Magnesium deficiency is a serious problem in pecan (Carya illinoinensis, Koch) orchards of the southeastern U. S. (2, 16). In 1967, almost half of the leaf analysis samples in Georgia contained less than 0.3% Mg (16). Many of these exhibited the characteristic Mg deficiency symptoms described by Sharpe et al. (12). Treatments to correct Mg deficiency have given erratic results. Sharpe et al. (11) applied sea water magnesia (80-90% MgO derived from sea water) to soil under pecan trees at rates of 0-5.4 kg/tree and obtained no yield increase, but it increased foliage Mg 7 years after treatments began. They also (12) reported that MgSO₄ improved foliage color of ‘Moore’ in one year, but ‘Moneymaker’ responded less rapidly. Others have reported that either leaf Mg content, yield, or foliage appearance was improved with MgSO₄ for citrus (4, 5, 10) and apple trees (3). Other materials sometimes effective as Mg sources when used as soil applications were MgO (3, 10), sulfate of potash magnesia (10), kieserite, MgCO₃, and dolomitic MgO (3); however, Ford (6) obtained no increase in growth or leaf Mg content and no reduction of Mg deficiency symptoms with soil applications of MgSO₄ to apple rootstock beds. Similar results were obtained by Woodbridge (15) for apple leaves.

Foliar sprays are sometimes used to prevent or correct Mg deficiency symptoms. Epsom salt sprays were effective on apple (3, 6, 15), but Calvert (personal communication) reported poor results on citrus.

Since Mg deficiency is a serious problem in many pecan production areas, a test was initiated in 1968 to determine best methods for correcting low tissue levels of Mg.

Materials and Methods

An orchard of over 100 mature pecan trees spaced 18 x 18 m apart located in Pierce County, GA was selected for the test. The owner reported that the orchard produced high yields of high quality pecans prior to developing a condition later identified as severe Mg deficiency. Trees had been in a state of decline for several years prior to the initiation of the test. Dieback in the tops resembled Zn deficiency; however, leaf analyses revealed extremely low Mg and high Zn. Leaf samples in 1966 revealed that the Mg content was 0.05%, which is lower than the 0.08% level obtained by Alben (1) when he grew pecans in sand culture without Mg. Leaves showed characteristic Mg deficiency symptoms described by Sharpe et al. (12). Treatments (Table 1) were replicated 5 times on ‘Moneymaker’ at one end of the grove, and 5 times on ‘Stuart’ at the other end in a randomized complete block design with single tree plots. All treatments, except the spray treatments and the check, were broadcast evenly underneath the trees in early spring. Dolomite (10% Mg) was applied at 224 kg Mg/ha (1 ton/acre) in winter of 1968 and again in 1969. Magnesium sulfate was applied at the rate of 224 kg Mg/ha as a single application in 1968 only and at annual rates of 34 kg Mg/ha for 3 years. Magnesium from K₂SO₄-2MgSO₄ (sulfate of potash magnesia) and MgO was also applied annually at 34 kg/ha. This rate is often used for agronomic crops. Since K has been shown to reduce Mg uptake (13), an additional treatment of K₂SO₄ was included, which supplied the same rate of K as K₂SO₄-2MgSO₄, to determine detrimental effects of K on Mg uptake. Raplex Mg, a by-product of the paper industry containing 4.1% Mg, was used at the rate of 34 kg of product/ha. Magnesium sulfate and Mg(NO₃)₂ sprays at equivalent Mg levels were applied to the point of run-off when leaves were approx 1 m matured each spring. An additional treatment of Claw-El Mg (Brandt Chemical Co., 4% Mg) foliar spray was applied to 15 trees at 30 g product/ha in 1969 and to 7 trees at 6 g product/ha in 1970 as described for the other sprays but had no effect on the parameters studied and will not be discussed here. All treatments were discontinued after 1970. The grove received a uniform application of N (112 kg/ha) each winter. A subsoil furrow was cut approx 46 cm deep 9 m from each side of each tree to reduce root crossfeeding in 1968 and 1969. In 1970 a trench was cut 127 cm deep, which extended well through the root zone. Vigor ratings (0 = poor; 5 = excellent) were made in August 1968 and 1969, and terminal shoot growth ratings were made at a height of approx 7 m in 1968, 1969, and 1970. Magnesium deficiency ratings (0 = no symptoms; 5 = severe leaf symptoms) were made at the same time.

Soil samples from the top 15 cm were taken under each tree during the winter each year to determine residual effects of treatments. The pH was determined from a 1:1 (soil:water) solution. Soil P, K, and Mg were determined from a 0.05 N HCl-0.025 N H₂SO₄ extract of the soil. Phosphorus was determined colorimetrically by developing the blue molybdenumphosphoric acid color. Potassium was determined from the extract by flame photometry and Mg was determined in 1970 only by atomic absorption spectrophotometry. Nematode assays were made from the soil samples collected February 19, 1970 by the sugar flotation method described by Jenkins (8) to determine whether these parasites affected results.

Effect of Magnesium Sources and Rates on Correction of Acute Mg Deficiency of Pecan

Ray E. Worley, R. L. Carter, and A. W. Johnson

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Abstract. Magnesium sulfate applied as a soil amendment (34 kg Mg/ha annually for 3 years or a single application of 224 kg Mg/ha) increased leaf Mg 5 years after initial application. Dolomite increased soil pH and soil test Mg but not leaf Mg. Sulfate of potash magnesia and MgO increased soil test Mg and slightly, though insignificantly, increased leaf Mg. Single foliar sprays of MgSO₄ and Mg(NO₃)₂ did not affect leaf Mg.
Leaf samples were collected at a height of approx 7 m August 12, 1968, June 15 and August 10, 1970, and again on September 18, 1972 and analyzed according to the procedures described by Jones and Warner (9) and Warner and Jones (14). Samples collected in 1969 were destroyed in a laboratory accident. Yield of each tree was estimated visually in August.

Results and Discussion

Magnesium deficiency symptoms. Magnesium deficiency symptoms were more severe in 1968 and 1970 than in 1969 (Table 1). In 1968, Mg deficiency was less when MgO was used than when K2SO4 was used, but these differences were not significant in 1969 and 1970. Potassium application is reported to reduce Mg uptake (3). The high rate of MgSO4 was the only treatment that caused significantly lower Mg deficiency than the check by 1970. Magnesium deficiency symptoms appeared less severe in reps located in Fuquay loamy sand (Arenic Plinthic Paleudult: loamy, siliceous, thermic) than in adjacent areas of Silsilo loamy sand (Arenic Plinthic Paleudults: loamy, siliceous, thermic), which are less well drained.

Mg deficiency symptoms in leaves were not visible until late July or August as reported by Sharpe et al. (12). 'Moneymaker' had pronounced interveinal chlorosis of leaflets with the area along the midrib and adjacent area remaining dark green. 'Stuart' responded with less distinct symptoms, a general light chlorosis along the edge of the leaflet with more darkened midrib area.

Vigor ratings. In 1968 vigor (not shown in Tables) was greater for trees treated with 34 kg/ha Mg from MgSO4 (vigor rating = 5.1) than for those treated with K2SO4. Raplex Mg, or the foliar sprays (vigor rating = 3.4 or less). In 1969 the only significant difference was between trees treated with 34 kg Mg from MgO and the control (vigor rating = 6.3 and 4.5, respectively). The general appearance of the grove improved slightly during the study.

Yield estimates. Total yields were not determined, but yield estimates were made in 1969 and 1970. Yield was too small to estimate in 1968. Estimates averaged 3.8 kg/tree in 1969 and 25.7 kg/tree in 1970. Yield increases suggest that the orchard was recovering, but no differences in yield could be attributed to specific treatments.

Soil analysis. Soil pH was relatively low at the beginning of the study and changed very little except when MgO or dolomite was used (Table 2). For the dolomite treatment, a pH of 6.0 was desired. The application in the spring of 1968 raised the pH to 5.7, and a second application applied the following season increased the pH to 6.0.

Soil P remained in the medium range for all treatments based on Georgia soil test standards. Only the K2SO4 treatment in 1969 and the K2SO4-2MgSO4 treatment in 1970 increased the soil K level over that of the check (Table 2).

Soil Mg remained low for all treatments at the end of the study, but differences due to treatments were significant (P = 0.05) (Table 2). Soil Mg levels were higher in plots treated with MgO than in other plots. Magnesium sulfate and MgNO3 sprays, Raplex Mg, and K2SO4 did not increase soil Mg, but all other treatments increased soil Mg over non-treated controls. More Mg was found in the top 15 cm soil layer when MgSO4 (34 kg Mg/ha) was applied annually, than when 224 kg Mg/ha was applied at the beginning of the 3-year period. This difference indicates that small annual applications of a soluble Mg source such as MgSO4 might be preferred over a single large application. The relatively high levels of soil Mg when MgO was used compared with the highly soluble sources also indicate that sources with low solubility might be preferred on sandy soils that leach nutrients easily.

Leaf analysis. A primary purpose of the study was to obtain increases in leaf Mg; however, none of the treatments had increased leaf Mg over that of the check by 1970 (Table 3). Trends were beginning to develop by the third year. Leaves from trees treated with K2SO4-2MgSO4 contained more Mg than those treated with K2SO4 in 1968 and 1970. Magnesium sulfate and MgO tended to increase leaf Mg in August of 1970. The orchard was not available for research

Table 1. Effect of Mg sources, rates and methods of application on pecan leaf Mg deficiency rating.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Mg deficiency rating (0 = none; 5 = severe)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1968</td>
</tr>
<tr>
<td>Dolomite^a</td>
<td>224 kg Mg/ha</td>
<td>1.5ab</td>
</tr>
<tr>
<td>Sulfate of potash</td>
<td>34 kg Mg/ha</td>
<td>1.0ab</td>
</tr>
<tr>
<td>Magnesium oxide</td>
<td>34 kg Mg/ha</td>
<td>.7a</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td>34 kg Mg/ha</td>
<td>.9b</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>56 kg K/ha</td>
<td>1.8b</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td>12 g/liter</td>
<td>1.7ab</td>
</tr>
<tr>
<td>Magnesium nitrate</td>
<td>18 g/liter</td>
<td>1.5ab</td>
</tr>
<tr>
<td>Raplex Mg</td>
<td>1.38 kg Mg/ha</td>
<td>1.5ab</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td>1.3ab</td>
</tr>
</tbody>
</table>

* Applied 2240 kg dolomite/ha during winter of 1968 and 1969.
* Mean separation within years of Duncan's multiple range test, 5% level.

Table 2. Effect of Mg sources, rates and methods of application on pH and residual K and Mg in soil under pecan trees.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Soil analysis^a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pH K (kg/ha)</td>
</tr>
<tr>
<td>Dolomite^a</td>
<td>224 kg Mg/ha</td>
<td>5.7c</td>
</tr>
<tr>
<td>Sulfate of potash</td>
<td>34 kg Mg/ha</td>
<td>5.3ab</td>
</tr>
<tr>
<td>Magnesium oxide</td>
<td>34 kg Mg/ha</td>
<td>5.5bc</td>
</tr>
<tr>
<td>Magnesium sulfate</td>
<td>34 kg Mg/ha</td>
<td>5.4ab</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>56 kg K/ha</td>
<td>5.3ab</td>
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<td>5.3a</td>
</tr>
<tr>
<td>Check</td>
<td></td>
<td>5.4ab</td>
</tr>
</tbody>
</table>

* Applied 2240 kg dolomite/ha in winter of 1968 and 1969.
* Sprayed to point of run-off when leaflets were ½ grown.
* Mean separation within years of Duncan's multiple range test, 5% level.
after the 1970 season; therefore, treatments were terminated. The orchard was observed during the next 2 years and appeared to improve substantially. As a consequence, leaf samples were taken again in September 1972. These samples indicated that leaf Mg from trees in plots treated with MgSO₄ was higher than that for all other treatments, except MgO and K₂SO₄ - MgSO₄. Magnesium in all samples remained at low levels. Even though dolomite increased the soil Mg, it did not increase leaf Mg or Ca levels. Camp (5) suggested that dolomite was ineffective in increasing leaf Mg due to competition with Ca. Calcium from dolomite becomes relatively more available than Mg at higher soil pH. Gammon et al. (7) also alluded to a similar competition between Ca and Mg in Florida pecan orchards. The positive correlation between leaf Ca and Mg in 1970 supports such a view, but the positive correlation between leaf Ca and Mg deficiency rating in 1968 (Table 4) did not indicate competition between these 2 elements at that time. The increased soil Mg from dolomite was apparently not available to the tree. The soil test was from the top 15 cm, however, and recent work has indicated that pecan trees obtain nutrients at deeper levels (17).

June leaf samples were higher in Mg than those collected in August, which probably accounts for the late appearance of Mg deficiency symptoms described by Sharpe et al. (12). The Mg content of leaves differed among treatments in the August but not in the June samples, which suggests that samples collected in August would be more representative of the tree’s nutritional status.

No consistent differences among treatments were found for leaf N, P, K, Ca, Mn, Zn, Fe, B, Cu, Al, and Mo. Ranges for these nutrients among treatments for 3 years were 2.50-2.89% N, 0.12-0.18% P, 0.92-1.46% K, 0.77-1.44% Ca, 185-470 ppm Mn, 77-187 ppm Zn, 49-125 ppm Fe, 15-37 ppm B, 9-16 ppm Cu, 364-1416 ppm Al, and 3.0-5.5 ppm Mo. Correlation coefficients. A matrix of correlation coefficients revealed significant negative correlation for vigor rating with Mg deficiency rating, vigor rating with leaf K, Mg deficiency rating with leaf Mg, Mg deficiency rating with soil pH, and leaf Mg with leaf K; and positive correlation for soil pH with vigor rating, leaf Mg with vigor rating, and leaf K with Mg deficiency rating. These correlations support the thesis that the orchard was suffering from Mg deficiency (Table 4). These relationships may be either direct or indirect associations.

Nematode counts. An assay for plant parasitic nematodes was made to determine if they were a factor augmenting the low Mg levels and general state of decline of the orchard. There were no significant differences among treatments except the number of ring and lesion nematodes were slightly higher in plots treated with Raplex Mg than in other plots. Though the number of nematodes in the soil was sometimes significantly correlated with vigor, yield estimate, and deficiency symptoms, they were associated with only 21% or less of the variation of these factors (r² = .21). Based on yield estimate, the number of nematodes in the soil apparently was below the economic threshold level.

Visual observations on the orchard since termination of the test indicate a continued general improvement. The grower applied MgSO₄ to the entire orchard annually since the termination of the test. Yield in 1971 and 1973 has increased and new growth has replaced some branches that have died. As of July 1974, however, some Mg deficiency symptoms were still visible in the most severely affected areas.

Though soil application of MgSO₄ was effective in increasing leaf Mg, changes occurred slowly. Early detection of pending Mg deficiency symptoms, they were associated with only .21% or less of the variation of these factors (r² = .21). Based on yield estimate, the number of nematodes in the soil apparently was below the economic threshold level.

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deficiency and application of MgSO₄, MgO or K₂Sₐ-2MgSO₄ appear to be a satisfactory solution to maintaining adequate Mg levels in pecan tissue. Delays in detection and correction may cause severe yield loss and tree damage requiring years to correct. Foliar sprays containing Mg as they were used in this study were not effective. Additional studies using several foliar spray concoctions and dates appear warranted. The studies also indicate that the use of dolomite as a Mg source was not satisfactory.

**Literature Cited**


**Effect of Time of Pruning or Nonpruning On Fruit Set and Yield of Peach Trees Growing on New or Old Peach Sites**

Jeff W. Daniell

Georgia Agricultural Experiment Station, Experiment

**Abstract.** Pruning dates as treatments were imposed on 4- to 6-year-old peach trees [Prunus persica (L) Batsch], growing on new and old peach sites. May and July pruning reduced the number of blooms in 1971 but had no effect in 1972. Fruit set and yield resulting from spring pruning or non-pruning averaged higher by an order of 2 percent. Time of pruning had no effect on fruit set in 1972, a year with no cold injury to blossoms. Therefore, the yields per hectare in 1972 reflected mostly the tree mortality where trees were growing on old peach sites. Significant increases in yield were obtained from February, March, and May pruning over November and January pruning. In addition, June pruning increased yields when compared to November, December, and January pruning. These data also provide further evidence that cold injury is involved at some point in the peach-tree decline process. The relationship of these findings to peach-tree decline is discussed.

Effects of pruning on yield of peach trees (6, 10, 16, 23) has been studied extensively and there appears to be good agreement in the literature as to the effects of severity of pruning. Severe pruning has been shown to decrease yields and tree growth (3, 14, 17, 19, 20, 21), delay maturity of fruits (5, 13, 22) and increase cold injury (4). However, most research appears to have been based on the assumption that the best time for pruning is during the winter; both from the standpoint of less injury to trees and for better utilization of farm labor. At the present time in Georgia, however, pruning is done mostly by off-farm labor during the winter.

There are conflicting reports on the effects of summer pruning. Summer pruning has been shown to decrease yields (1, 12, 18) and also to increase yields (2, 11, 15). This paper reports the effects of time of pruning or non-pruning on number of blooms, fruit set, yield of peach trees, and tree decline.

**Materials and Methods**

Tests were initiated in 1967 on 2-yr-old trees at Plains, and on 1-yr-old trees at Ft. Valley, Georgia and in 1968 on 1-yr-old trees at Ft. Valley. Both tests at Ft. Valley using 'Loring' trees on 'Elberta' rootstock were conducted on old peach sites with a history of severe decline. The test at Plains using 'Suwanee' trees on 'Elberta' rootstock was conducted on a new peach site with no known history of a peach planting. Time of pruning in tests at Ft. Valley consisted of 12 treatments; an individual pruning for each month of the year, with an unpruned control in the 1968 test. Ten treatments were used at Plains with the December and June pruning omitted.

Data presented in an earlier paper (7) showed that the time of pruning had an effect on tree mortality. In addition, early observations indicated that time of pruning also had an effect on number of blooms, fruit set, and yield of peaches. Consequently, bloom counts and fruit set was determined in 1971 and 1972. Fruit size and yield data were also taken in 1971 and 1972 but in the 1968 planting at Ft. Valley only. Cold injury to blossoms occurred in 1971 from a recorded low in the orchard of ~2.7°C on March 4th and ~3.3°C on March 5, but no cold injury to blossoms occurred in 1972. In this study, months were grouped into seasons as follows: December, January and February, designated as winter season March, April and May, designated as spring season June, July and August, designated as summer season September, October and November, designated as fall season.