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Filberts have been cultivated from early days. Pliny, 60 A.D., narrates: “Filberts and hazels... are a kind of nut and were called heretofore Abel-linae, of their native place... they come out of Pontus into Natolia and Greece and therefore they may be called pontick nuts.”

The name filbert is supposed by some to have originated from “Full Beard,” referring to the fact that in some varieties the husk entirely covers the nut. Others think the name has been derived from St. Philibert because August 22, the date dedicated to him, corresponds to the ripening date of the earliest filberts in England.

While there is one species of filbert (Corylus cornuta) native to Oregon, our cultivated varieties of filberts (Corylus avellana) were introduced to this country from Europe by Felix Gillet, a nurseryman in Nevada City, California. Between the years 1885 and 1905 he introduced Barcelona, Du-chilly, Daviana, Halls Giant, Montebello, Nottingham, and others. Most of these are important in the northwest to this day.

The natural growth of the filbert (hazelnut) is a bush or multi-trunked shrubby tree. In Turkey and southern Europe, it has been grown in this manner for centuries. However, more recently the tree has been cultivated in some areas and grown with one to five trunks. In Oregon, filberts usually are grown as a single trunk tree and may attain a height of 30 feet with proper management and soil conditions. While the tree itself is quite hardy, it produces satisfactory crops only under moderate climatic conditions. Because the catkins freeze at 15° F even when fully dormant, the female flowers freeze at 10° F when in bloom during January and February, and the tree cannot tolerate excessive dry summer heat, the commercial usefulness of the filbert tree is limited to the Willamette Valley in Oregon and to corresponding areas in Washington.

The tree may produce a few nuts when two or three years old, but it is not considered to be in commercial production until it is six years old. The average yield for all trees in Oregon over 12 years old is 12 pounds per tree. However, some trees produce 35 to 40 pounds of dried nuts annually. The potential may be even higher. A well cared for orchard should remain productive up to 40 years.

**Economic Importance**

**Crop value**

The exact contribution filberts make to Oregon’s economy is difficult to measure. Starting at the farm level and moving through the marketing channels, cash farm receipts total around $4 million annually. This figure varies from year to year, depending on size
of crop and growers' price. During the 1960-1967 period the crop varied from 6,600 to 11,700 tons, and cash farm receipts from $3.1 to $4.2 million. The value added by processing is estimated at $150 per ton. Therefore, the filbert industry contributes between $4 and $6 million annually to Oregon's economy.

**Geographic distribution**

The 1964 Census of Agriculture reported 3,324 filbert farms in Oregon growing 1,376,972 trees. However, new plantings have been made, so the tree numbers may be higher now. Limited nursery stocks slowed plantings immediately following the 1962 Columbus Day windstorm, but supplies have been adequate since 1967.

Although filberts, or hazelnuts as they are called in some states, are produced in about 26 states, the Willamette Valley of Oregon grows nearly 97% of the United States production and Washington between 2 and 3%. Thus, all commercial production of filberts in the United States presently comes from the Pacific Northwest. The northwest's production is 5 to 6% of world filbert production and 2 to 3% of our domestic production of all tree nuts (including filberts, walnuts, almonds, and pecans). Filbert prices are therefore influenced by supply and prices of all tree nuts.

**Marketing aids**

The Filbert Control Board, created in 1949, administers a Federal Marketing Order. The board is composed of five growers, three processor handlers, and one non-industry member. The marketing order provides for orderly marketing according to market demands and diverts surpluses into export or kernel markets for the purpose of stabilizing grower returns.

The Oregon Filbert Commission was established in 1951 for sales promotion and production research in filberts. Commission members are growers. Commission activities are financed by grower assessments.

**Production costs**

Production costs usually are classified into four major categories: (1) Cultural operations; (2) drying and handling; (3) harvesting; and (4) fixed charges. Representative costs based on 30 acres of mature filbert trees in a 100-acre orchard operation were computed to total $211.10 per acre in 1964 by OSU farm management specialists, county Extension agents, and selected growers. Around 32% of these costs were allocated to cultural operations, 30% were fixed charges, 24% harvest operations, and 7% to drying and handling.

Total cash costs amounted to $113.50 per acre and the total non-cash costs were $97.60. Amortization of established costs amounted to $44.60, bringing the cost per acre to $255.70. Assuming a 1,200 pound yield per acre, the cost per pound would be 21.3 cents; with an average yield of 1,440 pounds per acre, the cost per pound would be around 18.5 cents. On the other hand, if average yields dropped to 960 pounds per acre, the average cost would increase to 25.5 cents per pound. Thus it is important to follow recommended practices for increasing yields and to include all costs in determining the profitability of growing filberts.

The average price per pound received by growers from 1963 through 1967 ranged from 22 to 25 cents per pound.
The chief factor to consider in locating a filbert orchard in western Oregon seems to be soil; however, air drainage should not be overlooked. While low temperatures during the blossoming season have not been known to limit yields, late April frosts in low-lying areas frequently reduce cluster buds and succulent green shoots. No one direction of slope is better than any other, except as it relates to soil depth and moisture retention. Filberts do not tolerate wet soils during their active growing season, but since they are shallower rooted than most fruit trees, they will grow well in situations that may be borderline for such crops as cherries or walnuts. Not enough plantings have been made on sites above 1,500 feet elevation to evaluate their worth as commercial sites. Orchards should be planted on sites which can be committed to that use over a long period of time. Sites likely to be claimed for subdivisions, freeways, or industrial property within the next decade should be avoided.

Suitable soils

Much additional land in western Oregon is suitable for filbert culture, so a filbert orchard should not be located where the soil is poorly drained, shallow, too heavy, or too light. A filbert orchard which is relatively unproductive because of unsuitable soil can be a liability. Trees may grow well on shallow soil for the first 8 to 10 years and then become poor producers because they cannot develop deep root systems.

Soils suitable for filberts will allow the trees to develop active root systems to depths of 6 to 10 feet; however, most of a filbert tree's roots are found in the first two feet of soil. Root penetration can be stopped by rock, impervious hardpan, a high water table, or a lack of aeration in the soil.

Filbert trees withdraw moisture from the upper soil layers more rapidly than from lower depths. The top two feet of soil may be dry by the end of June, the third and fourth feet by the first of August.

Irrigation might overcome the low moisture problem presented by a soil which is too sandy or shallow, but there is considerable extra expense. Shallow soils are frequently poorly drained, so irrigation would not necessarily improve their suitability for filberts. Irrigation is likewise no remedy for soils which are too heavy. The greatest benefit of irrigation occurs in establishing the young orchard to obtain a large tree more rapidly.

Tile drainage of wet land has been attempted in a number of cases, with varying degrees of success. In land needing drainage, the subsoil layer that supports the water is usually so close to the surface that only a very limited depth of suitable soil lies above it. When subsoil is so compact and dense that water will not pass through, tree roots cannot penetrate it to provide normal growth. Tiling such soils could increase the area available for root activity earlier in the year, but would not provide optimum growing conditions. Where a small area of wet land intrudes into larger well-drained tracts to be planted to filberts, drainage is justified because it will allow cultivation throughout the area.

Determining soil suitability

The soil types of western Oregon have been classified and mapped. Soil maps located in county Extension and Soil Conservation Service offices give the soil series, texture, and sometimes
## Filberts—Nut Characteristics

<table>
<thead>
<tr>
<th>Variety</th>
<th>Average percent kernel</th>
<th>Shape</th>
<th>Size</th>
<th>Barcelona pollenizer</th>
<th>Productivity</th>
<th>Smoothness of kernel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>43</td>
<td>Round</td>
<td>Medium-large</td>
<td>None</td>
<td>Moderate</td>
<td>Smooth</td>
</tr>
<tr>
<td>Daviana</td>
<td>52</td>
<td>Oval</td>
<td>Medium</td>
<td>Excellent</td>
<td>Very light</td>
<td>Smooth</td>
</tr>
<tr>
<td>DuChilly¹</td>
<td>44</td>
<td>Long²</td>
<td>Large</td>
<td>Good</td>
<td>Heavy (alternately)³</td>
<td>Shriveled on outside</td>
</tr>
<tr>
<td>White Aveline</td>
<td>30</td>
<td>Flat oval</td>
<td>Small</td>
<td>Excellent</td>
<td>Moderate</td>
<td>Smooth</td>
</tr>
<tr>
<td>Montebello</td>
<td>42</td>
<td>Round</td>
<td>Medium</td>
<td>None</td>
<td>Moderate</td>
<td>Smooth</td>
</tr>
<tr>
<td>Brixnut</td>
<td>42</td>
<td>Round</td>
<td>Large-medium</td>
<td>None</td>
<td>Heavy (alternately)³</td>
<td>Some shriveling</td>
</tr>
<tr>
<td>Hall's Giant</td>
<td>46</td>
<td>Round</td>
<td>Medium</td>
<td>Good</td>
<td>Moderate</td>
<td>Some roughness</td>
</tr>
<tr>
<td>Royal</td>
<td>Low</td>
<td>Oval</td>
<td>Large</td>
<td>Poor</td>
<td>Moderate</td>
<td>Some roughness</td>
</tr>
<tr>
<td>Noosack</td>
<td>43</td>
<td>Long</td>
<td>Medium</td>
<td>Poor</td>
<td>Moderate</td>
<td>Rough</td>
</tr>
</tbody>
</table>

¹ Falls in husk, not freely.
² Characteristic crease on side of shell.
³ "Alternately" refers to crop production every other year.
the average depth for most potential orchard sites. Reference to the soil maps is the first step in determining the suitability of a site for filberts. However, even if the soil map gives information on the proposed site, further investigation of the site is essential.

To determine soil depth, dig holes and examine the soil. A post hole digger, soil auger, or shovel will suffice. Examine the soil to a depth of 4 to 6 feet in enough spots in the field to discover any variations in soil depth. Poor drainage is indicated by a greyish, yellowish, or reddish mottling of the soil. Dig holes in March or April and check to see if they fill with water overnight. Unless it has rained, water in the hole indicates the presence of a high water table. Trees can stand a fairly high water table in March and April if it becomes lower as the trees start to grow rapidly in May and the soil below four feet drains freely. All the small feeder roots affected by the water table will die. When drainage occurs, new roots will grow and use the remaining moisture.

Some soils may require special fertility adjustments prior to planting. Any adjustments should be based on OSU soil test interpretation by county Extension agents.

**Filbert Varieties**

Barcelona is the principal variety of filberts grown in Oregon. Its popularity is based on the in-shell market which favors its round shape and superior flavor.

The kernels of Barcelona have a coarse, brown outer coating, or pellicle, which is somewhat difficult to remove, and the larger sizes are inclined toward hollow centers. The Barcelona tree tends toward an alternate-year bearing habit; however, work currently under way shows promise of improving the tree’s yielding and bearing characteristics. While the Barcelona usually yields about two nuts per cluster, other varieties may set five or six. One serious weakness of the Barcelona is that it produces more blanks than many other varieties. A breeding program designed to develop varieties having heavy annual production, less blanks, and more desirable kernel characteristics is currently under way.

**Nut Development**

In order to clarify and provide better understanding of this section on nut development, a glossary of the most commonly used botanical terms follows:

- **Stigma.** The uppermost part of the female flower which receives the pollen (red in color).
- **Style.** Middle portion of female flower between the stigma and the ovary.
- **Ovary.** Lower part of the female flower which consists of a wall (eventually the nut shell) and two ovules.
- **Ovule.** Structure within the ovary which bears the egg.
- **Egg.** Female cell which, after fertilization, develops into the kernel.
- **Catkin.** Pollen-producing organ.
- **Pollen.** Pollen grains bearing sperm, formed in catkins.
Sperm. Male cell, borne in the pollen grain.

Pollen germination. The growth of a tube out of the pollen grain. This occurs when pollen is placed under suitable conditions such as on the stigmas of flowers.

Pollen tube. A tube bearing the sperm which, in the process of germination, grows down the style and into the ovary where it transfers the sperm to the egg.

Pollination. Placing of pollen on the stigmas of a female flower.

Fertilization. The union of sperm and egg to start the new generation (embryo or kernel).

Floral initiation and development

The life of a filbert nut begins with the initiation of flowers more than a year before harvest. Most of the flowers form in buds at the axils of the leaves on the current season’s growth. The male catkins begin to appear in June, although they do not reach maturity until the following December or January. The female clusters are first seen in late November or early December. The exact time of floral initiation is not known, but it certainly occurs well in advance of the external appearance of flower clusters. January is about the peak of the pollination season, varying some according to weather conditions. At this time the female cluster appears as a bright red tuft of feathery stigmas projecting out of the bud scales. Within the bud scales are the lower portions of 4 to 16 individual flowers. Each flower consists of a pair of long styles, most of whose surfaces are stigmatic in nature, i.e., receptive to pollen, and a tiny bit of tissue (0.25 mm or less) at the base.

The female filbert flower is very unusual in that, at the time of pollination, instead of having an ovary containing ovules with egg cells ready for fertilization, there is merely this rudimentary bit of tissue. Within four to seven days following pollination, the pollen tube grows to the base of the style, where the tip of the tube bearing the sperm becomes walled off and enters a long resting period.

Effective pollination stimulates the ovary to develop from this basal bit of tissue. It grows very slowly the first four months (until about mid-May) and then begins to grow rapidly, attaining 90% of its growth in the next five to six weeks. By mid-July the shell is full size, and shell hardening is well underway. During the middle of this rapid
growth period, i.e., mid-June when the ovaries are 8 to 10 millimeters in diameter, the ovary becomes a mature organ containing egg cells. The resting sperm becomes activated, makes its way toward the egg, and fertilization takes place. (This four- or five-month lapse between pollination and fertilization is one of the unusual features of filbert floral biology. In most plants, fertilization follows pollination by a few hours or a few days.) Following fertilization, the kernel develops rapidly, so it reaches full size in about six weeks (early August). From this time until harvest, maturation changes such as an increase in oil content occur. Towards October, the husk surrounding the nut spreads open and the nut falls to the ground.

Pollination

Pollinizer requirements

Filberts are self-incompatible, i.e., they will not set nuts with their own pollen. Also, certain combinations of varieties are cross-incompatible, i.e., pollen of some varieties is ineffective in setting nuts on certain other varieties. Controlled pollinations made on Barcelona have demonstrated that certain compatible varieties such as Daviana, Noosack, Halls Giant, Butler, and Gem set a normal nut crop, whereas other incompatible varieties such as Montebello, Kruse, Camponica, Ennis, and Barcelona set only a very few nuts or none at all. It is essential to choose a compatible pollinizer variety.

Earlier recommendations that three pollinizer varieties be placed in an orchard were based on the extended period of time during which female flowers continue to appear. It was thought necessary to have early, mid, and late pollinizers in order to pollinate all flowers. However, recent studies have shown that stigmas are receptive from the time they first appear as a tiny red dot at the tip of the bud until they extend to their maximum length and wither and fade. This could be from late November until early March in some seasons. Because each flower cluster is receptive to pollen for such an extended period, one pollinizer variety shedding heavily during the peak bloom, or even somewhat past the peak, will provide adequate pollination. Daviana, the principal pollinizer variety for Barcelona, sheds most of its pollen in January under ordinary weather conditions. Commonly used in orchards as a single pollinizer, it is successful in setting a normal crop.

Pollinizer spacing and placement

Once the pollinizer variety is chosen, the number and their distribution must be considered. Recent research on pollination plus the increasing use of mechanical harvesters has led to a revision of the recommendation that every third tree in every third row be a pollinizer. There is sufficient evidence now that fewer pollinizer trees are required.

Filbert trees produce a tremendous quantity of small and very light pollen grains which are well adapted to wind transfer. In still air, individual grains will fall one inch per second. Supposing a wind is blowing with a velocity of 7 yards per second (by no means unusual), pollen would travel a horizontal distance of 250 yards in 36 seconds. Isolated trees one-fourth mile from pollinizers have produced small crops, indicating that filbert pollen travels considerable distances.
In one study, female flower clusters were collected from an average producing orchard after visible pollen shedding ended. The individual flowers of each cluster were viewed in a microscope for the presence of pollen tubes. It was extremely rare to find a completely unpollinated flower cluster. On an individual flower basis, over 90% were pollinated; that is, they had visible pollen tubes, proving that pollination was widespread.

One further fact supports the contention that inadequate pollination is not usually a yield-limiting factor. Under controlled cross-pollination, where hundreds of pollen grains of our best pollinator varieties are placed on each female flower cluster, there is no better set than that found in commercial open-pollinated orchards.

While no extensive time trials have been made, the foregoing pollen behavior patterns indicate that one pollinator tree for every 14 main variety trees would provide adequate pollen. Placing the pollinizers in solid rows at 12- to 14-row intervals would accomplish two things: (1) Keep varieties segregated yet permit mechanical harvesting; and (2) make it possible to grow a larger percentage of the higher producing, higher value main crop variety.

There would be, of course, no problems concerning the number of pollinizers or their placement if a suitable pollinator variety could be found having nut shape and appearance similar to that of the main crop variety.

Research is currently directed toward this goal.

Blanks and Developmental Dropouts

Blank formation

Potential yields of all varieties are reduced by varying percentages of blank nuts. A blank nut consists of a shell without a sound kernel. Blanks occur when pollination stimulates the shell to develop, but the kernel fails to develop normally; either it fails to grow at all or it starts to grow and then aborts, especially in the early stages of growth. However, in some cases, kernels may grow to over half their expected size and then shrivel. These nuts also are culled out as blanks although they are not void of kernel. Lack of pollination is never the cause of blank nuts because a flower which is not pollinated simply does not develop beyond its tiny size at pollination. When pollen is withheld from female clusters by covering with bags, the clusters dry and fall off by late April or early May.

Factors which contribute to high percentages of blank nuts are not definitely established. Some evidence suggests that insufficient soil moisture in mid-summer results in a higher percentage of blanks. Other indications are that pollinizer variety or tree nutrition may influence blank production. Also, there appear to be varietal differences in blank production.

Flower cluster losses

Another yield-limiting factor, which is even more serious than blank nuts, is the precocious dropping of female clusters. In the Barcelona variety, this amounts to 35 to 50% of the clusters produced on the tree. The large majority of the flowers in these clusters have been pollinated and development has progressed for a few months at the normal very slow rate before being ar-
rested. Although the individual flowers are relatively much larger (1-2 mm diameter at their base) than at the time of pollination (0.25 mm in diameter), the clusters are still so small that their dropping is not conspicuous in the orchard. Part of the flowers in clusters which do hang on the tree, due to the normal development of at least one nut, are also subject to this arrested growth.

A close examination of nut clusters during summer will disclose a few tiny, undeveloped flowers embedded between the fleshy husks. All in all, the potential loss in the Barcelona variety due to these “developmental dropouts” amounts to about 75 to 85% of the total individual flowers produced by the tree.

Recent limited research indicates that developmental dropout can be reduced with a single spray of solubor, using 2 pounds per 100 gallons of water, applied about April 1. In 1969 trials, solubor increased nut cluster set by 20%.

Certain high-yielding varieties of filberts have the capacity to develop nuts from higher percentages of flowers than Barcelonas do.

### Growing and Selecting Planting Stock

**Method of propagation**

Most orchard trees are grafted to a root stock, but filberts are generally grown on their own root by simple layerage. With simple layerage, the suckers of a tree or most often a stool in a stool-bed are bent over in an S shape with one bend held in the ground to form roots and the tip end standing straight up above ground to form the tree. The sucker is put in place in the spring still attached to the stool, and at digging time in the fall it is cut loose from the mother or stool plant.

Trees grown from simple layers with the roots originating in a short space (2 to 4 inches), will produce fewer suckers after planting. The better layered trees do not have a crook at their base.

Some orchards have been budded or grafted to Turk rootstock. Turk is a different species, *Corylus Colurna*, which does not sucker. Some Turk-rooted trees have declined in vigor and productivity with increased age, indicating the possibility that a delayed incompatibility exists.

**Selecting planting stock**

Filbert nursery stock should be at least one-half inch in diameter at a point 6 inches above the soil line. Although filbert trees usually are sold by height, caliper or diameter provides a more reliable indication of the stored food reserve of a nursery tree. Dig nursery trees in early winter after the leaves have fallen and the plant tissue has hardened up. Be certain that the roots of dug trees do not dry out or freeze.
Intercropping with filbert trees

One way to get profitable returns from an orchard much sooner, while avoiding the usual drawbacks of intercropping, is to make a high density planting of filberts. For example, one could plant trees 10 X 18 feet and thin to a 20-foot triangle after 10 years or when the trees begin to crowd. Since per-tree yields in a closely spaced orchard are nearly the same as on a widely spaced orchard for the first five to six years, yield per acre goes up in proportion to the increased number of trees. Once the trees begin to crowd, prune back the temporary trees to allow the permanent trees to expand in a fairly normal pattern. An average yield for six-year-old filbert trees is about 5 1/2 pounds. The following chart shows yield per acre for different tree populations, assuming a 5 1/2 pound yield per tree at six years.

Sometimes a tree is planted in the center of each square, giving a "diamond" or "quincunx" planting arrangement. This gives twice as many trees per acre, but by the fifth or sixth year the trees may be too close together to cultivate in either direction. A square planting is difficult to thin to an efficient final arrangement. It can be thinned to a square with twice the original spacing or a very unequal triangle or rectangle. An equilateral triangle is also difficult to thin.

With the rectangular planting, the close spacing in the row soon limits cultivation to one direction. Special cultivating equipment or herbicides are required for weed control between trees.

### Effect of Tree Population on Per Acre Yield of Filberts (Sixth Year)

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Trees per acre</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td></td>
<td>Pounds</td>
</tr>
<tr>
<td>20 X 20</td>
<td>108</td>
<td>594</td>
</tr>
<tr>
<td>10 X 20</td>
<td>218</td>
<td>1,199</td>
</tr>
<tr>
<td>15 X 15</td>
<td>194</td>
<td>1,067</td>
</tr>
<tr>
<td>10 X 18</td>
<td>242</td>
<td>1,331</td>
</tr>
<tr>
<td>9 X 16</td>
<td>303</td>
<td>1,667</td>
</tr>
</tbody>
</table>

### Arrangement of permanent trees

Trees on deep, medium-textured bottom land will be larger when mature than trees on soils which are shallow, sandy, or clayey. These factors should be considered when planning final tree spacing.

Basically, there are three possible ways to arrange trees in an orchard: (1) square; (2) rectangle; and (3) triangle. The square is the least efficient in terms of numbers of trees per acre at a given spacing, and the equilateral triangle is the most efficient. The following table illustrates this point.

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Arrangement</th>
<th>Trees per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 x 20</td>
<td>Square</td>
<td>108</td>
</tr>
<tr>
<td>18 x 22</td>
<td>Rectangle</td>
<td>110</td>
</tr>
<tr>
<td>20 x 20</td>
<td>Equilateral triangle</td>
<td>125</td>
</tr>
</tbody>
</table>
Both the original arrangement and the system of thinning determine the final arrangement. It is impractical to grow temporary filbert trees in a square or triangular arrangement. This means that the rectangle is the most logical arrangement for orchards with filler trees. A rectangle can be thinned either to a square, another rectangle, or a triangle.

<table>
<thead>
<tr>
<th>P</th>
<th>P</th>
<th>P</th>
<th>+</th>
<th>P</th>
<th>P</th>
<th>P</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>+</td>
<td>---</td>
<td>P₂</td>
<td>+</td>
<td>+</td>
<td>9 x 16 to</td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>P₁</td>
<td>---</td>
<td>+</td>
<td>P</td>
<td>P</td>
<td>18 x 16</td>
</tr>
</tbody>
</table>

Rectangle to square

Rectangle 1 to triangle

Rectangle to another rectangle

P = permanent tree

+ = temporary tree

There is an advantage to thinning to a nearly equilateral triangle, especially when the original spacing is a rather close rectangle, such as 10 x 18. Thinning the 10 feet rows to 20 feet, as shown in the middle diagram, leaves the closest distance between trees at 20 feet. The greatest distance, P₁ to P₂, is the hypotenuse of a right triangle. It is calculated by the Pythagorean theorem which states that: The square of the side opposite the right angle is equal to the sum of the squares of the other two sides. Thus, in a 10 x 18 rectangle thinned to form a triangle, the greatest distance between trees would be:

\[ P₁ \rightarrow P₂ = \sqrt{(t-P₁)^2 + (t-P₂)^2} = \sqrt{100 + 324} = \sqrt{424} = 20.6 \text{ ft.} \]

Thus, the final spacing would be a triangle 20 x 20.6 feet.

**Establishing a New Orchard**

**Staking out the orchard**

The first essential in laying out an orchard is to establish base lines—two or more when the trees are to be planted on the square or rectangle system and one where the orchard is to be laid out on the triangular system.

For the square system, select one side of the field from which a line can be laid off parallel to the fence or road, using this side as the base line AB. (See diagram on page 16.)

With a tape or other means, lay out 60 feet on AB. Then on line AC, approximately at right angles to base line AB, lay off 80 feet, striking an arc using A as a pivot point. From point B, with a line 100 feet long, strike another arc cutting the previous one at point D. The point at which the arcs of AD and BD intersect will be the point through which the line AC may be located permanently and at right angles to base line AB.
It is generally an advantage to lay off another base line at the opposite side of the field from AD and at right angles with the base line AB.

For laying off by the square or rectangle systems, or by the hexagonal system, a set of wires should be provided of the same length as the distance apart that the trees will be set out. The set is composed of two wires with one end joined together in a small ring and the free ends fastened to separate rings.

After staking off the base line at the intervals desired for the trees, start staking the tract. By placing the wire over stake 1 and stake X, and drawing it taut, a stake can then be placed at point M. The wires should then be moved over so that the rings can be placed over stake M and stake 2; a stake should then be placed at the center ring at point N. This process can be carried on indefinitely, backward and forward across the field, until the field is completely staked out. Wires should be held in the same plane and drawn up to the same degree of tautness. Occasional checking by sighting or by re-measuring wires will be necessary to straighten out rows, especially if the field is uneven.

Other methods of staking out orchards can be used, such as the use of transit or by sighting from two sides of the field with a man to set the stakes at the points desired. On the whole, the use of wire is probably the quickest and most simple method for staking level land. A single long wire with soldered points indicating where stakes are to be set is often used alone.

The triangular or hexagonal system of planting requires only one base line. The base line should be measured off into the regular intervals at which trees are to be planted and stakes driven at each point. Place the rings over stakes 1 and 2 as shown, draw the wires tight, and set a stake at M. Then place the rings over stakes 2 and 3. The stake should then be placed at N, and so on throughout the field. In using this method, rows will become shorter each time so it will be necessary to fill out the side of the field. By placing one free ring over M in the second row and O in the third row, as illustrated, a stake can be placed at Y so the third row will be lengthened out to the normal length.
Using a planting board

A planting board may be of value to set trees in line after staking out the field. This board is 3 to 4 feet long with one notch at each end and another at one edge in the exact center. Before digging the tree hole, place the planting board so the stake, showing where the tree will be, fills in the center notch. After placing a stake at each end of the board, remove the center stake and the board. After the hole is dug, place the planting board over the two remaining stakes in the original position. With the tree trunk lined up in the center notch, the alignment of the original staking will be retained. The tips of the notches in the board should be in line with each other and the board must be used in one position only.

Planting the trees

Plant the trees in early winter as soon as possible after receiving them from the nursery. Do not let the tree roots dry out before planting. The earlier a tree is planted, the more chance it has to develop a working root system before it leafs out in the spring. The most active root growth period is in January and February, providing soil temperatures are 41°F or above.

Prune off the ends of any broken roots; also, remove any of the original layered wood remaining below the main area of rooting.

Dig the holes 18 to 24 inches wide and 10 to 12 inches deep. Digging in wet ground with a power auger may cause compaction of the sides of the holes. If this happens, break down the edges of the hole to eliminate the compacted area and partially fill the hole.

Plant the trees so that the top root is 2 to 3 inches below the soil surface. Spread the roots out and press down into the bottom of the hole. Tamp the soil firmly around the roots to exclude air pockets.

Pruning at time of planting

After the trees are planted, head back the tops, leaving a trunk 30 to 36 inches in height, to correspond with the reduction suffered by the root system in digging and handling. In transplanting, a considerable portion of the roots are lost and the water-absorbing capacity of the plant is materially reduced. If trees are not topped, their root systems may be unable to provide sufficient moisture to replace that lost by transpiration and trees will be retarded in growth or die. Trees cut back at planting as directed generally attain a larger size in less time than similar ones not cut back. If trees are branched, the laterals should be cut back to a few buds, or all laterals may be removed and the tree treated as a headed whip.

After pruning each tree, sterilize pruning tools with bichloride of mercury or rubbing alcohol to prevent spread of filbert blight.

Protecting against sunburn

Newly planted filbert trees should be protected against sunburn. Newspaper mats, heavy magazine paper, or any inexpensive material which can be loosely wrapped around the trunk is satisfactory. Protection is needed for only the first two or three years or until the top of the tree has sufficient growth to shade the trunk. Trees should not be wrapped too tightly, since the material may bind and girdle the tree as the diameter of the trunk increases. White-wash or white latex paint also can be used successfully. Do not use leaded paints for this purpose. Leaf growth left on the trunks also reduces sunburn.
Managing a Filbert Orchard

Cover crops

Annual winter cover crops are a part of soil management in most Oregon orchards. Cover crops prevent erosion and reduce the loss of soluble nutrients by leaching. The growing cover crop slows run-off and aids the penetration of rainfall or irrigation water. The decayed material substantially improves soil structure.

Cover crops provide for the annual renewal of organic matter to support the growth of beneficial soil organisms which aid in providing a continuing supply of necessary mineral nutrients. Cover crops reduce the amount of damaging soil compaction resulting from vehicular travel in the orchard during the late fall, winter, or early spring.

Usually the cover crop will be adequate if it is seeded early enough to permit germination with the first fall rains. Annual cover crops adapted to western Oregon north of Josephine County include:

- Willamette vetch, 40 to 50 pounds per acre with 60 pounds of winter barley or winter oats.
- Austrian peas, 75 to 90 pounds per acre.
- Crimson clover, 10 to 12 pounds per acre. Crimson clover should be seeded by September 1, but is not as well suited to older orchards as for young orchards (a heavy leaf cover may smother the crop before it becomes established).
- Winter barley alone at 60 to 70 pounds per acre provides a quick cover to protect against erosion.

Whenever legumes are used, slugs may become a problem and control measures will be necessary. A light application of nitrogen fertilizer applied to any cover crop at seeding time will often aid in establishing an effective soil-holding vegetative cover in advance of the heavy winter rains. Nitrogen application should not exceed 20 pounds of actual nitrogen (N) per acre to avoid the possibility of increasing the susceptibility of the trees to winter damage.

Some orchards are so situated that a winter growth of annual weeds or other volunteer plants makes an effective winter cover. If the stand is adequate to prevent erosion during the winter, these volunteer cover crops will be as effective as a seeded cover crop.

The time of planting cover crops is sometimes a problem. If the season is wet, planting made prior to soil preparation for harvest may grow up to hamper the harvest. In dry seasons, covers planted after harvest may be so slow in growth that inadequate stands will result.

Cultivation

The purposes of cultivation are: (1) to destroy a cover crop; (2) to control weeds; (3) to reduce moisture loss; and (4) to prepare for harvest.

The amount of moisture in that part of the soil where active filbert roots are located is usually just enough to supply the tree's needs from the last effective rains in spring until the fall rains begin. In unusually dry seasons, this stored moisture may not be sufficient. The highest concentration of filbert roots is always found in the top three feet of soil. The roots of the cover crop will usually penetrate at least half of this depth. A cover crop turned under too late, weed growth, or an intercrop will seriously reduce the amount of moisture remaining for the trees. The result will be a stunted tree and a light crop of small nuts with a higher percentage of blanks and shriveled kernels.
On the other hand, turning the cover crop under too early when the soil is still very wet results in soil compaction which could lead to potassium deficiency. Cultivation of wet soils is especially damaging to structure, leading to formation of nearly indestructible clods and development of "plow pans" or clay pans that limit moisture penetration and root growth. Particularly with heavy soils, it is best to leave the surface fairly smooth so that clods do not bake in the sun and become hard to crush. Deep cultivation to destroy a cover crop also destroys the tree's feeder roots. The ground will pack better for mechanical harvesting if it is not worked too deeply.

Cultivation saves moisture only by eliminating weed competition for moisture, so cultivate just enough to control weeds and to prepare the ground for harvest. Excessive cultivation destroys the natural soil structure, reduces humus and soil moisture, and limits the movement of water and air, thereby impeding root growth. Depth of tillage should be limited to 4 inches for working down the cover crop and should be reduced to 2 inches for the balance of the tillage season.

**Nontillage**

There has been a recent trend toward nontillage of orchard soils. The practice consists of letting weed growth or an early maturing permanent cover crop grow on the soil. A chain flail is used to keep the cover crop beat down to within an inch of the ground so it will not compete for moisture. About five flailings per year are needed. The advantages of this method are: (1) less soil erosion; (2) no tillage needed; (3) less soil compaction; (4) saving of time and equipment; (5) better harvest conditions; and (6) trees can utilize fertility in upper soil level.

**Pruning and training**

The objectives of tree training, done in the first and second years following planting, are totally different from those of pruning mature orchards. The objective of training is to develop a strong system of major scaffold limbs. Three to five major limbs are selected in the first two years. Thereafter, very little pruning is required or desirable for several years. Heavy pruning of young trees to facilitate cultivation close to the trunks is detrimental, as it prolongs the nonbearing period. Sucker growth will develop from the wounds, filling in the center of the tree and shading the other limbs.

Pruning of mature trees helps to maintain a high level of production of large nuts and discourages the alternate bearing habit of the filbert. Tree condition is the best indicator of the need for pruning. It is time to prune when a reasonable fertilizer and soil management program fails to produce an average of 6 inches or more annual terminal growth, numerous dead twigs appear in the tree center and lower
branches, lichen growths develop throughout the tree, and the outside rows show more vigor and better color than inner orchard rows. This may come as early as 12 years after planting in some orchards or as late as 20 to 25 years in others.

Experiments have shown that yields are reduced the first year after heavy pruning, but they are substantially increased in the second and subsequent years. It takes considerably less time to cut 50% of the bearing surface from 20% of the trees than it does to remove 5 or 8% of the bearing surface of all of the trees.

Since yield is slightly reduced the first year after pruning and since heavy pruning rejuvenates the tree for several years, it seems advisable to prune a portion of the orchard each year. Pruning one-fourth or one-fifth of the trees rather heavily each year provides a range of vigor which helps to even out alternate-year bearing in the orchard.

Remove as much of the unthrifty, moss-covered wood as possible, leaving a large scaffolding on which to grow new fruiting wood. Trim out the centers, shorten the low laterals (this also will make it easier to move equipment in the orchard), and in general, thin the tree so that light penetrates to all remaining parts. Cut off the limbs flush with a side limb or trunk wherever practical to do so.

Stubs do not heal over. They provide entry for wood rot organisms.
Wound dressings

Wound dressings are necessary when saw cuts are more than one inch in diameter. Filbert wood rots readily, so large wounds should be treated. Any material used should include a fungicide.

The following formula gives an inexpensive wound paint that is durable and an excellent fungicide: 20 pounds venetian red for adhesion, 3 pounds neutral copper (tri-basic copper sulfate) for fungicidal action, 1 gallon raw linseed oil for penetration. A mixture of one-half part iron oxide and 1 part lime may be substituted for venetian red. These amounts are approximate, and a little more oil may be required. This mixture makes a thick paint which thins somewhat if allowed to stand overnight. Apply with a stiff-bristled brush and work it well onto the cut at pruning time. Another satisfactory wound paint consists of one pint of raw linseed oil and one pound of Bordeaux powder.

Apply this mixture after the cut dries and checks. Store the paint in a non-metallic container.

Sucker control

All filbert varieties and all rootstocks except the Turkish hazel, Corylus Columna, will sucker to some degree. Prompt and careful removal of suckers during the first few years after planting greatly reduces the labor required for this operation in later years.

Begin removing suckers in the spring before the oldest ones of the current season’s growth have hardened to any extent. They should still retain part of the red color shown when they emerged from the soil. This means before they are over 6 to 8 inches tall. Remove soil from around the base of the tree so suckers can be pulled or cut off at the point of origin. At the same time, rub off all buds that are showing.

Repeat this operation three to four times a season for at least the first two years and then initiate a spray control program. Remove suckers each time a new crop of them appears above ground and before they harden. On good trees which are properly planted, this procedure requires less time than removing suckers only once or twice a year after they have become woody. Repetition of this process while the trees are young reduces the amount of suckering on mature trees.

Suckering once a year does little to reduce growth. Cutting suckers off at or just below the surface of the ground simply multiplies the number of suckers that grow. Some growers use a hoe or other cutting instrument to cut off suckers as soon as they appear above the ground; this is really a variation of the practice described above. In all suckering work, the time and labor necessary is increased the longer the suckers are allowed to grow and the tissues to harden.

The use of a 2,4-D spray when the leaves of suckers still have some of the red color that was showing when they emerged from the soil has been a satisfactory practice over a 15-year period, with no evident damage to trees. This is a much easier operation than removal of suckers by the hand methods previously described.

Dinitro general weed killer with oil also has been used successfully for sucker control. Because it may damage the bark of young trees, it should not be used for the first five years after planting and care should be taken to minimize its contact with the bark of the tree trunk. Paraquat has been used successfully without the bark damage associated with Dinitro.
**Orchard Nutrition**

**New orchards**

Soil sampling and testing of fields to be planted to orchards is recommended. Application and incorporation into soil of certain nutrient elements such as K and Mg can be done best prior to planting.

**Potassium (K).** K should be broadcast and plowed under during preparation of land for planting.

<table>
<thead>
<tr>
<th>If OSU soil test for K reads (ppm):</th>
<th>Apply this amount (Lb./A)</th>
<th>K₂O x 0.83 = K</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 75</td>
<td>300-400</td>
<td>250-330</td>
</tr>
<tr>
<td>75 - 150</td>
<td>200-300</td>
<td>165-250</td>
</tr>
<tr>
<td>Over 150</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

**Magnesium (Mg).** Mg should be broadcast and plowed under during preparation of the land for planting.

If the OSU soil test for Mg is less than 0.5 me/100 g of soil, apply 1.5 T/A of dolomite. Dolomite acts in a similar manner to limestone in the correction of soil acidity. The need for applications of Mg is usually greater where K and calcium levels in the soil are high.

**Lime.** Liming of orchard soils is most effective where the lime is mixed into the soil to as great a depth as feasible during the preparation of the land for planting. If the OSU soil test has a pH of less than 5.2 on valley floor soils or 5.6 on hill soils, apply ground limestone at the rate of 2 to 4 tons per acre.

**Nitrogen (N).** Apply N only after one growing season has passed. Young trees should grow 18 to 30 inches annually. Fertilization at planting time may burn the newly forming roots and retard growth.

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**Mature orchard nutrition**

In fertilizer experiments, filbert yields have been increased only by applications of nitrogen or nitrogen and potassium. Increased yield has not been observed to date from addition of other elements such as phosphorus, zinc, or boron. Further research in nutrition might show that some orchards would respond to fertilization with other elements.

If other factors are not seriously limiting, leaf size and color and shoot growth reflect the tree's nutritional condition. Short shoots and small, pale leaves may indicate a deficiency of nitrogen. With potassium deficiency, leaves are also small. In the case of severe potash deficiencies, the husks surrounding the nuts are abnormally short.

**Fertilizer needs and application**

Leaf analysis indicates which elements are present in adequate, deficient, or excessive amounts. Predictions of fertilizer needs of established orchards based on soil tests are usually not reliable.

A nutrient deficiency should be suspected if the cause of poor tree performance is not primarily one or more of the following:

- Lack of pruning
- Winter injury
- Physical injury
- Poor weather
- Poor pollination
- Deep cultivation

**Soil-borne pests**

- Poor soil drainage
- Disease
- Insects
- Rodents
- Shallow soil or limited moisture
Nitrogen (N). Leaf analysis guide for N application (mature trees):

<table>
<thead>
<tr>
<th>Percent leaf N in August</th>
<th>Lb./tree</th>
<th>Lb./A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1.8 (severe deficiency)</td>
<td>3-4</td>
<td>300-400</td>
</tr>
<tr>
<td>1.8-2.2 (deficiency)</td>
<td>2-3</td>
<td>200-300</td>
</tr>
<tr>
<td>2.2-2.5 (optimal)</td>
<td>1.5-2.0</td>
<td>100-150</td>
</tr>
<tr>
<td>Over 2.5 (excess)</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Apply this amount of N based on the percent leaf N in August.

Potassium (K). K deficiency is common in Oregon filbert orchards. Since K applications tend to reduce magnesium uptake, do not apply K unless leaf analysis indicates a deficient or borderline level.

Leaf analysis guide for K application (mature trees):

<table>
<thead>
<tr>
<th>Percent leaf K in August</th>
<th>Lb./tree</th>
<th>Lb./A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 0.5 (severe deficiency)</td>
<td>10-15</td>
<td>1,000-1,500</td>
</tr>
<tr>
<td>0.5-0.8 (deficiency)</td>
<td>6-10</td>
<td>600-1,000</td>
</tr>
<tr>
<td>0.8-1.0 (borderline)</td>
<td>4-6</td>
<td>400-600</td>
</tr>
<tr>
<td>Over 1.0 (optimum)</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Apply this amount of K₂O based on the percent leaf K in August.

Early fall applications of N could increase danger of winter freeze damage, so it is usually applied between February 15 and March 15. Adjust rates according to results of application in previous years.

Best use is made of the fertilizer if it is placed in the area starting halfway between the tree trunk and the drip line of the outermost branches and extending one-fourth the distance from trunk to drip line outside the drip line of the tree.

Diagram showing area to fertilize in relationship to tree trunk and limb spread.

Phosphorus (P). Filbert trees generally do not respond favorably to applications of P. Nut crops contain little P compared to crops such as grain, and trees are able to store P in buds and twigs for reuse in following seasons.

Phosphorus contents are expressed as the oxide (P₂O₅) on fertilizer labels. Multiply P₂O₅ by 0.21 to convert to P.

Preferably drill P 4 to 6 inches deep in the root zone; or place P in a concentrated band on the soil surface.

If banded, use a band 2 inches wide for each pound of phosphorus product applied at or near the drip line of the tree. Example: 10 pounds muriate of phosphorus per tree should be applied in a 20-inch band around the tree at the drip line.

Apply muriate of potash (KCl) in fall or before mid-February to avoid chloride toxicity. Chloride burn can be eliminated by using the sulfate (50% K₂O) or nitrate (44% K₂O and 13% nitrogen) forms of potash. Potassium levels often do not increase until the year following application. A single application is usually effective for two or more years.
Boron applications in amounts ranging from one-fourth pound per tree to four pounds per tree have reduced yields slightly in limited experiments.

Where test levels are low, make trial applications with adequate checks. Here it is wise to enlist the aid of the Extension Service.

Insects

The filbert worm is the most important insect pest of filberts. Leaf rollers, aphids, and the filbert bud mite are also serious pests. Normally the filbert worm is controlled with Sevin or Guthion applications about July 1, with a repeat application in three weeks in heavily infested orchards.

Detailed information on control of insect pests is available from your Extension agent.

Disease

Bacterial blight, commonly known as filbert blight, is the most important parasitic disease of the filbert in Oregon. Its prevalence and destructiveness varies with the season. The disease is usually very prevalent after heavy fall rains. If the fall rains are relatively light, the disease is usually of little consequence.

The most serious phase of filbert blight is trunk girdling and killing of trees up to five years of age. Trunks of older trees are seldom infected, but buds and nut-bearing twigs in the tops often are killed, reducing yield. Bud and twig infection due to bacterial blight can be materially reduced in both young and old orchards with 6-3-100 Bordeaux mixture or tri-basic copper sulfates (6 pounds per 100 gallons). A compatible wetting and sticking agent will increase effectiveness of these spray mixtures.

Orchard sanitation

Health authorities emphasize sanitation of nut crops. Contamination from animal manure is the principal concern. For this reason, and the fact that the crop is harvested from the ground, it is not advisable to use animal manure in nut orchards.

Bacterial blight kills buds and twigs, substantially reducing bearing area.

In a normal season, one spray application in late August or early September (before the first heavy fall rains) usually is sufficient to give commercial control of filbert blight. However, in seasons of heavy and prolonged rainfall during the fall and winter, a sec-
ond application may be necessary when about three-fourths of the leaves are off the trees.

Wounds from pruning, stripping leaves from the lower trunk, tillage equipment, frost damage, and other causes provide ready entry to blight organisms and should be avoided or treated promptly.

Blue jays and squirrels

Blue jays and squirrels often congregate in large numbers around filbert orchards. They consume large quantities of nuts.

Shooting is a common control method, but it is costly and time consuming.

Trapping with ordinary steel traps made for rodents has been fairly successful. Traps are more effective when attached to the top of posts (short posts for squirrels, long posts for blue jays). Prop the posts against trees along the outer row of the orchard. Nuts on the trees are the only bait.

Another method is the use of shelled filbert nut meats treated with strychnine and exposed in small feeding platforms in filbert trees. Use 5 quarts shelled filberts, ¼ ounce strychnine alkaloid, ⅛ pint starch paste, and ¼ tablespoon of glycerin.

Strychnine-treated barley kills ground squirrels. For safety, place the bait inside a section of clay drain tile. Strychnine-treated corn kills blue jays.

One grower uses an electric fence to keep squirrels out. A chicken wire fence 20 inches high is topped off with a slanted cover that exposes a gap almost large enough for the squirrels to pass through. The top of this surface entrance is strung with electric wire, shocking rodents as they attempt to climb over the fencing.

\[ \text{Deer damage} \]

Deer are particularly serious pests of young filbert trees in orchards next to wooded areas. So far no completely satisfactory answer to deer damage has been found. Deer fencing around the entire orchard is the most reliable solution but it is expensive. Special hunting licenses may be obtained for some locations. Chemical repellents have been partially successful in some instances. Bags of blood and bone meal hung in the trees are the most commonly used repellents. When replaced every two or three months, they have been relatively successful. Keeping dogs in the area also has been helpful.

Gophers

A single gopher may kill a dozen or more trees in a season. Usually it is attracted to the orchard by the succulent roots of the cover crop. When the cover crop is turned under, the gopher turns its attention to the trees. Gopher activity can be recognized by the crescent-shaped mounds of earth around either an open or plugged hole.

The most practical methods of controlling pocket gophers are by use of toxic baits and trapping. Over large and heavily infested areas, baiting is fastest and cheapest. Stragglers that are not poisoned will continue to throw up fresh mounds. These individuals can then be trapped. Early spring baiting before the young of the year are born is the most economical and satisfactory. Bait only where there is fresh gopher activity. The bait most commonly used is carrot sticks dusted with strychnine at the rate of one ounce of strychnine to 16 pounds of carrot sticks. The most effective bait for the large Willamette Valley gopher is strychnine-dusted red clover leaves dusted at the rate of one ounce of
strychnine to 10 pounds of clover. These baits must be applied by hand into the gopher’s main runway system. When using the clover leaf formula, it is necessary to open the runway through the mound and place a small handful of the bait in the runway with a long-handled spoon. The opening should then be closed to exclude light from the burrow. When using the carrot stick bait, baiting can be accomplished by means of a gopher probe. The main runway can be located by probing into the soil a foot to 18 inches back from the mound on the side where the crescent depression is found. When the probe drops into the runway, the release of the friction will be felt. Remove the probe and insert the bait material. Close the opening with a clod of dirt to exclude light. Each bait should be about 3 inches in length so the gopher will have to cut it before taking it down the runway.

In recent years, a mechanical device known as the pocket gopher burrow builder has been developed. Pulled behind a tractor, it builds an artificial burrow at an adjusted depth and at the same time drops grain bait at regulated intervals. It is being used very successfully for the control of all pocket gophers that will accept grain-type baits. No machine has yet been designed to use a vegetable bait such as is needed for the large Willamette Valley pocket gopher.

**Meadow mice**

The usual damage by meadow mice is girdling of both roots and stem. The mice are dependent on cover, and damage usually occurs when cover exists in the form of heavy sod, cover crop, litter, or snow.

The most effective, economical, and least hazardous control is by the use of poison baits. Wheat carrying 1% zinc phosphide is the most widely used bait in Oregon. This is followed by oat groats and strychnine mixed at the rate of one ounce strychnine to 12 pounds oat groats.

Bait location is important. The meadow mouse stays pretty close to its established runways, so bait should be placed directly in the burrow entrances or the runways. False cover can be made of box ends or tar paper rolls placed over or in the runways. This cover provides the mouse with a protected dining area.

**Weed competition**

Weed competition for moisture and nutrients limits the growth of young filbert trees more frequently than any other factor. Weed control close to the tree is most important in the first few years, yet that is where control is often the poorest. Hand hoeing is the most frequently used weed control method the first season. Limited experiments indicate that a mulch of sawdust or black plastic during the first two or three years after orchard establishment will reduce or eliminate weed competition and increase tree growth.

Several herbicides are registered for use on nonbearing orchards. Herbicides may be used after the first summer, when the soil has settled around the roots and there is no danger of the material reaching them. A good herbicide program around the trees with cultivation in the middle of the rows provides the best protection against weeds. In wet years, weed growth may become so rank it will prevent or retard normal harvest operations. If this is anticipated, some late-season chemical weed control may become advisable. Since federal herbicide registrations change from year to year, no chemicals will be listed here. Contact your Extension agent for current recommendations.
Most filberts are harvested by machines which pick them up from the ground and separate them from a majority of the leaves and sticks.

Leaves and trash on the ground

The amount of leaves that fall prior to harvest is a major consideration with pick-up operations. Leaf fall occurs earlier in potassium-deficient orchards. A heavy application of nitrogen can induce a deficiency of K, thus increasing leaf fall. Heavier fertilization with nitrogen with maintenance of sufficient K usually keeps the leaves on the trees longer. Drought, excessively deep cultivation, or mites and aphids also may cause early leaf drop.

Ground preparation for mechanical harvesting

Certain standards of evenness and firmness of ground are necessary for successful mechanical pick-up operations. Small undulations, dirt clods, or soft ground result in loss of yield or dirty product. Some soil types are so sandy or silty that they cannot be rolled firm enough for pick-up operations. Other soils have so much clay that they cannot be worked fine enough. Fortunately, the majority of soils in the Willamette Valley can be worked into a condition suitable for mechanical pick-up.

The usual procedure for ground preparation is as follows:

1. Disc under the cover crop (or winter weed growth) with a cover crop disc, field disc, or rototiller.
2. Use a spring-tooth harrow or peg harrow for summer weed control, often with a roller for mashing clods and a float or drag behind. Some growers use a rod weeder, Gent weeder, or Kimble.
3. Level the orchard floor, float it, and roll it two ways to prepare for harvest. Use sprocket rollers for clod mashing and smooth rollers for firming for pick-up operations. Smooth rollers are often filled with concrete or water.

A few growers use a rototiller for all cultivation. Most growers follow a similar ground preparation routine. Some use a chain flail to control weeds and cover crop. Variations in the combinations of equipment used and minor differences in equipment design are common.

If clods collect around the base of trees, attach part of an auto tire to the drag to help remove them. Use of herbicides around the base of the tree is helpful.

Grass and chickweed often grow after the orchard has been rolled and leveled and some nuts or fruits have fallen. No herbicides can be used at this time because they would contaminate the nuts.

Soil preparation for harvest should be completed by late August or early September to give the soil a chance to firm up by harvest time. Final preparation consists of leveling and rolling the soil to provide a smooth surface for harvesting.

Time of harvest

Rains and windy weather will bring the last filberts down but will also create muddy conditions for the pick-up operation. Either a helicopter or a ground-level blower will help remove the last portion of the crop so that harvest can begin before the fall rains create difficult conditions. A little rain before harvest helps to reduce the dust and firm up the picking surface. A once-over mechanical harvest is not possible before October in most years.
Windrowing

Before the pick-up operation, nuts are windrowed into one or two rows 2 to 4 feet wide between the rows of trees. They may be windrowed again for a final "clean-up" picking if there are enough nuts on the ground to justify the added work and the orchard floor is still smooth enough to permit it.

Sweepers for nuts vary in size and cost. Growers with large acreages generally favor the riding sweepers over the walk-behind kind. Small power sweepers for working close to trees are available. Some growers have a leaf blower attached to their sweepers. Most growers still use hand rakes to remove the nuts from around the tree trunks before sweeping. However, mechanical sweepers are available that will clean the nuts from the tree row without additional hand work. Some growers who were bothered with mud collecting on the canvas draper in front of the sweeper found that mud does not accumulate on a polyethylene plastic draper. The most recent trend is toward mounting sweepers on the front end of the regular farm tractor.

There are two basic designs for sweepers: (1) The reel type; and (2) the kind with revolving bars with metal tines. The reel type usually has rubber or fabric paddles. It is the design most commonly seen in Oregon.

Cleaning equipment on harvesters

Perhaps the greatest problem in mechanical harvesting is getting a clean product. Processors and buyers complain about "clean away" or "wash away" and usually dock the grower when it reaches a certain point. Prob-ably one of the cheapest places to clean the product is in the field.

Filberts present a difficult cleaning problem. Nuts must be separated from clods, hulls, blank nuts, leaves, rocks, and twigs. Cleaning methods include: (1) Blowing or sucking; (2) revolving rollers; (3) revolving drum or "squirrel cage"; and (4) revolving tines or brushes.

One of the best places to separate leaves and nuts by blowing is as they fall from the end of a conveyor into a bin or another cleaning device. Hulling cylinders have been developed for removing hulls. The squirrel cage helps to remove leaves, clods, and small sticks, but is too slow for many operations. The rollers pull leaves and twigs down between them and send the nuts to the rear. They work better when either completely dry or kept moist by application of water.

All of this cleaning equipment must operate rapidly enough to keep ahead of the pick-up section or the whole operation is slowed down and the nuts are not thoroughly cleaned.

Problems encountered in the cleaning process include: (1) hard clods the same size as the nuts; (2) mud-clogged conveyors; (3) wet leaves that will not blow; (4) sticks and trash that jam equipment; and (5) the whole process is too slow. If harvest conditions are too difficult, clean the nuts partially in the field and more thoroughly in a central plant.

Bulk handling

With rapid mechanical harvesting, the old methods of handling which employ small, hand-carried containers will
not suffice. There is no point in having harvesting and cleaning equipment capable of harvesting over a ton of nuts per hour if excessive labor is required to load and transport the product from the orchard. Handling must be mechanized. The orchard bin and the bulk trailer provide answers to this problem. When bins are carried on the harvester or are towed behind, a fork lift is required to move the bins out of the orchard and onto a truck or trailer.

Washing, Drying, and Storing

Washing

Filberts directly from the orchard will be either dusty or muddy and may be mixed with a considerable amount of clods, sticks, leaves, and rocks. This is particularly true since the advent of mechanical harvesting. Filberts must be cleaned before the trade will accept them, and cleaning is most easily done prior to drying the nuts. Most driers are equipped with a processing line which includes a de-rocker to remove rocks and dirt clods, a squirrel cage washer to remove mud, sticks, and leaves, followed by a fresh water rinse to finish the washing operation.

Sanitizing equipment using chlorine to kill harmful bacteria is the latest addition to the washing line. This treatment is necessary because there is not enough heat in the drying process to sterilize the nuts to recommended standards.

Drying

Damp or undried filberts should not be stored for any length of time, because kernels become moldy or off-flavored even if such a condition is not evident from the appearance of the shells. If nuts cannot be dried promptly, it is better to leave them in the field (they will not mold as easily when spread out on the ground) or at least provide storage where plenty of cool air can circulate around the nuts. Delay in harvesting, however, does not produce the best product.

To avoid loss of weight and spoilage, filberts should be dried to a moisture content of 8 to 10%. Since nuts are bought and sold on a dry-weight basis, one of the most important factors affecting the price the producer will receive is the amount of moisture in the crop he delivers. Optimum drying temperatures are 95 to 105 degrees Fahrenheit. Forced air circulation is probably more important than temperature in proper drying.

Dryers of various types are in use—prune dryers, hop dryers, and bin dryers. The amount of heat necessary to dry filberts to the required standard is so small that expensive equipment is not needed. Speed in drying is not essential except where large crops are handled.

Many inexpensive, fairly efficient dryers have been made by remodeling old buildings on the ranch. Place the heating unit so that it will provide an equalizing chamber under the drying bins and thus insure even amounts of warmed air passing up through all parts of the nut-drying area. The drying floor is made of wire cloth or expanded metal laid on strips one by two inches or two by three inches, so that at least 80% of the floor space is open, allowing air to pass upward. Provide outlets in the roof of sufficient size to allow free upward movement of moisture-saturated air. Few growers maintain drying temperatures continuously
for 24 hours a day. Aid in designing new dryers or in remodeling old buildings for drying purposes can be obtained from the Oregon Agricultural Experiment Station.

Small lots of filberts can be dried by spreading them out only a few layers deep on the floor in a dry room. The nuts should be stirred frequently.

In small lots of nuts, separate those containing no kernels by pouring all the nuts into water and then skimming off the ones that float. This is a slow process, but can be done well with a little experience.

With filberts, the kernel is firm at the start and becomes spongy during the drying process; as it approaches dryness, it becomes firm again. The internal color gradually changes from white to a creamy color, starting at the outside. When the color change reaches the center of the kernel, the nut is dry. Careful checking of both of these indices will help determine when the nuts are dry enough.

Storage

Storage is not a usual function of the producer since he normally sells the filberts undried as they are harvested from the orchard or immediately after drying. In the event storage is necessary, provide a uniformly cool, dry storage area that will not freeze and is isolated from the storage of strong odor products such as onions.

Ordinary storage is adequate until May following harvest, after which cold storage would be desirable to preserve quality. Temperatures recommended for cold storage are 36° to 40° F. Storage beyond one year is not advisable.