GRAFTING TO OVERCOME CHLOROSIS IN PIN OAKS

DONALD SCHOENEWEISS
Illinois Natural History Survey
Urbana, Illinois

Iron-deficiency chlorosis has long been a major problem in the cultivation of many species of trees and shrubs. Among those spècies commonly affected by chlorosis, pin oak (*Quercus palustris*) frequently exhibits the most severe symptoms. The development of yellowing or chlorosis due to iron deficiency has been attributed to many factors, including insufficient soil-iron content, despite the fact that other species such as red oak may grow vigorously and without developing any symptoms of iron deficiency when planted adjacent to chlorotic pin oaks. Results of extensive soil testing indicate that chlorosis among pin oaks, at least in Illinois nursery fields, is most often associated with high pH or alkaline conditions.

The recommended control measures for iron-deficiency chlorosis involve the application of iron-containing compounds such as ferrous sulfate, ferrous citrate, or iron chelates. These compounds are soluble in water and may be applied as a foliar spray, which gives only temporary results; as a trunk injection through holes bored in the plant, which seldom lasts more than 3 years; or as a soil application, which gives more lasting results. Although soil treatment with iron compounds is usually recommended for treatment of chlorotic nursery trees, in many cases little or no alleviation of symptoms occurs. This is true particularly where the nursery soil is an alkaline clay, as is often the case in Illinois. Even the incorporation of sulfur compounds for the purpose of lowering the soil pH, thereby releasing chemically bound iron, has often failed to overcome iron-deficiency chlorosis in pin oaks.

The material presented in this paper is part of a research project designed to investigate the various factors involved in iron-deficiency chlorosis and to approach the problem of control not only from the standpoint of chemical treatment but by changing, if possible, either the availability of soil iron or the ability of the plant to obtain iron from the soil under adverse conditions. Since many species, among them red oak, are able to obtian iron sufficient to support good growth under conditions, such as high soil pH, where pin oaks become chlorotic, the role of specific rootstocks was considered worthy of investigation.

In determining the role of the root system in chlorosis susceptibility, successful grafts of susceptible stems on resistant root stock would provide excellent research tools. Although very little information is reported in the literature on interspecific grafting of oaks, such grafts have been made successfully in the past, indicating at least some capatibility between oak species.

Red oaks to be used as rootstocks were propagated from

seed in the greenhouse. Young seedlings were transferred to 6″ pots containing a potting mix composed of ⅔ soil and ⅓ peat moss. These plants were maintained for 1 year with daily watering and monthly fertilization. During the month of February, 1962, 10 grafts were made at the Natural History Survey greenhouse with scion wood from potted 1-year-old pin oaks. At the same time, 40 seedling red oaks were transferred to the Hinsdale Nurseries greenhouse at Hinsdale, Illinois, where dormant 1-year-old scion wood from field-grown pin oaks was grafted onto the red oak rootstocks. All red oak seedlings had broken dormancy at the time of grafting and were in an active stage of growth. Pin oak scions at the Survey greenhouse were breaking dormancy at the time of grafting and scions at Hinsdale broke shortly after grafts were made. All 10 grafts at the Survey were succesful, while 30 of the 40 grafts made at Hinsdale succeeded. All plants were side grafted, tied with rubber budding strips, and wrapped with floral tape. Tape was removed 8 weeks after grafting, and budding strips were removed 1 - 2 months later or as soon as they became too tight. The stem portions of the red oak rootstocks were removed at the graft as soon as the pin oak scions began putting on vigorous growth.

As part of the overall research project on chlorosis in the several years preceding the present work, a hydroponic nutrient culture apparatus was employed with satisfactory results. Vigorous growth of oaks and other tree species was obtained when the trees were planted in crocks containing sterile sand or perlite and sub-irrigated with nutrient solution. Maximum growth was realized when plants were irrigated with a modified Shive's nutrient solution. This type of culture offers a distinct advantage in nutritional studies in that the concentration of individual nutrients such as nitrogen, phosphorus, potassium, iron, manganese, etc. can be varied without altering the concentration of the other nutrients. In this way mineral deficiencies in plants can be produced under controlled conditons.

To evaluate the relative ability of red oak and pin oak rootstocks to obtain iron under controlled conditions, one red oak seedling, one pin oak seedling, and one grafted pin oak on red oak were planted in sterile, chemically inert perlite in each of 18 one-gallon nutrient culture crocks. All crocks were sub-irrigated daily with a modified Shive's nutrient solution. Since a direct correlation between pH and chlorosis was found in field-grown pin oaks, one half of the nutrient solutions were adjusted to pH 5.0 and the other half to pH 7.0 (pH 7.0 was the highest that could be employed in these studies since nutrients precipitated at higher pH). The source of iron was also varied: ferrous sulfate ($FeSO_4$) and a chelated iron, Sequestrene 330 Fe, were each added to 3 crocks at each pH level. No iron source was added to the remaining 3 crocks at either pH level. Sub-irrigation with the adjusted nutrient solutions was begun on February 25, 1963, and final readings on chlorosis were made three months later.

At the time the test was concluded, marked differences in the development of chlorosis due to the various treatments was apparent. Chlorosis was severe on pin oak seedlings in iron-deficient solution and in solutions with $FeSO_4$ as the iron source, particularly at pH 7.0. Slight chlorosis was apparent on pin oaks with Sequestrene 300 Fe as the iron source at pH 7.0. Red oak seedlings developed a moderate chlorosis in iron-deficient solutions and exhibited slight chlorosis at pH 7.0 wtih $FeSO_4$ as the iron source. Grafted pin oaks on red oaks remained dark green in all solutions.

From the results of these tests it may be concluded that under the conditions of the experiment, either the availability or the uptake of iron was directly affected by pH; the chelated iron, Sequestrene 330 Fe, served as a better iron source than did $FeSO_4$; red oak rootstocks were apparently able to obtain a sufficient amount of iron in all solutions to support good growth of the pin oak scions. Had the experiment had been continud indefinitely, chlorosis would undoubtedly have appeared on the grafted oaks as well as the pin oak and red oak seedlings in the iron-deficient solutions. The results, however, were considered to be significant at the time the experiment was concluded.

Although the grafted oaks employed in the tests described in this paper were produced for use as a research tool rather than as a practical control measure for chlorosis in the field, the results obtained were promising and indicate that the use of grafted oaks in the field to overcome chlorosis problems should at least be investigated. All successful grafts of pin oak scions on red oak rootstock appear to be growing vigorously two years after grafts were made and are being maintained for future field planting. Additional grafts have been made with seedling pin oaks as rootstocks and red oaks as scion wood. To date most of these grafts appear to be successful. Future work already under way will include additional nutrient culture tests with grafts of pin oak on red oak rootstock and red oak on pin oak rootstock to confirm the results reported here and to determine the levels of available iron required to support active growth of red, pin, and grafted oaks. The possibility of incompatibility showing up in time among these grafts has not been overlooked. In the meantime, grafted oaks are providing an excellent research tool for investigation of some of the factors involved in the development of pin oak chlorosis.

MODERATOR MCDANIEL: Thank you, Dr. Schoeneweiss. We next have a very interesting paper by Prof. J C. Moore, Auburn University, Auburn, Alabama.