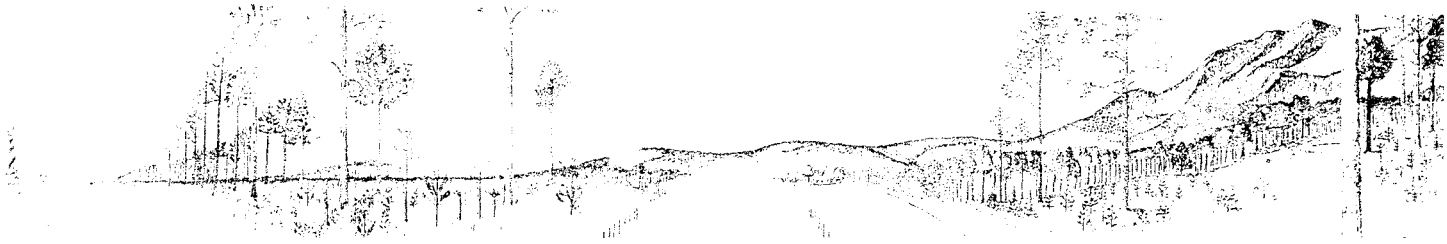

USDA forest Service Research Note SE-128 December 1969

FOLIAR ANALYSIS FOR PREDICTING LOBLOLLY PINE RESPONSE TO PHOSPHORUS FERTILIZATION ON WET SITES

Abstract.–Loblolly pine (*Pinus taeda* L.) planted in the South Carolina Coastal Plain on wet sites which had been ditched and bedded responded to P fertilization. Under conditions of severe P deficiency) tree height increased 82 percent in 3 years from application of 25 or 50 pounds of P per acre at planting. First-year growth data from four sites show that a response to P fertilization should be expected when needle content is less than 0.11 percent P I year after planting. As P content of the needles decreases below this level. response increases.

Phosphorus deficiency is prevalent in the soils of the Southeastern Coastal Plain. Pritchett and Llewellyn obtained significant growth increases from P fertilizers applied to slash pine (*Pinus elliottii* var. *elliottii*) in five of eight experiments on sandy. acid, flatwood soils in Florida. [1] Additional reports, both published and unpublished, have made foresters and soil scientists aware that tree response to fertilizers may be nil or of such magnitude that operational scale forest fertilization is warranted. Guides for identifying nutrient-deficient sites are needed.

Soil tests and needle analyses are useful for detecting soils and stands which need P fertilization. [2] but field experiments must be used to establish the relationship between percentage P in the needles of loblolly pine (*Pinus taeda* L.) and growth response from fertilizers. This note contains results of I- to 3-year-old plantings of loblolly pine on disked and bedded soils on wet Coastal Plain sites in South Carolina. Guides for P fertilization are proposed on the basis of relationships between percentage P in the needles and growth response to P fertilization.

METHODS

Data for this report were from plantings on four wet sites which had been drained by ditches and bedded. Seedlings were planted on the ridges; water stood in the furrows in rainy seasons. On one site, a long-range fertilization study was established in 1967. In 1968. two plantings were installed on each of the three other sites; one to test rates of P and the other to evaluate production application of P. All plots for sampling and measuring contained at least 20 trees.

Methods of site preparation, planting, and fertilization varied somewhat for the seven plantings. Site preparation, by bedding or by disking and bedding, controlled resprouting of woody competition, but some herbaceous competition became established the same year the seedlings were planted. Planting was both by hand and machine on beds.

[1] Pritchett. W. L.. and Llewellyn. W. R. Response of slash pine to phosphorus in sandy soils. Soil Sci. Soc. Amer. Proc. 30: 509-519. 1966.

[2] Pritchett. W. L. Progress in the development of techniques and standards for soil and foliar diagnosis of phosphorus deficiency in slash pine. *In* Forest fertilization, theory and practice symposium 1967. Tenn. Val. Authority, Muscle Shoals, Ala., pp. 81-87. 1966.

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In the 1967 study, 25 or 50 pounds of P as triple superphcsphate was broadcast over the entire plot after bedding. In the 1968 planting, 20 to 50 pounds of P per acre were broadcast over the total plot before bedding or applied in a strip just ahead of the bedding harrow. Check plots, plots with no fertilization, were installed in all plantings at the time of treatment.

Tree height was measured after planting but before growth began, and at the end of each growing season. Beginning 1 year after planting, needle samples were collected in the winter from the first flush of the previous spring. It was necessary to take needle samples from the main stem when trees had been in the field only 1 year. Needle samples were obtained from the lateral branches of older trees. [3] Five fascicles of needles were collected from a minimum of 20 trees per plot, composited for a sample, dried at 70" C., and then ground. A 0.5-gram sample was ashed in a muffle furnace at 450" C., the ash dissolved in 0.4N HCl, and analyzed for P by the colorimetric vanadomolybdate method.[4]

RESULTS AND DISCUSSION

On wet Coastal Plain soils, seedling height growth the first year after planting was related to percentage P in needles, and to P fertilization on sites where P deficiency was indicated by needle analysis. Method of P application did not influence percentage P in the needles or height growth the first year after planting: therefore, method of application was not considered a separate variable in the data presentation. Height growth differences for rates of 20 to 50 pounds per acre were within experimental error.

Under conditions of extreme P deficiency in the 1967 study, 25 or 50 pounds of P per acre increased height 82 percent in 3 years (fig. 1). The site was a Bayboro loam savannah which was ditched for drainage and then bedded and planted before broadcast application of P on the surface. Twenty-five or 50 pounds of P applied per acre produced 3-year-old loblolly pine 6.8 feet tall, compared with 3.7-foot trees without P fertilization. Although percentage P in the needles was higher at the 50- than at the 25-pound-per-acre rate. growth was the same the first 3 years after planting. Percentage P in the needles decreased from the first to second year after planting, on both P-fertilized and check plots. It was evident that P controlled the growth rate of seedlings on the check plots. Needle content of 0.122 percent P was sufficient the first year and 0.1 12 percent the second year, because higher percentages found in rhe 50-pound-per-acre application did not further increase growth. Likewise. needle content of 0.1 12 percent P the second year after planting was as good as 0.125 percent P for growth the third year.

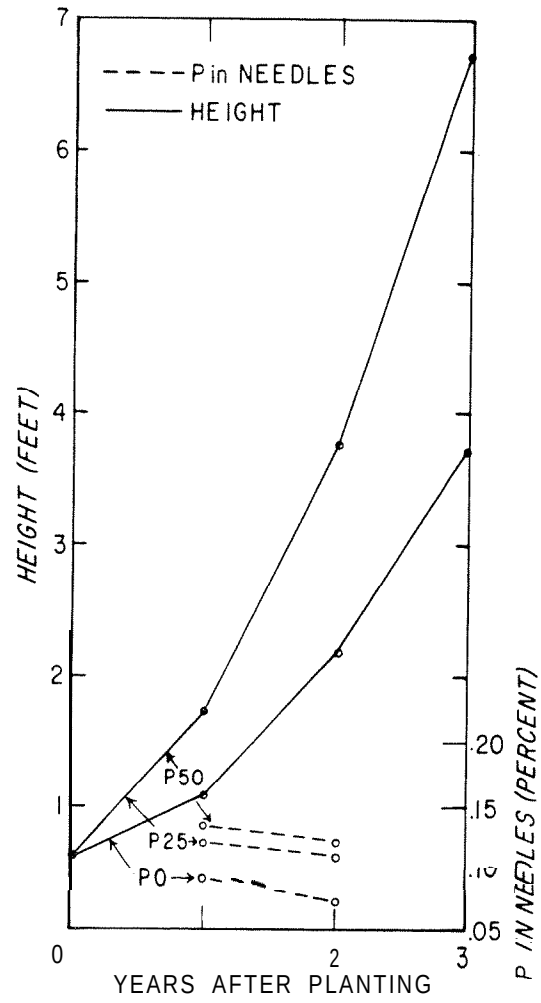

Figure I.-Tree height and percent P in needles of loblolly pine on drained. bedded Bayboro loam with application of 0, 25, and 50 pounds of P per acre.

[3] Wells, C. G., and Metz, L. J. Variation in nutrient content of loblolly pine needles with season, ape, soil. and position on crown. Soil Sci. Soc. Amer. Proc. **25:** 90-93. **1963.**

[4] Jackson. M. L. Soil chemical analysis. Englewood Cliffs. N. J.: Prentice-Hall, inc. 1958.

When the phosphate studies were installed. a consistent relationship between percentage P in the needles and tree growth the first year after planting was not anticipated. For wet sites. however, a highly significant correlation was found between percentage P in needles at the end of the growing season and height, growth the year of planting (fig. 2). As needle content increased from 0.08 percent to 0.1 2 percent P, height increment increased from 0.5 to 1.4 feet.

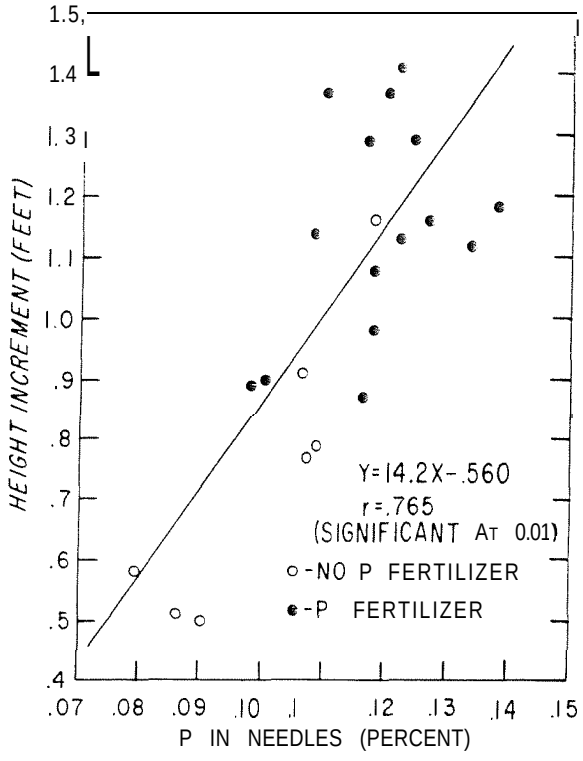

Figure 2.-Relationship between percentage P in needles and first-year height increment of seedling on wet sites.

First-year growth data in the Coastal Plain, at least on wet sites, indicate that response to P fertilization should be expected if P is less than 0.1 I percent in the needles (fig. 3). On the basis of figure 3, if needles of trees l year after planting contain 0.10 percent P, a 60-percent increase in height growth could be expected from application of 20 pounds of P per acre.

Similar plantings on two well-drained Coastal Plain sites, two Sandhill sites, and four Piedmont sites did not show a response to P fertilization 1 year after planting. Phosphorus in needles on the check plots ranged from 0.1 10 tc 0.163 percent which is above the critical value derived from experiments on wet Coastal Plain soils. Height growth on the well-drained or droughty sites was about equal to that on check plots on wet Coastal Plain sites, even though foliar P was generally high and was increased further by P fertilization. These first-year results indicate P was not deficient on the better drained sites, or that some other environmental factor controlled growth to such an extent that P supply had no influence. Needle samples will be more indicative of P supply as trees become older on sites where establishment is slow.

Needle analysis promises to become an effective method for detecting P-deficient trees and thus provide a guide for soil treatment on sites where trees are growing. A reliable soil test would be more useful because soils could be tested and fertilizer applied before planting. Soil P tests of all plots of all plantings of this report were made with North Carolina extracting solution (0.05N HCl and 0.025N H_2 SO,). Soil P was not significantly correlated with height growth or with increased height growth due to P fertilization. The soil test may prove more reliable as the trees become older. In sands of the Florida flatwoods, Pritchett and Llewellyn found that the amount of P extracted from unfertilized surface soils with 1 .0N NH_4OAc (pH 4.8) was correlated with slash pine response to P applied 3 years before measurement.' Further investigation of soil test methods, along with soils grouping by the comprehensive classification system, should improve soil testing and soil test interpretation.

Any estimation of financial return from P application based on S-year growth response would be subject to large error. On the soils where P fertilization almost doubles tree height in 2 or 3 years, a financial return on investment is assured. For a cost of about $10 per acre for P and application, several cords of additional wood should be realized, even by conservative estimates. Borderline cases, where growth increase from P is only about 20 percent the first 2 or 3 years, present economic considerations which require longer term study. Ellerbe and Smith reported that site index of loblolly pine was 16 points (feet)

[5] Pritchett and Llewellyn, *loc. cit.*

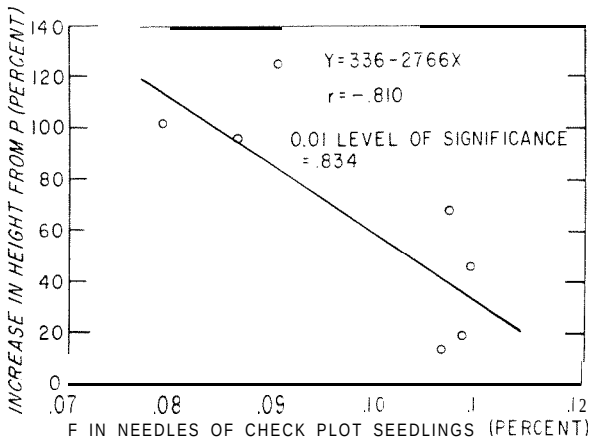

Figure 3.-First-year height growth response of seedlings from application of P in relation to percent ape P in needles of check plot seedlings (no P).

higher at 50 years where phosphate marl was found beneath the soil in localized areas of the lower South Carolina Coastal Plain." Because a comparison was made between trees on soils of the same series with and without marl, the 1 6-foot advantage of trees on soils with marl may be considered a long-term effect of an adequate P supply. Fertilization with P is expected to increase site index at least 16 feet at age 50 on some P-deficient sites such as the one from which data were collected for figure I.

After data are collected to establish relationships, needle analysis of trees 2 or 3 years after planting should yield more reliable predictions of P fertilization response because the trees will better reflect soil P supply. For larger trees. lower levels of needle P will be adequate for growth. Until more test plot data are available on older trees. a needle content of 0.085 percent P could be considered a tentative critical level for fertilization.

We do not know how long the treatment effect will last, or whether the growth difference will increase or decrease with time. Soil variability must be considered, and it must be recognized that some soils will require more P or more frequent P application than others. Foliar analysis will provide a good guide to the second application of P on established stands.

CONCLUSIONS

1. For 1- to 3-year-old planted loblolly pine trees in the Coastal Plain, phosphorus in the needles is a good index of phosphorus status of soil and plant.

2. Phosphorus fertilizers should be applied on wet Coastal Plain sites when mature needles from trees 1 year in the field contain 0.10 percent P or less.

3. Because older trees grow satisfactorily with a lower percentage P in their needles, 0.085 percent P in needles is suggested as the level below which P fertilizer should be applied to trees over 5 years of age.

4. When test plots or needle analyses indicate severe P deficiency, P fertilization should yield a good financial return.

Carol G. Wells, Soil Scientist
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[6] Ellerbe, C. M., and Smith, G. E. Apparent influence of phosphate marl on site index of loblolly pine in the lower Coastal Plain of South Carolina. J. Forest. 61: 284-286. 1963.