CHLOROSIS IN A SOUTHERN PINE NURSERY: A CASE STUDY

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A lime-fertilizer trial demonstrated how pine seedling chiorosis in the Stuart Nursery [3] near Pollock, La., could be minimized by adjusting soil pH to between 5.5 and 6.0 and moderately fertilizing to maintain growth. Exact rates of fertilization were not established because seedlings were using plant food remaining from earlier applications. The trial showed that improper use of lime and fertilizer creates imbalances between iron and manganese in the seedlings, and that this condition may induce chiorosis.

Chlorosis had been endemic in the Stuart Nursery for many years, persisting during the hot summer on terraces and at bed ends. Although eye-catching, chlorosis had had little effect on production until 1959, when it developed in May and spread rapidly to all parts of the beds. By late June, more than 10 acres of seedlings were seriously diseased, and unless a control could be found, complete mortality seemed inevitable in spots as large as 1 acre.

No certain cure was known, but test plots in the chlorotic areas were responding to applications of 45 pounds per acre of Sequestrine 330 Fe, a chelate recommended to correct iron chiorosis in acid soils. In July, similar applications were made on all chlorotic areas. Because 45 pounds per acre is an extremely heavy treatment, 15 pounds was applied each week for 3 weeks. This addition of iron restored needle color and renewed seedling growth; a normal crop of seedlings was produced.

Concurrent with the chelate treatment, steps were taken to determine the causes of the chlorosis. Bulk density and infiltration characteristics of the soil appeared unrelated to chlorosis or the recovery from it, and there were no nematodes present which were parasitic to plants.

Two unfavorable conditions were found: (1) soils in severely chlorotic areas were acid, with pH ranging from 4.1 to 4.6 and (2) available potash and phosphorus were highest in areas with the worst chlorosis. High phosphorus content seemed the more likely of the two to be related to chlorosis because at high concentrations in acid soil it decreases the availability of iron. More than 5,500 pounds per acre of superphosphate had been supplied to some areas during the past 4 years, and one block had received 3,300 pounds per acre in 1957. Also, the increased availability of manganese in soils of low pH may also have influenced chlorosis by

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decreasing the ratio of iron to manganese in forms available to plants.

Treatments

Since both pH and nutrient level appeared to need adjustment, e m p e r i c a l limefertilizer trial was established in April 1960.

The beds were sown to loblolly pine on April 5 and 6. Chlorosis appeared in May, increased gradually through June, and then leveled off.

Fertility was varied by adding 1,000 pounds of 6-24-24 per acre to some beds and nothing to others. Thus, each acre of the fertilized beds received 60 pounds of nitrogen, 240 pounds of phosphate (P205), and 240 pounds of potash (K20). A range in pH was created by applying 0, 0.5, and 2 tons per acre of finely ground agricultural limestone. Each lime-fertilizer treatment was tried on nine beds. On alternate beds of each major treatment, the following four additional treatments were superimposed to determine if selected minor nutrients were deficient or present in toxic amounts, or if the physical condition of the soil was responsible for chlorosis:

Iron chelate (Versenol F) at 30 pounds per acre.

Manganese sulfate at 200 pounds per acre.

Aluminum sulfate at 100 pounds per acre.

Puddling, i.e., wetting the soil and compacting it by running over it several times with a wheel tractor.

Responses

Seven weeks after treatment, pH ranged from 5.0 (where no lime had been added) to 6.2 (where 2 tons had been applied) (table 1). Available phosphate ranged from 6 to 354 pounds per acre, with the greater amounts being associated with the addition of 1,000 pounds of 6-24-24 per acre. Available potash was also increased by fertilization, but total nitrogen was unaffected.

None of the plots had exactly the pH and fertility levels encountered in 1959. The unlimed and unfertilized soil was less acid and had less available phosphate and potash. Fertilization, particularly when accompanied by liming, increased phosphate and potash to 1959 levels. Soil pH was increased to 5.5 by using 0.5 ton of lime and to 6.1 or 6.2 by using 2 tons of lime. The unfertilized, lightly limed beds were markedly lower in phosphate than the diseased beds of 1959. Available potash was similar.

A mid-July inventory showed that chlorosis was less severe than in 1959, and that the beds most affected were those that had been heavily limed and fertilized. Chlorosis was completely absent from more samples in unfertilized and unlimed or lightly limed areas than from those where rates of liming and fertilizing were heavy.

The minor mineral treatments did not affect discoloration, and puddling did not induce chlorosis.

TABLE 1.--Partial analysis of soils from study area, May 1960

Fertilizer and lime treatment per acre	pH	Total N	Available K_2O	Available P_2O_5	Organic matter	Chlorotic seedlings
		P.p.m.	*Pounds per acre*	*Pounds per acre*	*Percent*	*Percent*
No fertilizer, no lime.......	5.0	784	237	129	2.8	2.0
No fertilizer, 1/2 ton lime..	5.5	835	309	37	3.3	1.0
No fertilizer, 2 tons lime...	6.2	858	279	6	3.6	2.0
1/2 ton 6-24-24, no lime.....	5.2	802	519	226	3.1	2.0
1/2 ton 6-24-24, 2 tons lime.	6.1	796	489	354	3.2	10.0

Discussion

Excessive liming commonly causes iron-deficiency chlorosis, and too much phosphate can induce chlorosis in neutral or calcareous soils as well as in soils of low pH (2). Apparently, the presence of both factors contributed to its appearance in the limedfertilized area, as neither heavy liming nor fertilization alone was nearly as detrimental as both together.

The 1959 chlorosis was associated with concentrations of available phosphate similar to those of the limed-fertilized soil and with pH values that were 0.4 to 0.9 lower than those of the unlimed-unfertilized soil. Lowering pH increases available manganese and lowers the iron/manganese ratio. It may also increase the amount of iron fixed by phosphate in the soil (i). Both conditions contribute to iron-deficiency chlorosis (8 4). Differences in pH and the iron/manganese ratio, together with differences in phosphate level, probably explain why 1959 disease conditions were not encountered in the check area in 1960.

The low chlorosis rate on the lightly limed area indicated that the disease may be prevented or virtually eliminated by adjusting soil pH to about 5.5, which is near optimum for growing pine seedlings, and by maintaining the proper levels and balances among nutrients. The study-area soils had sufficient nitrogen, available potash, and available phosphate for most crops (1). A higher level of available phosphate is often maintained in pine nurseries but appeared unnecessary in the Stuart Nursery. Iron chlorosis can be successfully combatted with chelates, but it will recur in subsequent years if other nutrient imbalances are not corrected.

The remainder of the Stuart Nursery devoted to seedlings in 1960 received 0.5 ton of lime and no fertilizer; a normal crop was produced. By 1961, liming had brought most beds to a pH between 5.5 and 6.0. The only fertilization in that year was 100 pounds of nitrogen per acre applied as a topdressing to areas showing symptoms of nitrogen deficiency. No serious chlorosis developed, but seedlings were somewhat smaller than desired; the terraces and bed ends produced the largest and best-colored stock, indicating that only in these places was fertility sufficient for optimum growth. Fertilization was resumed in 1962, but the nursery was retired from production before specific fertilizer recommendations could be developed.

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