Fertilizing a Sugarbush
Proctor Maple Research Center

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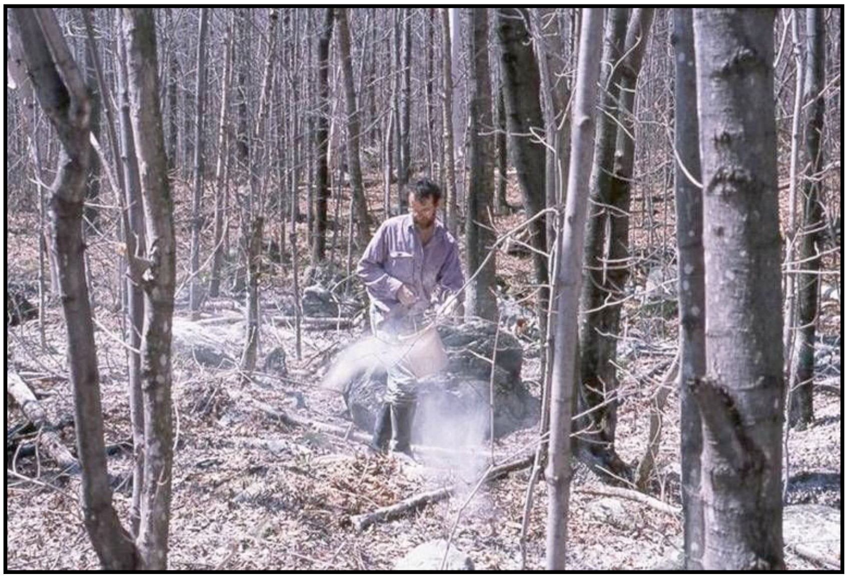


Vermont Agricultural Experiment Station

University of Vermont Extension

Introduction

This brochure is intended to help landowners and maple producers evaluate the nutrition of maple stands, and determine whether fertilization might be appropriate. There is an emphasis on learning some of the plants in your woods, as these are often valuable indicators of site quality, and are in many cases easier to interpret than chemical analyses of soil or leaves. Other topics include the materials that might be used in a fertilization program, and considerations for those people who choose to certify their syrup as organic. Two fertilization studies that were executed by the Proctor Maple Research Center in recent years are described here. Both had positive impacts on the stands. Landowners may wish to follow some of the same procedures that we did, in their own experimental fertilization program. Finally, some additional resources are mentioned for those people seeking further information.

Sugar maples growing on low fertility soils. Every stand is somewhat different, in terms of soil nutrient content, depth, moisture, slope, texture, as well as tree age, density, vigor, etc. There is no one successful practice to follow in terms of amount, makeup, or timing of fertilization, although there are definitely certain practices to avoid; for example, anything that injures trees or compacts soil during fertilizer application. While you should consider maple fertilization an experiment, with no guarantee of benefit to the trees, using appropriate methods will improve your chances of a successful outcome.

Why fertilize maple?

Sugar maple is a dominant tree throughout much of the northeast; in Vermont it is the most prevalent tree species in terms of both growing stock and saw-timber volume. Nevertheless, even when stand crowding is accounted for, sugar maple stands can grow at vastly different rates, and show wide variations in crown vigor. A large portion of these differences in stand condition are caused by differences in soil nutrition, which in turn are the result of differences in geologic resources. Fertilization cannot change the makeup of the soil to the degree that the underlying rock determines soil type and nutrition, but it can supply, at least temporarily, nutrients that are not present in adequate amount by the weathering of rocks, or those that have been depleted by various causes, such as acid rain.

Why not fertilize maple?

Trees may have slow growth, thin foliage, branch dieback, or slow taphole closure. There may be many reasons other than poor soil nutrition for these problems. Fertilization will not overcome poor growing conditions presented by a site that is too wet or too dry; it is not a substitute for proper tapping practices, or a remedy for logging damage and soil compaction. Fertilization will not prevent insect defoliation, which can occur on stands with very good, as well as poor nutrition. Tree crowding can greatly decrease tree growth, but fertilization will not improve this situation. **In short, fertilization is not a substitute for proper stand management, and it is not likely to aid a site that is simply inappropriate for a sugarbush.** It is important to eliminate these other causes before attempting fertilization as a remedy. In addition, fertilization will probably not increase the growth rate or vigor of trees already growing on a rich soil, where nutrients are already in adequate supply. This brochure will help you distinguish rich sites from poor sites.

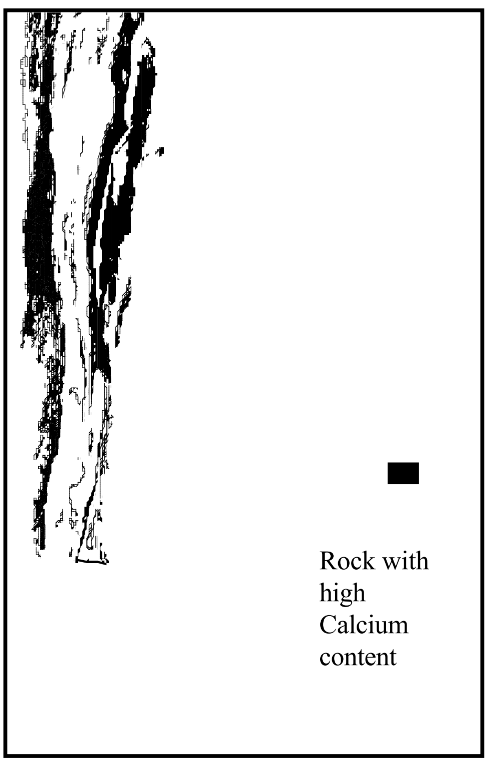
What nutrients are likely to be low in a maple forest?

Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) are the most common nutrients in plants. While it is possible to discover a sugar maple stand somewhere that is deficient in any of the these nutrients, calcium is probably the most variable nutrient in the forests of the Northeast. There is abundant evidence that maple stands on soils with high amounts of calcium are faster growing and are often healthier than stands growing on calcium poor soils. In addition, sugar maple reproduction is often superior on high calcium soils. Where calcium is high, soil pH is higher, and this makes other nutrients such as Mg and sometimes K more available, while at the same time lessening the negative impact of iron, aluminum and manganese, which can be toxic to sugar maple roots in very acid soils.

Nitrogen can also be low on a variety of sites, which can cause low vigor and slow growth; however, adding N can in some cases cause tree damage, and most sources of N are not considered organic. A discussion of some of the issues surrounding N is found later in this brochure.

Where do sugar maple stands with low nutrition occur?

The range of sugar maple extends from Nova Scotia and New Brunswick west to Minnesota and south to Illinois, Missouri and the southern Appalachians. Because of the geologic history of the continent, only a portion of this range is likely to occur on soils of low nutrition, particularly low Ca. Most of northern New England, and a portion of Quebec have large areas of sugar maple growing on low Ca soils (see map below as an example of regional variation in Ca in one state) and these areas constitute the heart of the maple syrup producing region. Other areas including scattered regions in the remaining Canadian provinces, the Adirondack Mountains of New York, portions of western Pennsylvania and northern Minnesota may also have low soil Ca. Most of the rest of the maple region has moderate to high soil calcium due to the prevalence of limestone bedrock. Portions of Quebec and perhaps northern New England may also have low K, but this is much less common than low Ca.



Bedrock geology of Vermont (left). Calcium is emphasized here because a recent survey of maple stands across Vermont showed that of all the nutrients sampled, the best relationship was between the amount of Ca in the soil (and foliage) and tree growth rate. Similar results have been found in other states. Most soils in western Vermont are derived from limestone with high Ca and Mg content, as are major portions of eastern Vermont. The Green Mountain soils are mostly derived from lower fertility rock such as schist. Bedrock maps do not tell the whole story however; between the bedrock and the soil are deposits of glacial till of varying thickness and originating from rock sources both near and far.

Maidenhair fern (right) in a maple stand is an excellent indicator of a soil that is rich in calcium, where fertilization is not needed and probably would be of no benefit.

How to assess the nutrition of your stand

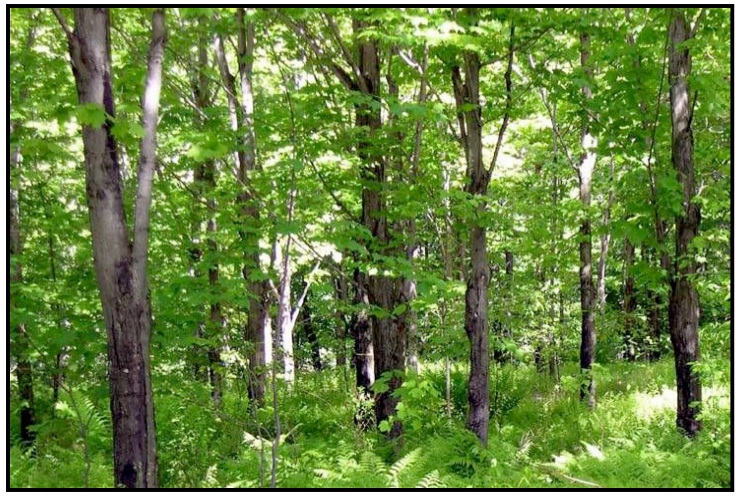
Both soil and foliar samples can be used to determine the nutrient status of a maple stand. **Soil testing,** although commonly used and sometimes informative, is somewhat problematic, as soil nutrient levels often vary considerably within a short distance, sampling methods can vary widely, and the numbers can be difficult to interpret. The pH (in water) of forest soils with good sugar maple growth may be as low as 5. Soil tests usually cost less than $10 each. The USDA Natural Resources Conservation Service has soil maps and soil scientists who may be able to help you assess your soil nutrition; in Vermont see http://www.vt.nrcs.usda.gov/soils/ . **Foliar samples** can give a more complete and reliable picture of nutrient status. Samples should be collected in August from sun-exposed leaves using a pole pruner or shotgun. Each sample will cost around $25 for analysis, and several samples should be collected and analyzed in order to give a true picture of a stand's nutrient status. A description of soil and foliar sampling can be found in the publication *Essential Elements of Sugarbush Fertilization,* by B. Burns (see references).

An adjunct to soil and foliar nutrient sampling is to **take note of the plants growing in the stand**. Many wild flowers and ferns are found only in sites with rich soils, and their presence often indicates a soil that should support good sugar maple growth without additional fertilization. A "rich" soil is one that has a higher pH and abundant calcium, along with adequate amounts of other nutrients. At right are a few of these "indicator plants." Other indicator plants include those which are described in wildflower guides as typically found in "rich woods." Certain trees and shrubs such as basswood, white ash, hickory, witch hazel and northern white cedar also indicate richer soils. The greater the abundance of these plants in your stand, the greater the likelihood that the stand does not need fertilization.

There are no plants that positively indicate a "poor" soil or a site where the sugar maples would clearly benefit from fertilization; however, the absence of rich soil indicator plants and trees, as well as the absence or scarcity of maple regeneration is often a good indicator of a nutrient poor soil. Trees typically growing with sugar maple on more acid soils are American beech, yellow and paper birch, red and striped maple, red spruce, and eastern hemlock.

Some Plants of Rich Woods (below and right**).**
If any of these plants are frequent in your woods, the trees will probably not benefit from fertilization.
a) Blue cohosh develops blue berries in mid-summer; b) Herb Robert often grows on moist ledges c) Jack-in-the pulpit (note flower below leaves); d) Wood nettle (not the tall nettle of barnyards) grows in rich moist woods; e) Dutchman's breeches flowers in the spring and has distinctive leaves all year.

Thinning vs. Fertilizing. An overcrowded stand in which trees have no room for expansion is likely to benefit more from thinning than from any fertilization program. A forestry professional can assess the stocking levels and recommend which trees to remove. Landowners who keep track of the relative sweetness of their sugar maples (this can be started when the trees are only 1”-2” in diameter) will know which are their future crop trees. Instructions for testing sweetness of sap can be found in the North American Maple Syrup Producers Manual at http://ohioline.osu.edu/b856/.



Wet or dry sites

Ideal sugar maple growth occurs where soils are moderately well drained. Sugar maples may also be present on sites that are either too wet or too dry for the trees to be large and vigorous. Fertilization is not likely to benefit the trees at these sites. Poorly drained sites usually contain an abundance of plants that prefer wet soils. Small patches of these plants indicate areas were forest roads should not be created. In addition to these herbs, some tree species, such as red maple, red spruce and balsam fir will be more common in wet areas. Sites that are too dry for ideal sugar maple growth often have thin soil with dry bedrock ledges. Sugar maple may be accompanied by oak, pine, and paper birch on such sites.

Plants of wet sites (right). a) Sensitive fern is common in wet soils in the sun and semi-shade, b) False hellebore is one of the first plants to emerge in the spring, in wet forest soil.

Plants of dry sites (left)
Bracken fern, up to 3’ tall, prefers dry sterile soil

Fertilization of Sugarbushes: Studies From Northern Vermont

Study 1: Fertilization to Improve Vigor and Growth

Two groups of sugarbushes from northern Vermont were selected for study in 1988; one group with mostly healthy crowns and one group with poor crown condition. The stands in poor condition had lower soil pH and their foliage contained much lower levels of calcium (Ca) as well as somewhat lower levels of nitrogen (N), potassium (K) and magnesium (Mg). The understory of the poorer sites lacked plants that indicated a soil rich in Ca and other nutrients. None of the stands had very wet or ledgy areas which might indicate a site too wet or dry for good sugar maple growth.

At each site, we established _ acre plots far from the edge of the woods. Some plots were fertilized and some served as unfertilized controls. Treatment consisted of either a fertilizer blend of K, Ca and Mg, at about 400 lbs/acre for the total mix, or this same mix with additional lime at 3000 lbs/acre. See the front cover and picture below for application methods. Lime was applied once, the fertilizer blend applied twice. **All fertilizer was applied in the late spring, once the ground was dry.**

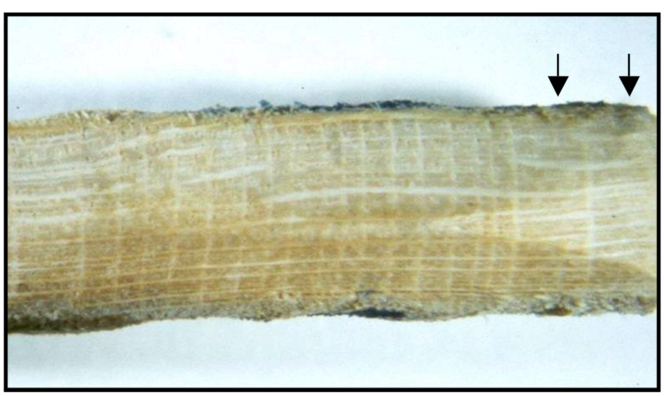
Three years after fertilization, trees in the plots with the blended fertilizer plus lime had significantly less dieback and faster diameter growth than trees in the other plots. Trees receiving the blended fertilizer alone improved somewhat less, but still showed improved growth compared to the untreated trees.

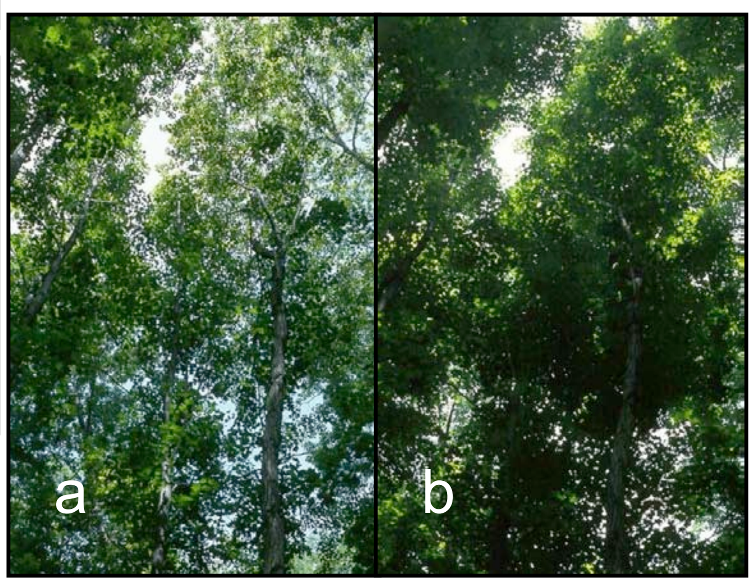
In 1998 trees in all plots were cored in order to measure the long-term effects of fertilization on diameter growth (see graph at right). Trees from the poorer sites showed long-lasting effects from the fertilizer; however, trees at a nutrient rich site showed no response to fertilization.

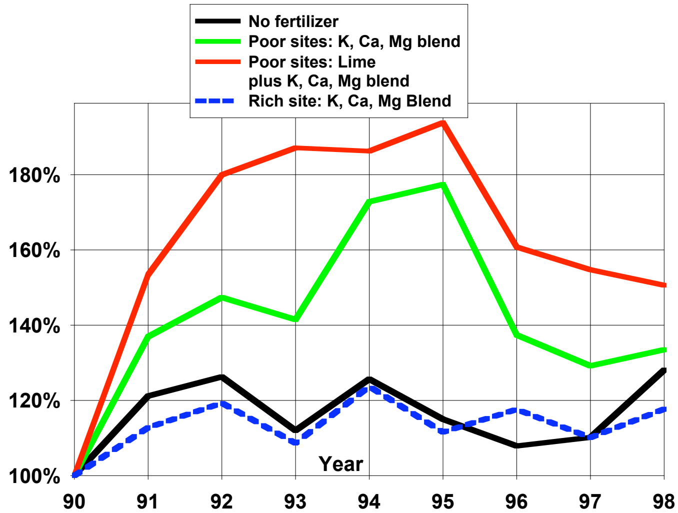
Hand fertilizing (top left), in the spring with a spinner-spreader. The rate of application can be adjusted by opening the chute or changing walking speed.

Sugar maple core (bottom left), taken with an increment borer. Note wide rings (arrows) indicating a recent increase in the diameter growth rate

The Importance of Controls. (bottom right). Two shots of the same trees in an unfertilized plot: a) July 1989; b) July 1991. The improvement was due to increased rainfall and decreased insect feeding. Without controls, a landowner might credit changes like these to the effects of a fertilizer treatment. **A wise landowner will fertilize only a portion of his woods and leave a portion alone, in order to see whether fertilization has made a difference.**







Long-term changes in diameter growth rate following fertilization.

Cow manure in a young stand. Manure adds many nutrients, in particular N. In this study, manure stimulated growth in this young stand of maples growing on thin, ledgy, acidic soil.

Nitrogen and organic certification:
Nitrogen (N) is a critical nutrient for plant growth and it can be deficient in sugar maple stands; however,results are mixed on the effects of adding N. Landowners should be aware that N fertilizer is usually synthetic. Organizations that certify maple syrup as organic, such as the Northeast Organic Farming Assoc. (NOFA), do not allow the use of synthetic fertilizer in the sugarbush. An example of a synthetic fertilizer is 10-10-10, which is 10% N 10% P and 10% K. While there are non-synthetic sources of P and K readily available, there are few bagged sources of organic N. One source is Chile Nitrate, which is derived from rock mined in that country. Manure (see picture) is another source of organic nitrogen. The use of a synthetic fertilizer on a sugarbush would disqualify the landowner from obtaining organic certification for his syrup for 3 years.
N should not be added late in the growing season, as this may lead to winter injury.

Maple regeneration. Maples of all sizes and ages should be present in a healthy sugarbush. While grazing by deer and other animals can greatly reduce the survival of these seedlings, soil pH and soil Ca may also play a major role in their success. Regeneration of maple is usually abundant where soil Ca is high. Several studies have shown that added lime has increased the survival and growth of maple regeneration in nutrient poor soils. Absence of any sugar maple regeneration may indicate a site where the canopy trees were selected for maple, but the site is more appropriate for other tree species.

Further reading

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Wilmot, T.R, Ellsworth, D.S. and Tyree, M.T. 1996. **Base cation fertilization and liming effects on nutrition and growth of Vermont sugar maple stands.** For. Ecol. Manage. 84: 123-134.

Wilmot, T.R. 2000. **A survey of sugar maple nutrition in Vermont and its implications for the fertilization of sugar maple stands**. Maple Syrup Digest 12A(3): 18-21.

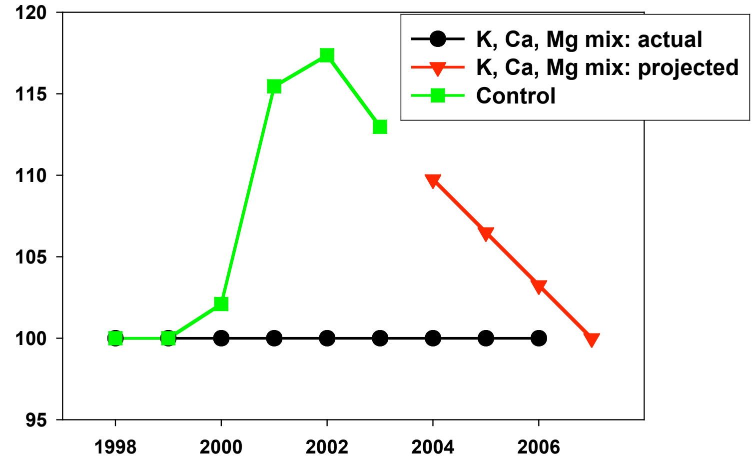
Study 2: Fertilization to Increase Sugar Production

One sugarbush in northern Vermont was treated with several different fertilizers in this study in order to measure the effects on sap volume and sweetness. The site had mature trees > 100 yrs old, moderately fertile soils, and the crowns were mostly healthy. Plots containing 10-14 taps each were fertilized with a blend of K, Ca and Mg with or without lime; or 10-10-10 fertilizer (N P K) with or without lime. Lime and K, Ca, Mg fertilizer rates were the same as in the study described above; the rate for 10-10-10 was 270 lbs/acre.

Sap volume (collected under gravity) and sap sugar from all plots, including unfertilized controls, was monitored each season for 4 years after fertilization. All treatments improved total sap sugar (volume x sweetness) by a small amount; with the blend of K Ca Mg showing the best improvement (figure 11).

It should be emphasized that soils in this study site were not nutrient deficient. Studies by others in nutrient poor sites have occasionally shown larger increases in sugar production after fertilization; while some studies have shown little or no improvement.

Increase in sugar production, compared to the untreated trees. The most successful treatment at this site, a mix of K, Ca, and Mg, is shown. Data was only collected through 2003; after that, we project that the improvement will gradually taper off.



What fertilizers and how much?

Like all plants, sugar maple requires many nutrients for growth. Major nutrients include nitrogen (N), phosphorus (P), potassium (K) calcium (Ca) and magnesium (Mg); there are also many micronutrients which are required in small amounts. Nutrients most likely to be in short supply in some northeast forests soils are Ca, N, K, and Mg. **Ca** is largely responsible for soil pH and is highly variable across the region (see map). Where soil Ca is high, soil pH is higher, which in turn makes other nutrients more available. High soil Ca is often associated with high rates of diameter growth and successful maple regeneration.

Limestone is the major source of Ca; dolomitic lime also contains Mg. Finely ground lime is more rapidly incorporated into the soil than coarse lime material. In order to raise soil pH, large amounts of lime need to be added. In experiments in Pennsylvania, Vermont and Quebec, amounts applied ranged from about 1.5 to 10 tons per acre with positive results on calcium poor soils. Applying this much material in the woods can be a difficult and time-consuming chore (see picture on front cover), as the terrain of most sugarbushes does not allow easy access to mechanical equipment. Care should be taken to avoid damaging trees during application.

Potassium deficiency has been identified in some northeast forests, particularly in SE Quebec, and low K may be linked to slow growth or poor crown condition. In some Quebec experiments it was found that high soil Mg was responsible for reducing soil K, and therefore liming material should not be dolomite, which adds more Mg. K is best added to the forest using potassium sulfate, available through most fertilizer companies; rates of 200-400 lbs per acre have been used successfully.

Magnesium can be added using dolomitic lime, a material that usually contains _ to 1/3 as much Mg as Ca, or by magnesium sulfate (epsom salts).

Phosphorus is rarely deficient in northeast sugar maple stands.

For Nitrogen, research results are mixed as whether adding N alone to maples is a good idea (see box above about N). **Note**: in addition to N, other fertilizers can be synthetically made. Consult with your fertilizer company if you have concerns about synthetic materials and organic certification.

Fertilization of sugar maple in forest stands has increased the growth rate and sugar yield of mature trees at some sites in Eastern North America. The use of lime at rates of 3000 lbs/acre or greater has been shown to be an effective treatment to raise pH and increase foliar calcium in some nutrient poor stands, while additional small amounts of potassium and magnesium have also been used successfully to correct deficiencies.

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