Liming for Filbert Production in Western Oregon

Circular of Information 650
August 1975

Agricultural Experiment Station
Oregon State University, Corvallis
ABSTRACT

The application of lime to acid soils in the Willamette Valley increased the yield and quality of filberts and growth of filbert trees. Liming increased the uptake of nitrogen and depressed manganese absorption. Pronounced effects of lime on the pH and calcium content of the soil were observed 4 years after liming even in the surface 4 inches of soil. Calcium moved downwards to depths exceeding 8 inches with the translocation of calcium increasing with time. Liming resulted in an increase in the downward movement of potassium in the soil. The application of dolomite lime gave increased magnesium levels at all soil depths over the 4 year period. Soil test trends indicated that the residual effects of lime would persist considerably longer than 4 years.

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ACKNOWLEDGMENTS:

M. L. Gedrose, Oregon Portland Cement Company, provided materials and assisted with the field trials.

Robert L. Stebbins and Michael H. Chaplin, Oregon State University, Department of Horticulture, performed the leaf analyses and advised in the conduct of this study.

The Oregon Filbert Commission and the Soil Improvement Committee of the Northwest Plant Food Association provided funds for soil and plant analysis.
Prior to 1970, low yields and poor tree growth were observed in several north Willamette Valley filbert orchards. In diagnosing these problems it was noted that poor production was often associated with high foliar levels of manganese (Mn) and low soil test values for bases such as calcium (Ca) and magnesium (Mg). Low foliar concentrations of potassium (K) were also common. K levels in the surface soil (0-6") were frequently fairly high but were much lower at greater depths in the soil. The application of K fertilizer did not significantly increase tree growth or the K content of the leaves.

Lime trials to evaluate the effect of calcitic and dolomitic lime on filbert production were commenced in two Washington County filbert orchards in 1969. It was felt that these treatments would increase the base saturation of the soil, enhance the downward movement of K into the rooting zone, and reduce the solubility and uptake of Mn by the trees and thus improve the growth and root production.

Location of Trials

The filbert orchard acreage in Washington County is about equally divided between "hill" and "valley floor" soils and one site on a typical soil of each was selected for conducting the liming study.

The Frank Horton orchard located on a Laurelwood soil west of Laurel was selected as the "hill" orchard site. The trees in this
The orchard were 6 years old. The Wendland orchard, located on an Aloha soil east of Laurel was selected as the "valley floor" site. The trees in the Wendland orchard were 12 years old. The soil test values for these two locations are given in Table 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>pH</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>Ca (meq/100g)</th>
<th>Mg (meq/100g)</th>
<th>CEC</th>
<th>% Base Sat. 'n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horton</td>
<td>5.6</td>
<td>51</td>
<td>265</td>
<td>2.8</td>
<td>.40</td>
<td>14.7</td>
<td>24</td>
</tr>
<tr>
<td>Wendland</td>
<td>5.8</td>
<td>103</td>
<td>242</td>
<td>6.4</td>
<td>.90</td>
<td>14.1</td>
<td>56</td>
</tr>
</tbody>
</table>

*1/ Soil samples taken from 0-8" soil depth.

Initially both orchards had moderately low pH, high P, and moderately high K values. The Horton orchard had low and the Wendland orchard moderately low Ca, Mg, and % Base Saturation values.

Plot Layout

Eight groups of trees were selected in each orchard and each of the 4 lime treatments was applied to 1 tree in each group. The trees in each group were selected on the basis of similar size, vigor, and uniformity. Treated trees were separated by at least one "buffer" tree which received no lime treatment.

Lime treatments

The lime treatments were designed to meet the following criteria:

A. Provide 100% base saturation in the surface foot of soil using calcitic limestone.

B. Provide 100% base saturation in the surface foot of soil using calcitic limestone and dolomite lime.
C. Liming at one half the rate of A and B using Calcitic limestone and dolomitic lime.

D. Check - no lime.

The lime treatments applied are given in Table 2.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Horton Calcitic Lime</th>
<th>Horton Dolomitic Lime</th>
<th>Wendland Calcitic Lime</th>
<th>Wendland Dolomitic Lime</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>D (check)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Materials were applied so that the treated tree stood in the center of a 20' x 20' treated area. Tree spacing in both orchards was 20' x 20'. All materials were applied March, 1969. The lime and dolomite were mixed with the surface four inches of soil using a tandem disc in the Horton orchard. At the Wendland orchard the lime was applied on a flail-management orchard floor and left for the rain and earthworms to carry into the soil.

Results

Filbert Nut Yields

The average nut yields recorded by the different lime treatments over a 5 year period are reported in Table 3 and Figure 1. These results indicate that the lime treatments increased the yield of filberts on both orchards with the yield increase being more apparent after 1970 which was two years following the application of the lime. Both rates of liming gave increased yields but there was no significant difference between the low and high rate of lime application. The high rates of
<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>WENDLAND</th>
<th>HORTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 4L</td>
<td>11.1</td>
<td>2.7</td>
</tr>
<tr>
<td>B. 3L + 1D</td>
<td>10.5</td>
<td>2.2</td>
</tr>
<tr>
<td>C. 1L + 1D</td>
<td>11.1</td>
<td>2.1</td>
</tr>
<tr>
<td>D. Check</td>
<td>11.7</td>
<td>2.1</td>
</tr>
<tr>
<td>TOTAL AVE. YIELD OF NUTS (LBS/TREE)</td>
<td>88.8 9590</td>
<td>48.8 5270</td>
</tr>
<tr>
<td>TOTAL YIELD (lbs/A)</td>
<td>9590</td>
<td>5270</td>
</tr>
</tbody>
</table>

1/ 4L = 4 Tons Ground Limestone/Acre
1D = 1 Ton Dolomite Lime/Acre
2/ Based on 108 trees per acre
Figure 1: Effect of Lime Applications on the Yield of Filberts

Figure 2: Effect of Lime Applications on the Size of Filberts
lime application (treatments A and B) used in these trials represent higher liming rates than would normally be suggested on the basis of the lime requirement (SMP) test currently used by the Oregon State University Soil Testing Laboratory for these two soils. The lower lime rates used in these trials are close to the rates which would be suggested for these orchards.

The application of dolomite lime which contains magnesium (Mg) did not increase filbert yields over the application of an equivalent amount of calcitic lime which does not contain Mg. Although the Mg soil test values in the non-limed surface soil were low for both locations, the Mg levels in the sub-soil, particularly below 8", were considerably higher (Figure 10). This distribution of Mg in Willamette Valley soils is common and is probably related to the non-response of deeper rooted crops to Mg applications on soils with low surface soil test values for Mg.

The results in Table 3 show that on the basis of 5 crops that the lower rate of liming (Treatment C) increased filbert yields by a total of 1221 and 939 lbs/A in the Wendland and Horton orchards respectively. Based on 1973 soil test values, which indicated that the lime treatments were still reflected in higher levels of bases, it is probable that the limed trees would continue to be more productive for several more years without further additions of lime.

Nut Size

In 1973 harvested nuts were checked for size using Oregon-Federal grade standards. Nut size data were based on composite samples of 800 nuts per treatment. The results, which are illustrated in Figure 2, show that the lime treatments increased the percentages of jumbo and
large nuts with a corresponding decrease in the percentages of medium and small nuts. The beneficial effect of lime on nut size was more apparent in the Horton trial than the Wendland trial.

Tree Growth

It has been reported by Painter and Hartman\(^1\) that to maximize nut production, the annual terminal growth of filbert trees should be 6 inches or more. Terminal twig growth for the different lime treatments was measured in the Horton orchard in December 1972 (Table 4). Terminal growth on each tree in the trial was measured on one branch on the south side of each tree. About 150 measurements were made for each treatment. The results indicate a substantial increase in terminal twig growth for limed trees compared to non-limed trees with 8 tons of lime/A (Treatments A and B) giving more growth than 4 tons of lime/A (Treatment C). The application of Mg did not result in an increase of terminal twig growth. As N fertilizer was not applied to the trial trees in the Horton orchard in 1972, these results indicate that on the high lime treatment the mineralization of N in the soil was sufficient to provide for reasonable growth. It is not known if liming could result in adequate growth in the absence of N fertilizer over a period of years.

Table 4: Average Terminal Twig Growth, Horton Orchard

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Terminal Growth-inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 8L</td>
<td>6.15</td>
</tr>
<tr>
<td>B. 7L1D</td>
<td>5.42</td>
</tr>
<tr>
<td>C. 3L1D</td>
<td>4.74</td>
</tr>
<tr>
<td>D. check</td>
<td>3.55</td>
</tr>
</tbody>
</table>

8L, 7L, 3L = 8, 7, and 3 tons L/A respectively
1D = 1 ton dolomite lime/A.

Leaf measurements also indicated that leaf growth was increased through the application of lime in both the Horton and Wendland trials. The data in Figure 3 show that the weight of leaf samples was substantially increased at both locations by liming. The application of Mg did not increase the weight of leaves.

Nutrient Content of Leaves

Leaf samples were removed from each tree in the trial each year between August 10 and 15. Each sample consisted of 50 mid-terminal leaves and petioles removed at eye height from all sides of the trees. The leaves were analyzed for nutrient content in the Department of Horticulture Laboratory at Oregon State University. N was measured using a kjeldahl distillation procedure and arc emission spectometry was used to measure other nutrients.

Nitrogen levels in the leaves were increased by the lime applications in 1972 and 1973 in the Horton and Wendland orchards (Figure 4). Consistent changes in leaf N content due to liming were not recorded in 1969 or 1971. N levels in the leaves were not increased by the application of Mg. Considering the greater amount of leaf growth on limed trees (Figure 3) the total uptake of N by limed trees would be substantially greater than by non-limed trees.
Figure 3: Effect of Lime Applications on the Weight of Filbert Leaves

Figure 4: Effect of Lime Applications on the N Content of Filbert Leaves
Concentrations of manganese (Mn) in leaves were reduced slightly by liming at both the Horton and Wendland locations (Figure 5) in 1973. Mn levels in the leaves were much higher in the Horton orchard than the Wendland orchard. High concentrations of Mn in plant leaves are used in the diagnosis of soil acidity conditions with many crops in western Oregon. Mn concentrations in the leaves varied from 464 to 540 ppm at Hortons and from 140 to 204 ppm at Wendlands.

The potassium (K) concentrations in the leaves varied from 0.80 to 1.00% but did not appear to be significantly correlated with the lime treatments. Total K uptake, however, would be greater for the limed treatments because of the greater tree growth recorded for these treatments by comparison with the non-limed treatments.

The calcium (Ca) concentrations in the leaves varied from 1.35 to 1.55% in 1973. In the Horton orchard the higher liming rates resulted in a small increase in the Ca content of the leaves but this trend was not apparent in the Wendland orchard.

The application of dolomite lime resulted in increased concentrations of magnesium (Mg) in the leaves (Figure 6). In the Wendland orchard the application of ground limestone resulted in increased concentrations of Mg in the leaves by comparison with trees receiving no lime. Mg concentrations in the leaves varied from 0.15 to 0.27%.

**Nutrient Properties of Soils**

The trials were located on soils which were initially moderately acid. (Table 1 and Figure 7). In common with many soils in the Willamette Valley, soil acidity decreased with depth. The Horton surface soil (0-4") had a low and the Wendland soil a moderately low level of base saturation. The surface soils in both orchards contained
Figure 5: Effect of Lime Applications on the Mn Content of Leaves

Figure 6: The Effect of Lime and Dolomite Applications on the Mg Content of Leaves
moderate amounts of potassium (K) (Table 1 and Figure 9) but K levels were substantially lower in the sub-soil.

The lime treatments resulted in increases of pH levels particularly in the surface soils (Figure 7). Soil pH increases persisted for at least 4 years following the application of lime. The application of lime to the surface soil resulted in appreciable increases of pH in the 4-8" soil depth and small increases in pH indicated some lime effect in the 8-20" layer of soil. Further evidence of liming effects at different soil depths is provided by observing calcium (Ca) levels (Figure 8). Ca levels paralleled pH values and were substantially increased throughout the duration of the trials in the surface soils but only slightly increased in the subsoil, particularly the 8-20" depth.

The soil test information indicates that the application of lime did have some effect on the downward movement of potassium (K) in the soil (Figure 9). This effect was particularly apparent in the 4-8" soil depth where in 1973 the K soil test for the limed treatment was almost 350 ppm and for the non-limed treatment was 250 ppm. Liming resulted in some increase of K levels in the 8-20" soil depth. This effect was more apparent in the Horton orchard where the heavier lime application was made.

These results indicate that the application of lime could result in greater K uptake by filberts by displacement of K downward into the rooting zone.

The application of dolomitic limestone increased soil magnesium (Mg) levels throughout the 4 years of the trials (Figure 10). These increases were particularly apparent at the 0-4" soil depth but small increases in Mg levels were also observed at the 4-8" and 8-20" depths. Mg levels in the soils increased with soil depth at both locations. Higher levels of Mg in subsoils compared to surface soils are common in the Willamette Valley.
Figure 7: The Effect of Lime Applications on Soil pH
Figure 8: The Effect of Lime Applications on Soil Calcium Levels
Figure 9: The Effect of Lime on Soil Potassium Levels
Figure 10: Effect of Dolomite Applications on Soil Magnesium Levels
Summary

The yield of filberts, nut size, shoot growth, and leaf size were increased by the application of lime.

The downward movement of potassium from the surface soil into the subsoil was enhanced by the application of lime.

The application of lime resulted in increased pH and calcium levels in the surface and subsoil over a 4-year period. Soil test trends indicate that these residual effects of lime would extend well beyond 4 years.

The application of dolomitic lime resulted in elevated soil magnesium (Mg) levels with a strong indication that the higher soil Mg levels would extend beyond a 4-year period. Mg applications did not result in increased nut yields or tree growth.

Some of the effects of liming such as downward movement of potassium and increased calcium and pH levels in the subsoil were more apparent 2 to 4 years following the application of lime than immediately after liming.

Filbert production was enhanced about equally by the high and moderate rates of lime application. Indications were that residual effects from the high lime applications would be more prolonged compared to the lower application rates.

Liming increased the uptake of nitrogen (N) by filbert trees probably by enhancing the mineralization of N in the soil. Liming also enhanced the total uptake of potassium.

Less leaf drop prior to harvest was experienced with the limed trees thus facilitating the harvesting operation.
Conclusions

Liming can be beneficial in filbert orchards. In this study a nearly adequate nitrogen (N) level in the leaves was maintained without applying N fertilizer, indicating that N applications could be reduced materially where liming is done. Also, at the current price paid for filberts, the increase in yields would pay for a normal liming by the third year following application or sooner.

Inasmuch as low liming rates provide as much yield increase as high rates, it would seem desirable to start with a rate of no more than 2 to 3 T/A (which would take special spreading equipment) and then after four years come in with annual maintenance rates using sufficient lime to counteract the acidity resulting from fertilization. This annual maintenance rate could be applied with ordinary fertilizer spreaders.

Soil tests should be taken as a basis for determining the need for liming. The suggested liming rates would be based on a lime requirement soil test as indicated in the following table:

<table>
<thead>
<tr>
<th>If the OSU buffer test for lime reads:</th>
<th>Apply this amount of 100-score lime initially (T/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 6.1</td>
<td>2 - 3</td>
</tr>
<tr>
<td>6.1 - 6.4</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Over 6.4</td>
<td>0</td>
</tr>
</tbody>
</table>