.6	2.5	12.9	12.1	1.0	12.1	3.8	58.5	25.0	2.3
N_oP_3	6.4	2.6	14.3	13.4	1.1	12.8	3.8	63.1	25.4	2.5
N_1P_o	5.6	2.3	11.1	11.0	1.0	11.3	3.6	51.1	22.4	2.3
N_1P_1	5.9	2.5	11.9	11.7	1.0	11.7	3.6	55.6	24.7	2.2
N_1P_2	6.4	2.5	13.6	13.8	1.0	12.2	4.0	62.4	30.5	2.0
N_1P_3	6.3	2.5	12.6	12.3	1.0	13.0	3.7	60.5	26.5	2.3
N_2P_o	5.6	2.5	11.1	12.0	0.9	11.7	3.8	60.9	24.8	2.4
N_2P_1	5.9	2.5	11.8	13.8	0.8	12.6	3.8	61.9	25.2	2.6
N_2P_2	6.4	2.7	14.4	14.4	1.0	13.2	4.0	70.9	28.2	2.4
N_2P_3	6.1	2.5	13.6	14.2	1.0	13.3	3.9	67.4	27.0	2.5

TABLE VI

AVERAGE 2-0 SEEDLING HEIGHT, DIAMETER & SHOOT TO ROOT RATIO BY FERTILIZER LEVEL.

	Douglas-fir			Ponderosa pine		
	(CM) Ht.	(MM) Cal.	S/R	(CM) Ht.	(MM) Cal.	S/R
N_o	32.5	4.3	2.6	12.2	3.7	2.4
N_1	30.5	4.1	2.9	12.0	3.7	2.2
N_2	32.5	4.4	2.7	12.7	3.9	2.5
	No significant differences at the 95% level					
P_o	29.8^a	3.7^e	3.1^i	11.7^m	3.7^q	2.3^u
P_1	30.9^b	4.2^f	2.7^j	12.0^n	3.6^r	2.4^v
P_2	32.8^c	4.5^g	2.7^k	12.5^o	3.9^s	2.2^w
P_3	33.9^d	4.6^h	2.5^l	13.0^p	3.8^t	2.4^x

a is significantly different from b at the 95% level
b is significantly different from c at the 95% level
c is significantly different from d at the 95% level
e is significantly different from f at the 95% level
i is significantly different from j at the 95% level
m is significantly different from n at the 95% level
n is significantly different from o at the 95% level
o is significantly different from p at the 95% level
r is significantly different from s at the 95% level
v is significantly different from w at the 95% level

Douglas-fir seedlings shoot to root ratio decreased with increased phosphorus fertilization leading to better balanced trees. Again, the P_1 level. of phosphorus made a significant difference in a Douglas-fir seedlings growth characteristic - this time a better balanced tree. The ponderosa pine shoot to root ratio remained fairly stable throughout the levels of phosphorus fertilization.

CONCLUSION

Nurseries located in various areas should explore plant nutrient requirements for the species they produce and environment in which they live. Significant gains can be made when nursery cultural practices are tailored, based on soundly collected data, to your nursery. At the J. Herbert Stone Nursery, we have found that phosphorus fertilization incorporated into the soil prior to sowing generally at the rate of 800 pounds superphosphate per acre can contribute to the production of more desirable planting stock. The end product can lead to better survival and growth in our forests.

REFERENCES

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