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OLIVINE: A POTENTIAL SLOW-RELEASE MAGNESIUM SOURCE FOR NURSERIES

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Magnesium is essential for plant growth. About 10% of the magnesium in green plants is in the pigment chlorophyll which gives plants their green color as well as their ability to change light energy to chemical energy through the process of photosynthesis. The remainder of magnesium in a plant has many uses. High concentrations of magnesium are usually found in parts of plants where lots of energy is required such as the growing tips of roots and shoots or areas where seeds are being formed.

MAGNESIUM DEFICIENCY

The need for magnesium in higher amounts in these areas of rapid growth helps to explain why magnesium deficiency symptoms appear as they do. Magnesium moves readily from one area inside a plant to another. If there is not enough magnesium for all parts of the plant when conditions are right for rapid shoot growth or a heavy seed set is occurring, the magnesium will be preferentially transported to areas where it is needed most. When this happens, the older leaves on plants turn yellow because the magnesium needed for the rapid shoot growth or a heavy seed set is occurring, the magnesium will be preferentially transported to areas where it is needed most. When this happens, the older leaves on plants turn yellow because the magnesium needed for the green pigment chlorophyll was moved elsewhere. This also helps explain why male holly or podocarpus plants remain green while adjacent female plants with a heavy seed crop turn yellow. The extra drain on the limited amount of magnesium present due to seed production has used most of the magnesium required to maintain the green color in leaves.

Magnesium deficiency can be caused by a lack of magnesium or an imbalance in the proportion of magnesium to some other nutrients. The offending nutrient in most cases where adequate magnesium is present in Western North Carolina soil but is not getting into the plant is calcium. It is not uncommon for us to see a calcium to magnesium ratio of 10 or 15 to 1 in soils that have been limed with high calcium limestone. A more desirable ratio for most plants being grown in the mountain soils of North Carolina would be 3 or 4 to 1. Ammonium and potassium are reported to have an even greater influence on available magnesium. However, these nutrients commonly are not applied in high quantities on mountain soils although on some sandier soils high potassium fertilization has caused magnesium deficiency symptoms to appear.

In the soilless media commonly used for container production, calcium and magnesium are provided by mixing ground dolomitic limestone with the potting media. Eventually this can lead to magnesium deficiency even though the calcium to magnesium ratio in the dolomitic limestone we are using is about 2 to 1. The reason for this is two fold: 1) Magnesium carbonate is more soluble than calcium carbonate; and 2) Irrigation water in some parts of the U.S. contains significant amounts of calcium but little or no magnesium. Therefore, with the great amounts of water used to irrigate container grown plants, the magnesium in the limestone is dissolved and either used or washed away faster than calcium. This helps to explain magnesium deficiency in some container-grown junipers and photinia following a long hot summer.

Correcting Magnesium Deficiency Probably the best and most common way to prevent magnesium deficiency from ever occurring is to have the soil tested before planting, then lime with dolomitic limestone. Dolomitic limestone is also the best bet in containers where the crop permits incorporating relatively high rates or top dressing late in the season.

However, under certain circumstances dolomitic limestone cannot be used. In the North Carolina mountains, many of our crops will not grow well at the elevated soil pH that results when the tons of dolomitic limestone needed to supply calcium and magnesium to our soils are added. To supply needed calcium without raising soil pH too high, gypsum (calcium sulfate) is used. Generally one gypsum application pre-plant incorporated will provide the necessary calcium for a 3 or 4 year crop cycle. Longer duration crops like Fraser fir will need a top dressing of gypsum every few years.

However, using gypsum instead of dolomitic limestone presents problems because there is no magnesium in gypsum. Magnesium must be supplied unless large amounts are already present in soils or deficiencies will occur when the calcium in gypsum becomes available to plant roots. Calcium and magnesium must be applied to maintain the proper balance or one will be come deficient in the plant.

Yellowing of older needles on field grown eastern hemlocks and Fraser fir often occurred in Western North Carolina either the year gypsum was applied or the next season. Research showed that spraying new shoot growth when it was 3 in. long and again when it was 6 in. long with an Epsom salts (magnesium sulfate) solution containing 4 lb of Epsom salts in 100 gal of water would raise tissue magnesium levels to 0.10 to 0.15 percent. This is the level needed to maintain acceptable growth and color during commercial production of eastern hemlock and Fraser fir. However, this technique requires spraying every year which means 8 to 10 extra trips to the field for magnesium fertilization on a crop of 6 ft hemlock. To avoid these extra trips to the field an inexpensive, dependable, slow-release source of magnesium was needed. That lead us to olivine.

OLIVINE

Olivine is a natural mineral consisting of a solid solution rich in magnesium ortho silicate (forsterite) and iron ortho silicate (fayalite). Major deposits of high quality olivine exist in the North Carolina mountains, Norway, and the state of Washington. This high quality olivine contains about 90% forsterite and 10% fayalite.

Olivine is a greenish gray sand with a hardness similar to silica sand but somewhat heavier. Like other natural minerals with a slow rate of decomposition or reaction, olivine must be crushed to reduce particle size and increase surface area in order to be useful for plant growth.

The current primary commercial uses for olivine are in sand blasting (olivine will not cause silicosis as happens with silica sand) and by foundrymen in producing nonferrous castings as well as iron, manganese, and stainless steel.

Field Tests. Our first large long term test with olivine was initiated when we encountered an established (3-2-2) crop of eastern hemlock growing in a Porters silt loam soil. Plants were yellowing, more severe in older needles, which is characteristic of magnesium deficiency. Magnesium deficiency was confirmed by tissue analysis while magnesium status in the soil was determined by a soil test.

Soil test (exchangeable) magnesium was less than 5% of the cation exchange capacity, a low soil test level, and tissue magnesium levels were below the 0.10% level considered to be the lower critical limit.

In April, 1983, plants were treated with 400 flour olivine applied in a 6 to 8 in. wide band around the trees at the following rates: 0, ½ or 1 oz. Mg/tree. This is 0, 2.63 and 5.23 oz. of olivine, respectively, per tree. (We calculate that our olivine is 19% magnesium). Eighteen plants per treatment with 3 replicates were employed. Tissue samples were collected from the most recently matured twigs, dried at 105°F and submitted to the North Carolina State University Department of Soil Science Analytical Service Lab for determination of tissue magnesium levels at the end of the 1983, 1984, and 1985 growing seasons. A control magnesium treatment was applied following current recommendations with the epsom salts spray mentioned earlier.

The results shown in Table 1 indicate that magnesium concentration in trees receiving no magnesium was below the desirable 0.10 to 0.15% at the end of the 1983 season and continued to decline. By the end of 1985, these plants were uniformly yellow and dropping needles.

Table 1. Foliar magnesium level in *Tsuga canadensis.*

Treatment	% Mg in tissue[1]		
(oz Mg/tree as olivine)	1983	1984	1985
0	0.08	0.07	0.06
½	0.10	0.09	0.08
1	0.12	0.13	0.15
Control[2]	0.10	0.12	0.12

[1] 0.10 to 0.15% Mg is desirable.
[2] 4 lb $MgSO_4$/100 gal sprayed annually.

One-half ounce of magnesium from 400 flour olivine raised the magnesium percentage to the desired level in 1983 but was not able to sustain this level. One ounce, however, not only raised tissue magnesium percent to well within the desired range, but also continued to provide magnesium such that tissue levels of magnesium increased throughout this test with no repeat application of olivine. The magnesium sulfate spray, applied annually, also raised tissue magnesium to acceptable levels.

Our success with hemlocks prompted us to work with Fraser fir. By comparison with our hemlock site, the Frazer fir site soil test magnesium was not quite as low, 9% of CEC, but still lower than preferred, and the trees were a little older (3-2-3). This study was expanded to include 200 and 400 flour olivine, SulPoMag (0-0-21, 11% Mg) and the standard Epsom salts spray. Our first tissue samples were taken in 1985 even though first treatment was in spring, 1984. This is because Fraser fir is much slower growing than Eastern hemlock with all new shoot growth ceasing by mid-summer each year. First year results are shown in Table 2.

Table 2. Foliar magnesium level in *Abies fraseri.*[1]

Source of Mg	Oz/tree	% Mg in tissue 1985
Check	0	0.08
Olivine 200	½	0.10
OLivine 200	1	0.10
Olivine 400	½	0.11
Olivine 400	1	0.12
SulPoMag	½	0.11
SulPoMag	1	0.10
$MgSO_4$ Spray	—	0.10

[1]0.10 to 0.15% Mg is desirable.

The 1985 results indicate that Olivine 200, Olivine 400, and SulPoMag are at least as effective as our annual Epsom salts sprays. The next few years should let us know how long a single treatment of olivine or SulPoMag will remain effective. Since considerable difference exists in the cost to treat an acre with these materials (Table 3), efficacy over the life of the crop is very important. In fairness to SulPoMag, other essential nutrients, potassium, and sulfur, are provided when SulPoMag is applied. If these are needed by the crop, SulPoMag may be more economically attractive.

Table 3. Cost to treat magnesium deficiency.

Source	Mg rate/tree, oz	$/acre[1]
Olivine 200	½	19.92
Olivine 200	1	39.91
Olivine 400	½	25.44
Olivine 400	1	50.98
SulPoMag	½	48.30
SulPoMag	1	96.60

[1]Plant population = 1700 trees/acre

DISCUSSION

These results suggest that olivine has potential as a long term slow-release source of magnesium. A reduction in annual labor costs by eliminating the need for Epsom salts sprays plus the relatively low materials costs for olivine are seen as advantages.

Work is continuing in looking at rates and particle size for olivine use in the field. Questions exist concerning technology for applying finely powdered olivine efficiently as well as how it will interact with other fertilizer materials if blending, pelletizing, etc. occurs.

A major potential use for olivine would seem to be in container production, particularly in warmer climates where long growing seasons and high water use are common. We are currently analyzing data from the 1987 growing season with *Photinia* × *fraseri*, compact Andorra juniper, and 'Hino Crimson' azalea as test subjects. Thanks to support from the Horticultural Research Institute, research into olivine's potential for the nursery industry will continue.

CHIP BUDDING OF MAGNOLIAS

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Chip budding is well suited for the propagation of magnolias because it allows great flexibility in the scheduling of propagation. It is often practiced as a bench grafting technique in winter, and again in late summer and early fall. It is also used for outdoor grafting in spring, and in mid-to-late summer. In reality, chip budding is possible throughout the growing season. Highly specialized facilities are not required. If a greenhouse is used, grafts can be placed on an open bench. Grafting cases are not needed.

As a technique, chip budding is simple, easy to learn, and yields a high percentage of successful grafts. Close matching of stock and scion diameters is not necessary, permitting flexibility in rootstock utilization. Callusing of chip buds is rapid, and the graft unions are strong. Growth from the scion is vigorous, strongly upright, and of good form, frequently branching the first season. While these positive inducements apply generally to many species of broadleaved plants, they apply particularly well to magnolias.

PROCEDURE

I chip bud predominately onto established rootstocks in containers in the greenhouse, from late January to early March. Rootstocks are brought into the greenhouse (60°F minimum temperature) in early January, and set on an open bench. The stocks are ready for grafting when the buds swell.

The steps in chip budding are as described by Howard (1) and Macdonald (2). I prefer to collect scionwood the same day as I will use it, but pre-cut, dormant scions can be successfully stored by refrigeration in damp sphagnum moss in polyethylene bags for at