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SYMPTOMS OF NUTRIENT DEFICIENCY IN YELLOW-POPLAR SEEDLINGS

Abstract. --Visual symptoms are described for leaves of yellow-poplar seedlings supplied N, P, and K in varying concentrations ranging from minimal ,to excessive.

Probability of growth responses to added N is high when tissue levels are below 2 percent; no response is likely when they exceed 3 percent.

INTRODUCTION

Of all the commercial hardwood species found in the Southeast, yellow-poplar (Liriodendron tulipifera L.) seems to be one of the most responsive to differences in site quality and nutrient supply. A recent study examined the relative influences of the major nutrient elements upon nutrient uptake and seedling growth. The study results provide some tentative descriptions of symptoms of mineral nutrient deficiency for yellow-poplar seedlings.

METHODS

In late March 1962, 81 yellow-poplar seedlings, each 1 year old, were planted outdoors in individual glazed crocks containing perlite. For the first 6 weeks, each seedling was supplied with a complete nutrient solution made up with tapwater. On May 11, selective nutrient treatments with nitrogen, phosphorus, and potassium were begun. These treatments provided each seedling with one of three dosages (a zero level, a level of expected nutrient sufficiency, and a level of expected nutrient excess) of each of the three elements. The dosages were applied in all 27 possible combinations (see table 1). All treatments were replicated three times.

Table 1. --Nutrient concentrations

Element	Treatment level		
	1	2	3
	- Parts per million -		
N	0	300	600
P	0	200	400
K	0	150	300

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Calcium, magnesium, and iron were supplied to all pots in a supplemental solution containing 160 p.p.m. Ca, 49 p.p.m. Mg, and 5.6 p.p.m. Fe. Because tapwater was used in making up the nutrient supply solutions, trace elements were not needed. The seedlings were supplied with the treatment solution once weekly, and all pots were flushed with tapwater 2 or 3 days later.

DEFICIENCY SYMPTOMS

The symptoms of N deficiency appeared within 2 weeks after the first treatment application. Two weeks later the symptoms of P and K deficiency were observed. Although the intensity of these deficiency symptoms sometimes varied with time, their character did not change over the course of the growing season.

N Deficiency

All leaves of the seedlings deprived of N ranged in color from pale yellowish green to pale green. In seedlings also deprived of P or K, the N-deficiency symptom always appeared first, was the most consistent, and was never masked by the lack of either of the other two nutrients.

P Deficiency

The immature leaves of some of the seedlings deprived of P were thin, limp, somewhat translucent, and had a faint pinkish-bronze color. These symptoms appeared only on those seedlings supplied with N but not with P, indicating that N fertilization either induced or intensified the response to lack of P. Neither as strong nor as consistent as those for N deficiency, these symptoms were somewhat more pronounced in June than in September.

K Deficiency

The mature leaves of the plants deprived of K were often flecked with dark purplish brown between the veins.

NUTRIENT IMBALANCE SYMPTOMS

Abnormalities .in leaf coloration are not always the result of deficiencies of a particular element. An excess of an element or group of elements may also produce unusual responses in both morphology and color of leaves. The leaf color responses of the test seedlings to high concentrations (treatment level 3) of N, P, or K are described below.

High N

No consistent symptoms developed as a result of high N supply, but the leaves of several plants supplied with high concentrations of N were faintly mottled with yellow-green spots between dark green veins.

High P

The leaves of the seedlings supplied with 400 p.p.m. P, 300 p.p.m. N, and 150 p. p. m. K were dark green along the veins and flecked with yellowish brown in the interveinal areas. In these seedlings, the areas close to the leaf margins were predominantly brown; and the margins themselves were often fringed with black. (On seedlings deprived of K, the yellow color between the veins was often absent.) The same symptoms were more pronounced in seedlings deprived of N. Some of the seedlings supplied with high concentrations of N and P died; and subsequent analysis of pot leachates revealed that after both N and P were applied at their highest levels of concentration, the pH of the nutrient solutions dropped from 6 or above to approximately 3 within 3 days.

High K

No consistent symptom developed in seedlings supplied with high concentrations of K, although a very dark reddish-brown "burn" was often observed on the margins (or tips) of the leaves.

TISSUE ANALYSES

Nutrient deficiency symptoms are most meaningful when they can be correlated with measured concentrations of an element in leaf tissue samples. Accordingly, the leaves on the test seedlings were sampled late in September, ovendried at 65° C., and ground in a Wiley mill to pass a 40-mesh screen. The leaves of the seedlings deprived of N generally contained less than 2 percent N. Only 2 of the 54 seedlings supplied with N contained less than 2 percent of that element. The highest concentrations of N (over 4 percent) were found in the leaves of those seedlings supplied with N at the highest rate. These results and those of Finn (Unpublished data. U. S. D. A. Forest Service, Ames, Iowa.) suggest that the range of the optimum level for N in yellow-poplar seedlings is wide--perhaps from 2.5 to 4.3 percent (see table 2).

Under field conditions, the P concentration in yellow-poplar leaves commonly ranges from 0.10 to 0.30 percent (Mitchell and Chandler 1939). In this experiment, the concentration of P in the leaves which exhibited the P-deficiency symptoms described above was usually below 0.10 percent. The highest concentrations measured in this experiment, 0.70 to 1.0 percent, were considerably higher than the optimum value of 0.34 percent reported by Finn and White (1966). Color abnormalities induced by high P fertilization would not be as likely to occur in seedlings grown in nursery soil, where the P in fertilizer would tend to be fixed and, therefore, less available.

Table 2. --The interrelationships between nitrogen content of leaves, leaf color, and the likelihood of response to N fertilization[1]

N status	Leaf N content	Leaf color	Probability of growth response to N fertilization[2]
	Percent		
Deficient	Less than 1.6	Pale yellowish green	High
Suboptimum	1.6 to 2.4	Pale green to green	Medium to low
Optimum	2.6 to 4.2	Green to dark green	None
Above optimum	Greater than 4.4	Very dark green, sometimes mottled	Negative response possible

[1]Based on data reported here supplemented by data from other sources (Chapman 1933; Finn 1966; Mitchell and Chandler 1939).

[2]Based on the assumption that no other growth factors are limiting.

The leaf tissue from the seedlings not supplied with K (other than that in tapwater) generally contained less than 1 percent K. The K content of these leaves averaged 0.77 percent but ranged from 0.2 to 1.5 percent. The leaves of the seedlings supplied with K at the intermediate level (150 p. p. m.) averaged 1.8 percent K; the corresponding value for the high K treatment (300 p. p. m.) was 2.3 percent.

GROWTH RESPONSES .

The growth responses of the seedlings supplied with high concentrations of N and P were masked by the interaction of the two nutrients and the resulting increased acidity described above. In general, however, the seedlings responded vigorously to N but only slightly to K. No growth response to P was observed. When some degree of nutrient balance was maintained, seedlings grew well under high nutrient concentrations.

CONCLUDING COMMENTS

Based upon the results of this study, the following observations can be made: Yellow-poplar seedlings are much more sensitive to the supply of N than to that of P or K. The minimum requirements for P and K are apparently low. Seedlings will probably show a growth response to N fertilization when their leaf tissue levels are below 2 percent but not if these levels are above 3 percent.

Although the nutrient deficiency symptoms discussed in this paper are similar to those observed by Finn (Personal communication, 1967.1, they must be considered tentative. Further research will more accurately determine deficiency levels in both leaf tissue and soils. Leaf color is best used as a supplemental tool in conjunction with an adequate soil testing program. It is hoped, however, that these descriptions will aid forest nurserymen in recognizing fertility problems caused either by excesses or by deficiencies of the three major elements.

LITERATURE CITED

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