CHAPTER TWENTY-NINE

Mineral Nutrient Problems

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Mineral nutrients are taken up by the plant from the soil solution in various ionic forms. These ions are replenished through mineral decomposition and decay of organic matter and from fertilizer amendments. Mineral nutrients have a significant effect on plant growth rate. A mineral nutrient deficiency exists when the plant's growth rate is limited by the availability of a certain nutrient. If plants are supplied with an excess of a certain mineral nutrient, however, they may continue to take it up until growth is retarded. This is referred to as a mineral nutrient toxicity. In addition to deficiencies and toxicities, mineral nutrient disorders can also be caused by an imbalance in the relative availability of different nutrients.

The 13 essential mineral nutrients are customarily classified into two categories: macronutrients and micronutrients. Macronutrients, which are used by plants in relatively large amounts, include nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. The seven micronutrients, iron, manganese, zinc, copper, boron, molybdenum, and chloride, are required in very small amounts, and the difference between deficiency and toxicity can be quite small.

B

C

Figure 29-1. Chlorosis can be caused by a deficiency of a number of mineral nutrients. For example: (A) nitrogen, (B) magnesium, (C) iron.

Occurrence: species and season

All seedling species and stock types are susceptible to both deficiencies and toxicities of mineral nutrients, although different species may express these disorders with different symptoms. Young and actively growing seedlings are most susceptible to nutritional problems.

Symptoms

DEFICIENCIES

When a seedling is unable to obtain enough of a mineral nutrient, the first effect is a reduction in growth rate. Often this initial growth reduction goes unnoticed because this "hidden hunger" is not accompanied by visible symptoms. Eventually, however, nutrient-deficient seedlings may become stunted.

If the mineral nutrient deficiency is not corrected, the seedling may exhibit certain visible deficiency symptoms. These can be useful in diagnosing the deficiency and prescribing corrective fertilizer amendments. Some common deficiency symptoms, such as nitrogen chlorosis, are well known to experienced nursery managers.

Unfortunately, however, different species of seedings exhibit mineral nutrient deficiencies in different ways. Phosphorus deficiency, for example, is expressed as foliar discoloration that varies with species, ranging from dull green to purple in color.

To complicate matters, some symptoms can be caused by a deficiency of any of several different mineral nutrients. For example, chlorosis (yellowing) can be caused by a deficiency of nitrogen, magnesium, or iron (Figure 29-1). Sometimes mineral nutrient deficiencies can be identified in the cover crop—phosphorus deficiency in oats, for example (Figure 29-2). Deficiency symptoms alone are not particularly helpful when dealing with the problem of multiple deficiencies; these obviously can become quite complicated. Nevertheless, deficiency symptoms can help identify nutritional problems when considered in conjunction with soil and foliar nutrient tests and practical experience. Some nursery manuals contain lists of deficiency symptoms for tree seedlings, but new seedling growers should seek the advice of experienced nursery managers or specialists.

Figure 29-2. Mineral nutrient problems can also be recognized in the cover crop. This chlorosis in oats is caused by a deficiency of phosphorus.

TOXICITIES AND IMBALANCES

Mineral nutrient toxicities and imbalances are particularly difficult to diagnose because an excess of one nutrient may induce a deficiency of another. Extreme toxicities are expressed as needle tipburn or leaf margin scorch, the typical symptoms of fertilizer burn (see Figures 31-1B and 31-1C). Foliar symptoms have been useful in diagnosing toxicities of certain micronutrients, such as manganese (Figure 29-3), but these diagnoses should be made in conjunction with nutritional analysis of seedling tissue. Experienced nursery managers or specialists should also be consulted.

Predisposing factors

Seedling nutritional disorders can occur without any predisposing stress factors, although some environmental conditions may indirectly inhibit the uptake of nutrients. Soil factors, especially pH, can have a significant effect on mineral nutrient availability. Because most conifers grow best in slightly acid soils, nursery managers try to maintain soil pH in the range between 5.0 and 6.0. Hardwood species can tolerate a slightly higher pH, around 6.0, although the requirements of individual species vary.

Any injury or disease that weakens or destroys the fine feeder roots can lead to nutrient deficiencies. The chlorosis that is symptomatic of some root diseases, such as Phytophthora root rot, may actually be caused by a mineral nutrient deficiency. Heavy rainfall or over-irrigation can lead to waterlogging of the soil, resulting

in anaerobic conditions in the root zone. When roots are unable to respire normally, mineral nutrient uptake is altered. Prolonged water stress can also cause mineral nutrient deficiencies, because many nutrient ions are absorbed into the root system with normal transpiration water uptake.

Loss potential

Mineral nutrient deficiencies rarely result in seedling mortality. Growth losses do occur, however, but are impossible to quantify because they typically begin before foliar deficiency symptoms become visible. Stunted seedlings or those with visible nutrient deficiency symptoms are normally culled out on the grading table, but seedlings that are merely weakened by nutritional problems may not be identifiable. Nutritionally weakened seedlings are at a disadvantage on the outplanting site, and suffer severe transplant shock and slower initial growth.

Mineral nutrient problems appear:
All ages
Any time throughout rotation

Management

Mineral nutrient deficiencies are easily managed and should not be a serious problem in a modern forest nursery. They can be prevented by regular testing of soils and seedlings, proper soil management, and well-planned applications of the proper fertilizers.

NUTRIENT ANALYSIS

Soils from areas designated for seedling production should be sampled and tested for mineral nutrient content the fall before sowing, so that presowing applications of fertilizer can be incorporated into the soil. This is especially important for nutrients like phosphorus and calcium, which are not mobile in the soil and therefore cannot be applied as a top dressing over the seedling crop. Soil pH can also be adjusted at this time by applying limestone or dolomite to raise pH or sulfur to lower it.

Figure 29-3. Foliar symptoms can be used to identify toxic levels of certain nutrients. This is manganese damage in spruce. Such diagnoses should be made in conjunction with tissue analysis.

Both seedlings and soil should be analyzed for nutrients at the end of the first growing season, so that fertilizer programs may be adjusted during the second year. To ensure the accuracy of the analysis, soil and seedling samples should be collected systematically. Considerable variation can occur within a nursery, so sampling schemes must be designed to reflect this variability. Contact the testing laboratory before collecting samples. Laboratory personnel can often recommend a scientific sampling technique and give advice on handling and shipping of samples.

Many laboratories offer soil and seedling testing services. Because tree seedlings have different nutritional requirements than agronomic crops, nursery managers should patronize laboratories that have experience with tree-nursery crops. Each laboratory uses slightly different analytical techniques; this may affect the test results. Nurseries should continue to patronize one laboratory so that results are comparable from year to year. Interpretation of test results requires experience. Laboratories that have previously tested tree seedlings and have accumulated test results from other seedling nurseries will be able to provide better recommendations than inexperienced laboratories. Nursery manuals contain soil fertility targets for tree seedlings, but these values must be interpreted with an understanding of the soil conditions and species at a particular nursery.

SOIL MANAGEMENT

Many different soil factors affect seedling nutrition. Nursery managers can improve the nutritional status of their crop by using proper soil-management practices. The sandy soils that are best for tree seedling production are inherently infertile; growers need to maintain soil fertility with organic amendments and cover or green-manure crops. Organic matter has both physical and chemical effects on the soil: it increases the cation exchange capacity, and it improves the physical structure of the soil. Cover or green-manure crops also function as "catch crops" that supply readily available forms of mineral nutrients as they decompose. Legumes fix atmospheric nitrogen which is subsequently released to the seedling crop. Beneficial soil microorganisms, notably mycorrhizal fungi, have been shown to increase the availability of certain mineral nutrients, specifically phosphorus. Nursery managers should use cultural practices that encourage mycorrhizae.

FERTILIZER APPLICATIONS

The most practical and effective way to control soil fertility in forest nurseries is with fertilizers. Fertilizer application rates should be prescribed using previous experience or general recommendations, but the best practice is to base prescriptions on soil and seedling test results, taking into account experience with the particular species of seedling. Fertilizer application equipment should be calibrated carefully and tested regularly to make sure it is functioning properly (Figure 29-4).

The timing of macronutrient fertilizer applications should be based on seedling phenology, rather than calendar date, and on the characteristics of individual fertilizers. Certain immobile nutrients like phosphorus and calcium should be incorporated before sowing. Phosphorus fertilizers are most effective when banded alongside or under the seed. Nitrogen and potassium are more mobile and therefore may be applied as top dressings during the growing season.

Newly sown seedbeds are usually not fertilized until several weeks after seedlings emerge. Fertilizers can burn young, succulent seedlings, and high levels of nitrogen are thought to stimulate soil pathogens. Excessive nitrogen fertilization will also promote shoot growth at the expense of root growth, resulting in a seedling with a poor shoot-to-root ratio. With older seedlings or transplants, growers should not wait until deficiency symptoms appear, but should apply fertilizers based on periodic nutritional analyses of the soil and of seedling tissue. Later in the growing season, high nitrogen fertilization rates may delay hardening of seedlings.

Most nursery soils are not normally deficient in micronutrients, but proven deficiencies can best be treated with foliar applications of chelate fertilizers. Because of the narrow range between deficiency and toxicity of most micronutrients, individual-element fertilizers should be used rather than commercial micronutrient mixes.

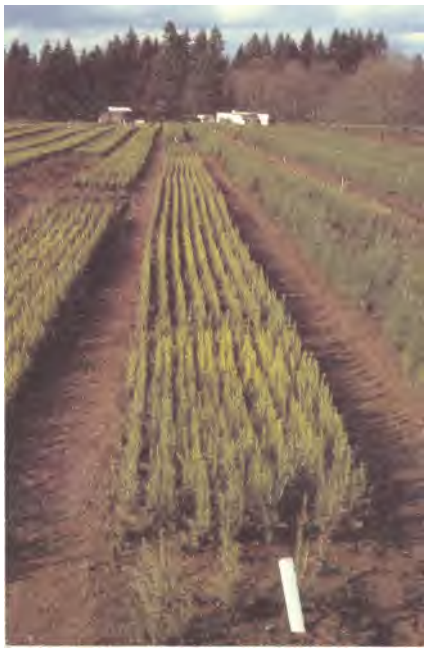

Figure 29-4. Differences in foliage color indicate uneven application of fertilizer from improperly calibrated equipment.

Selected references

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