Filberts

in Oregon

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Filberts have been cultivated from early days. Pliny narrates: "Filberts and hazels . . . are a kind of nut and were called heretofore Abellinae, of their native place. . . . They come out of Pontus into Natolia and Greece and therefore they be called Pontick nuts. . . . These filberts likewise are covered with a soft bearded husk, and as well the shell as the kernel is round and solid, all of one entire piece." He refers to Cato and Theophrastus as early writers mentioning hazels. Filberts were connected with European mythology and witchcraft, and even today many people use a hazel wand to locate underground water.

The name filbert is supposed, by some, to have originated from "full beard," referring to the fact that with some varieties the husk entirely covers the nut. By others, it is thought to have been derived from St. Philibert, as August 22 is dedicated to him, a date that corresponds in England to the ripening date of the earliest filberts.

### Districts Adapted to Filberts

The Willamette Valley of Oregon and corresponding territory in Washington have proved suitable for filbert growing. In the Willamette Valley filberts have been grown for about four decades, and results show that production on suitable sites and soils is a commercial success.

Tests made in various other sections of Oregon for the past few years indicate that filberts can be commercially grown, more or less profitably, in certain districts outside of the Willamette Valley.

The fact that filbert catkins when fully dormant are killed at a temperature of about -15° F. prohibits commercial production in most parts of eastern Oregon. In some places in eastern Oregon, however, hardier varieties survive and bear a few nuts. Along the coast the success of filbert growing has not yet been fully demonstrated, although in the Coast Range Mountains some orchards are doing very well.

In the Umpqua Valley a few orchards on good land are profitable. Near Scottsburg the oldest and largest filbert tree in the Pacific Northwest is located. It is more than 100 years old, with a spread of more than 50 feet. South of the Umpqua Valley filbert growing has not proved successful. Considerable experimental work and testing must still be done before the value of this fruit can be definitely determined for many sections of Oregon.

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COVER: Oregon filbert nuts in husks (twice natural size).
Locating Orchards

In the Willamette Valley of western Oregon the chief factor in locating a filbert orchard is soil. Any soil, whether hill or lowland, is suitable if it meets the requirements outlined later. No one direction of slope has any particular advantage over another, except that on south and west slopes the soil is usually shallower and dries out more rapidly. Orchards on hill soils probably will average smaller in size of tree and less in production than those on lower soils, which are generally deeper. In one study made on filberts, 30 orchards on valley floor and river bottom soils yielded on the average 912 pounds per acre while 15 orchards on hill soils averaged 791 pounds per acre.

Elevations greater than 1,200 to 1,400 feet above sea level have been tried out so seldom that little is known as to the suitability of these locations.

Suitable Soils

Filbert plantings being made at the present time and potential importation of nuts from foreign countries make it likely that future competition in the industry will be as keen as that which now exists in other kinds of fruit growing. For this reason orchards located where production will be only average or below average will in most cases prove unprofitable. There is enough fertile land in Oregon for all the filberts needed without locating them on soil that is of doubtful quality with respect to depth, fertility, or drainage.

Too much emphasis cannot be placed on the necessity of selecting the best soils for filbert production on a long sustained basis. Too often the owner is encouraged by growth and production of trees until the eighth or twelfth year. At this time, having exhausted the productive capacity of the soil, tree growth and nut production become stationary instead of increasing as expected.

With trees on mediocre soils, production does not increase with increasing age and size of trees and extreme fluctuations in crop yields occur. A good crop for size of trees one year may be followed by several years of low production. In a year of heavy production, new shoot growth is very short and unproductive and may require two or more years for the tree to develop the strong shoot growth that precedes heavy production. When orchards reach this condition, because of the soil on which filbert trees are grow-
ing, there is little that can be done to improve production. Natural physical conditions associated with fertility and moisture-holding capacity of the soil strictly limit its productive capacity.

The exact type of soil best suited to filberts varies in different districts, but in all cases it should be deep, fertile, and well-drained.

In judging the suitability of a location for a filbert orchard, a cursory observation of surface soil is of little value. Soil samples sent in for chemical analysis or similar tests are of little or no value in determining suitability for filbert orchards. Where soils have been mapped by state and federal workers, such maps are of value and are available either free or as reference information on file at county agent’s offices in the Willamette Valley. Some soil types are always unsuitable, and reference to soil maps may eliminate some locations without further investigation. Performance records of filbert orchards on many soil types, with chemical and physical analysis data for soils that indicate their comparative value for filbert production are on file at Corvallis with the Oregon Agricultural Experiment Station and the United States Department of Agriculture.

It has often been stated that filberts will do well where wild hazel grows. Without doubt wherever wild hazel is very large and vigorous, filberts will grow well. Wild hazel will grow in many places, but its growth may be only that of a small shrub. Filberts should be planted only on soils where wild hazel grows exceptionally well.

**Depth**

Good filbert soil should be 8 to 10 feet or more in depth. Recent investigations show that it is doubtful whether a soil 6 feet deep will maintain a mature orchard in regular, heavy production. Deep soils naturally afford a large supply of water and plant nutrients during the dry season. The effective depth of any soil is determined by the distribution of tree roots in it. If roots can grow to a depth of only 3 feet, effective soil is shallow regardless of what is below. The idea that filbert trees are shallow-rooted has practically been discarded since investigations have shown that under favorable soil conditions roots readily grow to a depth of 8 to 11½ feet. Root penetration is stopped by rock, impervious hardpan, water table, sand or gravel, and lack of aeration in the soil. All of these conditions except lack of aeration can be located in the field by boring with a soil tube to a depth of 8 to 10 feet. Aeration of soil can be determined only by laboratory methods. Compact subsoils with a mottled color, indicating poor drainage, are often found. Besides affording few or no openings large enough for roots to enter, this kind of subsoil layer often supports a water layer that further restricts or inhibits root development. Other subsoils may become tighter and harder in the lower levels with a minimum of mottling, and these too serve as a barrier to roots. Still other soils are easily dug with tools but the particles are so minute that there are no open spaces large enough for roots to enter. Spaces are filled with water continually, so the soil may be water-logged without standing or excess water. This type of subsoil is difficult to recognize except by experience and a knowledge of soils in which this condition is found. Loose gravel and coarse sand have such large spaces that there is an excess of air as well as a shortage of moisture, which allows no root growth.
When any of the foregoing types of subsoils occurs close to the surface, it will prevent roots from going deeper than the surface soil, thus establishing the effective depth of the soil at a shallow level.

**Fertility**

Fertile soil is essential to proper development of filbert trees. As the fruit is largely borne laterally on one-year-old wood, plant food materials should be present in the soil in sufficient quantity so that, with a plentiful supply of moisture, good vegetative growth can be obtained each season. Attempts to obtain this growth by means other than high soil fertility usually meet with failure.

**Drainage**

Filberts will not thrive in waterlogged soils. Trees will survive very adverse conditions, but tree growth and yields of nuts will be better in optimum conditions. In soils where the water table, lying on a heavy impervious subsoil, comes close to the surface for long periods of time during rainy seasons, filbert trees may survive for years. Some trees 25 years old are still growing on such soil but they are little higher than a man’s head and have produced few nuts.

Filbert orchard soils should be well drained during the entire year, yet should be capable of storing a large quantity of water for the trees during the dry season. Filbert roots make a very extensive growth during winter in western Oregon, but if the soil is water-logged this growth is retarded or entirely inhibited. Growth of tree tops is dependent on the formation of new roots. As a result of lack of root growth, when the demand comes during the growing season for large amounts of plant food materials and moisture, the root system is not extensive enough to provide for a good, vigorous growth of the top.

Tile drainage of wet land has been resorted to in a number of cases but with indifferent success in growing filberts. 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 grow in it, and thus there is little more soil for trees after drainage than before. Where a small area of wet land intrudes into a larger tract to be planted to filberts, drainage is justified because it will allow cultivation tools to work through the area at the same time that the main planting is being cultivated.

**Soil types**

Soil types on which filbert orchards are commonly found are: (1) Newberg and Chehalis of the river bottoms, (2) Willamette of the valley floor, (3) Olympic and Aiken basaltic soils of the hills, and (4) Sites and Melbourne shale and sandstone soils of the hills. Orchards are less often found on Salkum, Polk, Amity, and Carlton soils.

In Newberg and Chehalis soils, sand and gravel subsoils are commonly found, and where these are close to the surface the soils are shallow. When these soils are located in the upper part of river valleys, sands and gravels are likely to be coarse and close to the surface. Trees on these subsoils characteristically make a vigorous growth and are productive until they become so large as to exhaust all the moisture in the soil above the sand or gravel before the fall rains begin. When such exhaustion of moisture occurs during August or September,
conditions become serious and irrigation is necessary.

Willamette soils are fertile, unless poorly farmed in the past, and are practically always of good texture in the upper three feet. Below this level many varieties of subsoils have been found. Where the character of the subsoil has one or more undesirable features (discussed above), the value of the land will depend on the depth of soil above undesirable subsoil. Olympic and Aiken soils may be underlaid by a tight compact subsoil at a depth of 10 feet or less, or sometimes by rock. When sampled with a soil auger or soil tube the surface of samples from low levels usually has a glossy bright red color. When this subsoil becomes very tight and difficult to bore and the surface of the samples appears waxy, few roots will be able to enter.

Sites and Melbourne soils, derived from both sandstone and shale, are extremely variable. Two undesirable types of subsoil are often found. One is a tight, compact, sandy layer that contains few roots. If the layer of this material is thin, it can be penetrated by a few roots, and these roots will develop a profusion of fine rootlets in the more open strata below. If more than a few inches thick, this layer effectively limits root penetration. The second unfavorable type of subsoil is moist and apparently friable, but actually is composed of such minute particles of clay and colloidal material that there is not space for roots. If this subsoil occurs near the ground surface, therefore, it causes the soil to be shallow as far as tree growth is concerned. This is one of the most difficult subsoils to recognize except after experience with it.
Pollinating varieties

The varieties listed below are some of those grown in commercial orchards in Oregon as pollinizers.

Daviana. Tree vigorous, upright, close growing, very light producing. Nut medium in size, thin shelled, and of good quality. Tree very subject to bud mite. Has proved a good pollinizer for Barcelona and in some seasons for Du Chilly.

Du Chilly. Tree medium vigorous, spreading; growth distinctive, as shoots tend strongly to come out at right angles. Production medium. Nut large, long, flattened; shell medium thick, slightly rough. Husk one-third to three-fourths longer than nut. Nut does not drop freely. Pollinizer for Barcelona.

White Aveline (White Filbert). Tree medium size to small; usually not very vigorous; production medium. Nut distinguished from Red Aveline by white skin of kernel. Catkins grayish yellow in color in contrast to the red or purple of Red Aveline and Purple Aveline. Excellent pollinizer for Barcelona.

Bolwyller (Halls Giant). Tree upright, compact, distinguished by pointed bright red buds. Nuts large, round in cross section, with broad base and coming to a sharp point. Color bright, glossy, rich brown. Production usually light. Used almost exclusively as a pollinizer for Brixnut.

The four varieties listed below are all old ones, but they have been propagated relatively little until recently. They are proved pollinizers for the Barcelona.


Nottingham. Tree vigorous, upright, with close growth and fairly productive. Nut medium to small, long, slightly flattened, increasing in width up to two-thirds of length then abruptly tapering to point. Color dark brown, with very fine striping. Shell thin. Husk one-third longer than nut. Nut drops freely.

Woodford or Nixon (which are believed to be the same variety). A very desirable early pollinizer for Barcelona. It sheds its pollen early in December when the first Barcelona flowers are receptive, and when no other pollen is available.

In the future new varieties will undoubtedly be introduced to the public. Thousands of seedling trees are fruiting in this area; from these, promising ones are being selected and named. Some of these seedlings have such qualities as large size, thin shell, and white kernels, which make the nuts appear attractive. Any new variety, however, before becoming established commercially, must be grown for years under orchard conditions. Growers may be justified in planting a few trees of a new variety as a test, but those wishing the safest investment will plant principally the old standard varieties. As any list of new varieties now being put on the market will be out-of-date within a very short time, because of the elimination and addition of varieties, no list of such varieties is given.
Pollination of Filbert Trees

Self-sterility of filbert varieties makes interplanting a necessity in order to provide cross-pollination. An orchard of one single variety invariably produces a few scattering nuts, therefore self-sterility cannot be said to be absolute, but in a commercial sense it is so nearly complete that it may be considered so. This has been proved true by experiments and by the experience of growers.

Under normal conditions the blooming season of the filbert extends over a period of at least three months, counting the time from the beginning of pollen shedding by early varieties to full bloom of pistillate flowers of late varieties. Within this period there is (for many varieties) a natural sequence of blooming. Considerable variation occurs in the sequence from season to season and in the length of time during which a variety may be in bloom. These variations are caused by climatic conditions. Seasons have been noted where late blooming varieties have shed pollen at the same time as normally early blooming varieties.

With Barcelona a long period exists during which pistillate flowers (figure 1) are opening. The period of pollen shedding of any of the pollinizers is relatively short. In some years the short pollen-shedding period does not coincide with the maturity of the greatest number of pistillate flowers. Because of this fact, if any one variety is used as a pollinizer, pollination may not be satisfactory. This is apparently the case in orchards where Du Chilly has been used alone as a pollinizer for Barcelona. Du Chilly sheds its pollen fairly late, and therefore in some seasons pollinizes only the later Barcelona pistillate flowers.

If any single pollinizer is used for a certain variety, it should be one that normally sheds its pollen during the middle of the pistillate blooming time of the main variety. Thus with the very long blooming season of Barcelona, Daviana has been used alone in many orchards, as it practically always sheds its pollen at a time when a large number of Barcelona pistillate flowers can be pollinated. A study of blooming records of varieties would seem to indicate that for the most regular production, early and late blooming

Figure 1. Filbert flowers. Above, female or pistillate, and below, male catkins in bloom.
pollinizers in addition to midseason varieties would aid in getting a set of nuts in certain seasons. In the first orchards of Du Chilly in the Pacific Northwest only one variety for pollination purposes was included. The decided tendency at the present time is to use two or three varieties.

Varieties planted as pollinizers are in the orchard primarily to shed pollen. A crop of nuts on pollinizers is a matter of secondary importance in comparison with pollen shedding. In many pollinizers a heavy crop of nuts is followed in the succeeding year by a light crop of catkins and pistillate bloom. A heavy nut crop on the pollinizer may result in a light crop on the main variety the following year due to a lack of pollen. No satisfactory pollinating variety is known that will annually shed large amounts of pollen and also produce heavy crops of large sized nuts.

The combination of White Aveline, Daviana, and Du Chilly as pollinizers for Barcelona has been successful. If only one of the group is used, it should be Daviana. Because of bud mite infestation, Daviana seldom bears heavily; consequently, it regularly produces a large supply of catkins and pollen. On that account the control of the bud mite on Daviana is not advisable. Occasionally Du Chilly bears a heavy crop of nuts, which is generally followed by light catkin production. White Aveline is the least satisfactory of the three from a growth standpoint; Montebello can be substituted for it.

Bolwyller is used as the pollinizer for Brixnut and in that combination bears more heavily itself than in any other so far noted. The nuts can be mixed with Brixnuts. Bolwyller, however, has been known to bloom out of season for Brixnut. It has been used sometimes as a late pollinizer for Barcelona and is excellent for that purpose in years when pollen is needed after Du Chilly has finished shedding pollen. This late need for pollen does not occur regularly but such a season occurs occasionally.

Du Provence sheds its pollen from midseason to late season for the pistillate bloom of the Barcelona. It seems to produce a regular crop of catkins. The nuts can be mixed with a small size grade Barcelona.

Montebello is an early blooming variety and may be used to supplant White Aveline. Care should be taken, however, that young trees have been propagated from a strain that is interfertile with Barcelona. Different introductions from Europe have shown considerable variation in this respect. Montebello nuts can be mixed with Barcelona nuts.

Nottingham has a pollen-shedding season quite similar to that of Daviana but it generally begins a few days earlier.

In addition to the foregoing varieties, a good many seedlings have been tested. Many of these have proved infertile with Barcelona, but too little is known regarding season of blooming, catkin production, and other important factors for any of them to be recommended. Furthermore, very few of them are available for planting.

For the few Oregon plantings made with Du Chilly as the main variety, the following pollinizers are of value: Daviana, Alpha, Gasaway, and Clackamas. In Washington, Nooksack has been used in recent years.

Proportionately, one pollinizer tree to eight trees of the main variety has been the regular practice. The use of one pollinizer to five trees is not out of proportion when orchards are
young, or in unfavorable seasons after they are more fully grown. In favorable seasons and in older orchards, a smaller number of pollinizers than one in eight will be effective. Some growers have planted pollinizers in the ratio of 1 to 15 or 1 to 24. It is in unfavorable seasons, which occur frequently, that a greater number of pollinizers will undoubtedly prove their worth.

When pollinizers are used in the ratio of one to eight, a pollinizer planted every third tree in the row with two solidly planted main variety rows intervening gives the best distribution of pollen. When trees of more than one variety are used as pollinizers the varieties are planted in rotation. If the orchard is located on a site where there is a prevailing wind during the blooming seasons, pollinizers should be planted in the outer row toward the direction of the wind.

If any change in pollinizers is considered, it is recommended that early and late blooming varieties be included.

Grafting one limb in every tree to a pollinizing variety provides the best distribution of pollen but presents several difficulties unless nuts from these limbs are very similar to those of the commercial variety or so small they will not be picked up. If all nuts are harvested together, tolerance in grading rules may be exceeded. Grafting pollinizing varieties in the trees will delay production as the blossoming of grafted limbs will be behind the main part of the tree. The difficulty of obtaining a good stand of scions often still further delays nut production. In some cases several years have been required to graft in the required number of pollinizers.

In an orchard lacking pollination, it can be provided by bringing in limbs with unopened catkins of the proper variety. If this is done just as the first pollen is being shed and the limbs are put in buckets of water suspended in the trees, considerable viable pollen will be shed that will aid in setting a number of nuts. This procedure is not practical on a large scale, but it can be used in a limited way until the trees planted or grafted for pollination purposes begin to produce pollen.

Many growers have attempted to pollinate their filbert trees by bringing native hazel branches into the orchard at the time pollen is being shed. This has failed in every case noted, since the pollen of native hazel is incompatible with filberts.

**Methods of Propagation**

**Seedlings**

Seedling filbert trees are comparable to seedling apple trees in their variability. They should not be planted for orchard purposes as they do not come true to variety from seed.

**Cuttings**

Since the earliest publications concerning filberts, directions have been given for production of filbert trees from cuttings. Directions have been given for the use of hardwood, semi-hardwood, and softwood cuttings taken from either top or sucker growth. As sucker growth is more easily obtained, instructions usually call for 8- to 12-inch cuttings made from such growth. Suckers that come from far enough below the ground have lighter colored bark on that portion than on the part above the ground. Cuttings made with the light-colored bark at the base may root under proper conditions. Twenty
to 50% of such cuttings will root even if a whole sucker is used. This is the only condition under which general rooting is obtained, but better results can be obtained by allowing suckers to root while attached to the tree. As the use of bottom heat, various media, and stimulants have failed to furnish satisfactory results, propagation of filberts by cuttings in any form is too uncertain to be satisfactory.

Layerage

Layerage is a method of propagating plants by rooting stems or branches while they are still attached to the parent plant. Practically all filbert orchards have been planted with trees propagated by some form of layerage. Good layered trees have the base of the roots concentrated in a small space at the basal part of the tree trunk. Suckers usually originate from this part of the tree trunk and from the portion of the old layered sucker from which the tree was produced (figure 2). If tree roots are scattered along the remaining portion of the layered sucker, such trees when established in the orchard will produce suckers somewhat in proportion to the amount of layered sucker left on the tree. Good trees can be produced with roots massed on 2 to 4 inches of the base of the tree.

Except when high prices prevail for nursery stock, propagation by layerage in a bearing orchard cannot be advised. It is detrimental from the standpoint of tree growth and nut production. In young orchards the aim should be to produce trees that will yield heavily: hence suckers should be removed and not used for propagation purposes. Layerage of suckers from trees that have been grafted or budded is not practical since the rootstocks from which the suckers arise are seedlings, and the new trees will not be true to the variety.

Mound layerage

Mound layerage consists in piling earth around the base of a plant and causing the stem, lower branches, or suckers to take root. This is probably the simplest and oldest method of propagating filberts. Suckers grow up from the base or crown of trees. If they come from deep enough in the soil or if the soil is mounded up so that the base of the suckers is in moist soil throughout the season, they will take root. The oldest suckers, or the ones that started growth first in the spring, may take root by the end of the same year, but most of them will require a longer time. Even when rooted by this method, development of roots is so sparse and limited that
trees are usually not suited for planting in the orchard.

In order to obtain nursery trees that will produce few suckers when permanently planted, it is necessary to remove the lower portion of rooted suckers, leaving only roots that were formed nearest the surface of the soil. Rooted suckers should then be transplanted to the nursery and grown for a year or two until their roots have become strong and vigorous.

**Continuous layerage**

During recent years continuous layerage has been almost abandoned. At least 90% of trees propagated by this method are fan-shaped for the first few years. Roots tend to develop on the old layered wood and often at some distance from the new upright shoot.

Figure 3. A tip-layered filbert tree with the bases of the roots confined to a short space. If a tree of this type is set shallow with the roots pressed downward, suckering is reduced to a minimum.

As a consequence, the large amount of old layered wood planted with young trees is a source of never-ending sucker growth afterwards.

**Tip layerage**

Nearly all commercial layered trees are produced by tip layerage. In propagation by this method shoots are bent in a V-shape and the lower part of the V's are buried at least 6 to 8 inches deep. The ends of tips of shoots are placed in an upright position so that they may continue growth to form tops of new trees. Adequate soil moisture should be maintained so that root development will take place on the base of layered shoots.

Tip-layered trees will have buds and resulting limbs in a whorl around the trunk instead of in the form of a fan as with continuous-layered trees. First-class tip-layered trees do not have a crook at their base and have roots massed within a space of 2 to 4 inches (figure 3).

**Budding and grafting**

Budding and grafting have been used to a limited extent during recent years in the propagation of filberts. On the whole, the success of these methods has not been very encouraging because of failure to obtain regularly good stands of buds or grafts. These methods are used chiefly to propagate new varieties for which there is not enough material available for layerage purposes, and for propagating standard varieties on nonsuckering stocks. The process of budding and grafting filberts seems to demand more care than is usually necessary with fruits. Even under the best conditions uniform success is very rare. The cleft and the whip graft are used in grafting and the shield bud in budding. The scions in either budding or grafting are
usually covered with paraffin, which must be kept shaded.

Seedling trees to be used as rootstocks in budding and grafting are ordinarily grown from nuts of commercial varieties—usually Barcelona. Nuts can be stratified during the winter in moist sand and then planted in the field in the spring, or they can be planted directly in the field in the fall after harvest. The first method avoids loss of nuts caused by rodents robbing plantings during the winter. Seedlings grown from such seeds are not suckerless. Some may have very few suckers while others may have many. On the whole, such seedlings will probably average fewer suckers than layered trees of the Barcelona variety, because Barcelona is one of the most vigorous varieties known and produces suckers as profusely as any. In comparison some varieties produce very few suckers, so seedlings are apt to range between the two extremes in suckering.

There is a limited use of the Turkish filbert, Corylus colurna, for rootstocks on account of its nonsuckering habit. Unfortunately the behavior of this rootstock has been so variable under different conditions and so many conflicting reports have been received as to its suitability that no definite recommendation can be made at present.

Planting Filbert Trees

Time of planting

Early winter planting should be practiced with all fruit trees in western Oregon. This means that trees should be planted as soon as they can be obtained from the nursery in a dormant condition and when soil is in condition to be worked. Such early planting usually results in trees developing new roots during the winter season. When growth starts in the spring trees planted in early winter make more and stronger growth than spring-planted trees. Late planting does not give time for new roots to be formed before buds start growing. With a small root system, it is impossible for trees to take in a sufficient supply of water to cause good strong growth on recently planted trees. Late plantings should be avoided wherever possible, as trees will more or less stand still throughout the following summer and they seem to sunscald easily.

Planting distance

The minimum distance for planting filbert trees is 15 feet apart, but the recommended distance is 20 feet. In extremely fertile soils 25 feet may be preferred because trees in very fertile soil increase in size rapidly and corrective measures for crowding become necessary at about 14 years of age.

In the past it has been advocated that trees be planted close together with the idea of removing extra trees later when they have begun to crowd each other. Some very heavy crops have been harvested during the early life of orchards planted this way, but the objection is that few people will remove vigorous bearing trees at the proper time. Of those who have removed every other row of trees on the diagonal, to eliminate crowding, about one-half say they have regained maximum production in 3 years' time while the other half claim they have never regained high production.
Recent investigations indicate that by systematic-rejuvenation pruning in crowded orchards, production can be maintained even in closely spaced plantings without removing any trees. This will be discussed under the heading of pruning bearing trees.

The number of trees needed to plant an acre of orchard at different distances apart is given in Table 1.

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<thead>
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<th>Planting distance</th>
<th>Square or rectangular Trees per acre</th>
<th>Triangular or hexagonal Trees per acre</th>
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**Staking out the orchard**

The first essential in laying out an orchard is to establish base lines—two or more where the trees are to be planted on the square system and one where the orchard is to be laid out on the hexagonal 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 (figure 4). With a tape or other measure 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 the 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. (figure 4).

For laying off by the square system, 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, staking of the tract should start. By placing the wire over stake 1 and stake X, and drawing it taut, a stake can then be placed at point M (figure 4). The wires should then be moved over so that the ring 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 remeasuring 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 it will probably be found that the use of wire is the quickest and simplest method that can be employed for land not too uneven.

A single long wire with soldered points on it indicating the points at which 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 (figure 5), draw the wires tight, and set a stake at M. Then move over until the rings are 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 that 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 that the third row will be lengthened out to the normal length.

Many older orchards are planted on the hexagonal system, because of the supposed advantage of planting more trees to the acre at any given distance apart. But in those cases where trees began to crowd because of the unexpected size attained, owners were confronted by the impossibility of uniformly thinning the stand. Quite a number of growers at present face this situation, and because of this fact alone, hexagonal plantings are not recommended. Unless some effective pruning practice can be developed that will control the size of filbert trees, thinning the stand of trees in the orchard will be a necessity for the majority of present orchards.

**Using a planting board**

A planting board is of value to set trees in line after the field has been staked out. This board is 3 to 4 feet long with a notch at each end and another at one edge in the exact center. Before digging the tree hole the planting board should be so placed that the stake, showing where the tree will be, fills in the center notch. A stake should then be placed at each end of the board after which the center stake and the board can be removed. After the hole is dug, the planting board should be placed over the two remaining stakes in the original position. With the tree trunk 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.

**Figure 5.** Laying out the orchard by the hexagonal method.
Setting the trees

It is not advisable to dig tree holes considerably in advance of planting. Exposure of soil to weather tends to harden the sides of the holes, especially in certain types of soil, so that tree roots will not easily penetrate the soil.

During all operations incident to transplanting trees, care should be taken to prevent roots from drying out, especially in the case of 1-year-old trees, the roots of which are fibrous and very tender. Trees should be kept in a barrel of water or covered with moist earth or sacking at all times until planted.

Before planting trees, the remaining parts of the original layered wood should be pruned away as much as possible. On 2-year-old trees old layered shoots should be removed and broken ends of the main roots smoothed off.

Deep planting should be avoided but trees should be set so that the roots are in moist earth during the dry season. Late planted trees have to be set deeper than ones planted earlier because their root systems will not be so completely developed by the time of the dry season. Some growers set trees on a small mound within the hole and then press the roots downward along the sides of the mound so that the ends of the roots will be deep enough to be in moist soil throughout the summer. Fine earth can be sifted around the roots and packed with the hand to avoid open air spaces which allow the roots to dry out. After this, 2 or 3 inches of soil should be placed on the roots and tramped down firmly. No damage will result from trampling if sufficient soil is placed on the roots before they are packed. Above this, loose soil should be placed to form a mulch to prevent evaporation from the firmly packed soil beneath.

Young trees grown in a crowded nursery have not developed a tough resistant bark. The practice of planting trees as shallow as possible frequently places the bark that was below the soil line in the nursery above the ground, thus exposing very tender tissues to sunlight. Unless trees are protected from direct sunlight, sunscalding frequently results on the southwest side of the trunks. Such injured spots on trunks provide an entrance place for filbert disease organisms and as a result many trees are killed. To prevent sunscald some sort of protection should be placed around the trunks. Protection can be made of newspaper mats, heavy magazine paper, or any cheap material that will last for two or more years until the bark on the trunk becomes thick and resistant to sunscald. Trees should not be wrapped too tightly since the material may bind and girdle the tree when the diameter of the trunk increases. Whitewashing trunks is sometimes resorted to, but protectors seem to be more effective in preventing sunscald.

The same protection should be used against winter injury as for sunscald, since protection will prevent excessive fluctuations in the temperature of the bark when sunlight is reflected from snow onto the bark. This reflection raises the temperature of the bark considerably above that of the air, and, when cold night temperatures follow, killing of the bark in that area may result.

All filbert trees should be protected from the first two or three years after planting.
Pruning at time of planting

After trees are planted, tops should be headed back to correspond with the reduction in the root system. In transplanting, a considerable portion of roots is lost and the water-absorbing capacity of the plant is materially reduced. If tree tops are left at their original size, their root systems will be unable to provide sufficient moisture to replace that lost by transpiration and trees will gradually die back and in some cases completely die. Generally, cutting tree tops back to a height of 18 to 24 inches will be satisfactory. Trees cut back at planting as directed generally attain a larger size in less time than similar ones not cut back.

The exact height at which a tree should be cut off when planted is not always related to the height of the tree in later years. With filbert varieties that grow upright, the relation is direct; but with this type, attempts to develop high-headed trees are not of much importance. With drooping, spreading filbert trees, later training and pruning are of greater importance than the height at which they are cut off when planted. If the tree is a straight whip, it should be cut off at the desired height. If it is branched, the laterals should be cut back to a few buds, or all laterals may be removed and the tree treated as a whip.

Pruning and training young trees

Pruning, whether cutting back or thinning out new growth of young trees after they have become established, results in smaller trees in comparison with similar unpruned trees. Young unpruned trees will be the largest, the first to come into bearing, and will produce the heaviest crops. Unpruned trees, however, usually de-

velop branches close together and crossing limbs, which will require removal later. Cutting off large limbs makes large wounds, which provide a place of entrance for various fungi. Filberts seem to be especially susceptible to wood rotting fungi. Furthermore, it takes longer for filbert trees to heal over a wound than most other kinds of trees. Removing excess branches while they are small results in wounds that readily heal over, and early pruning for this purpose is advisable even though it results in decreased tree size.

Cutting back the tops of trees at the time of planting, whether they are straight whips or with short laterals, results in the formation of many shoots. Careful selection of desirable shoots and removal of those not desirable can be done during the early summer of the first year, so that little actual growth will be lost. If all shoots are allowed to grow, so many extra limbs will usually be formed that considerable shoot growth will have to be pruned out. This serves to decrease or limit the size of the tree for the first year. If excess shoots are removed as soon as it is possible to determine which ones are satisfactorily placed, preferably while the shoots are still red in color and easily broken off, little loss in growth results.

Permanent scaffold limbs, 3 to 5 in number, chosen from new shoots as outlined above, should be well spaced up and down and around the trunk. With the short trunks advised, the spacing apart of the limbs, as recommended for most fruit trees, cannot be used and, in fact, is not essential. Apart from breakage caused by snow or sleet, no reports have ever been received of filbert trees breaking in
A modified leader type of tree is very difficult to develop with filbert trees and adds little to the trees' value, since breakage is such a minor factor.

A large number of laterals will be produced between the base and the tip of scaffold branches. Most of these laterals will be short and only a few will have length and diameter enough to be secondary scaffold limbs. If secondary laterals are too numerous or poorly located they may be removed, but as a rule, this is not practical. Small, weak shoots, if left, will become the first fruiting wood. After a few years they will be shaded out and die, or they can be removed after their fruitfulness is past. Leaving small, weak shoots in the tree helps to prevent the formation of undesirable water sprouts, which will appear if such shoots are removed. Water sprouts tend to grow upright, interfering with the development of the permanent part of the tree.

Pruning bearing trees

Pruning of bearing filbert trees up to now has been largely "convenience pruning." Low hanging branches that interfere with cultural practices, and removal of dead or broken branches have been the main object of pruning. Recent experimental work, however, indicates that heading back trees into 3- and 4-year old wood stimulates new growth, especially close to the point where the cut is made.

This newly stimulated growth is highly productive and is helpful in maintaining production in old crowded trees. This type of growth is proving to be so successful in maintaining vigor of crowded trees that removal of alternate rows of trees to overcome crowding with its accompanying drop in production is no longer recommended.

Heading back should be done just above a lateral branch so that no dead stubs will be left. If the cut is made where buds or shoots have grown some time in the past, adventitious buds are likely to develop also. When branches 1½ inches or more in diameter are cut off, the wound should be allowed to dry from 2 to 4 weeks, then it should be painted with Bordeaux and linseed oil paste. This paste is made by stirring raw linseed oil into one of the commercially prepared powdered Bordeaux mixtures until a thick, smooth preparation, the consistency of house paint, is formed.

Removing Suckers

All filbert varieties and all rootstocks except the Turkish hazel, Corylus colurna, will sucker more or less. Suckering can be reduced by the use of properly grown nursery stock, good root pruning before setting, and proper planting practices. Prompt and careful removal of suckers during the first few years after planting greatly reduces the labor required for this operation in later years.
to four times a season for a few years. This operation must be repeated at the proper time, which is when a new crop of suckers appear above the ground and before they harden. If this procedure is followed on good trees, properly planted, less time will be consumed than if suckers are removed once or twice a year after they have become woody. If consistently carried out, suckering will be reduced so that by the time the trees are bearing little time will be required.

Suckering once a year does little to reduce growth. Cutting off just below the surface of the ground simply multiplies the number of suckers that grow.

Filbert cultivation practices are essentially the same as for other kinds of fruit trees. Under conditions prevailing in filbert growing districts of the state, cultivation is primarily for the purpose of conserving moisture during the growing season. During the past few years the tendency has been for growers to reduce the frequency and depth of cultivation. This tendency is in line with results obtained in soil investigations, which show that cultivation that destroys all weed or cover-crop growth and maintains a shallow mulch is sufficient.

Under ordinary seasonal conditions plowing or disking the orchard should be done during the early part of April, as after that time rainfall usually decreases. Cover crops of any kind grow rapidly then, using not only moisture received by the soil as rainfall but also a part of that stored during the period of heavy rains. A cover crop can safely be allowed to remain on the soil during the rainy period, but after that time it should be turned under. Turning under cover crops or other vegetative growth early in the season stops loss of water by transpiration except by filbert trees. Later rainfall helps replace water used by the trees. If both trees and cover crops are using moisture from the soil at the same time, the withdrawal of moisture may be so great that in the summer there may be an insufficient amount for the trees. In many seasons, early growth of cover crops may be poor and there will be very little green manure material to turn under at the time it should be destroyed. As far as the crop of nuts is concerned, however, it is best to plow the cover crop under at the proper time rather than to wait for additional growth to be made.

Maintenance of soil fertility

In maintaining soil fertility, a program that insures the incorporation of large amounts of organic matter into the soil is of first importance. Growing cover crops is the cheapest and usually the most satisfactory method of supply-
ing organic matter. Vetch such as hairy, Willamette, or common, with some grain such as wheat, oats, or rye is the most commonly grown cover crop and the one most generally suited to various soils. Vetch seed should be sown in early September at the rate of 40 to 50 pounds per acre with an equal or variable amount of grain. In many cases the greatest growth occurs in late spring after the time that crops should be turned under to avoid loss of soil moisture. There is a tendency to delay turning vetch under in order to obtain a greater quantity of green manure.

Vetches have a fairly definite dormant period, little affected by temperatures during which growth is suspended. Since resumption of growth is often so late in the spring that little spring growth occurs before time for plowing under, the time is too short in Oregon for fertilizers to be effective in increasing cover-crop growth.

Where they can be grown, early maturing cover crops offer an important source of organic matter. Winter-hardy crimson clover sown at the rate of 10 to 15 pounds per acre, turnips 2 to 5 pounds, and even common mustard, sown 2 to 10 pounds per acre, respectively, give heavy crops on some soils. These crops mature early and the seed is relatively cheap. The seed of common mustard should be screened out of winter grain, as seed screened from spring-sown grain has very low germination.

All cover crops should be sown early in order to obtain as much growth as possible before cold weather. The preferable time for sowing is the first part of September, immediately after the first rain that is heavy enough to wet the soil to a depth of 6 to 8 inches. When the cover crop is sown in dry soil, early September rains may sprout seed and, if followed by a dry period, small seedlings may be killed by consequent lack of moisture. On the other hand, if early rains continue, by harvest time there may be a heavy ground cover of sown crops and native weeds that materially interferes with picking up nuts. Nevertheless, the value of a high-yielding cover crop for nut production is so great that it should be seeded in early September, if possible.

On some soils cover crop growth can be greatly increased by the use of commercial fertilizers, and this may be the most satisfactory method of using commercial fertilizers in filbert orchards. Commercial fertilizers applied directly to trees showed no profitable or beneficial results until in the season of 1943 when decidedly beneficial returns were obtained by the use of commercial fertilizers. Nitrogen is low in nearly all soils where filberts are grown, but a fertilizer carrying nitrogen alone seldom benefits a cover crop. Practically all soils on which filberts are grown are also low in either sulphur or phosphorus or both but the amount of potash seems to be adequate in all soils of valley floor types, but not hillside types. Soils of the Olympic, Melbourne, and Aiken series are low enough in potash that addition of potash in fertilizer mixtures has increased the quantity and quality of the nuts produced. In these hillside soils the application of 10 pounds per tree of 60% muriate of potash has been significantly beneficial in experimental plots with trees 20-25 years of age, but without benefit on Willamette, Chehalis, or Salem sandy loam. On that account commercial fertilizers usually should contain phosphorus and sulphur as well as nitrogen.
In experimental work on filbert trees and cover crops, commercially fertilizers most successfully used have contained 675 pounds of ammoniated phosphate 16-20-0 for nitrogen and phosphorus, 313 pounds of gypsum for sulphur, and 200 pounds of muriate of potassium. With cover crops, one-half of the above amounts has given good results but when one-fourth of these amounts was used on cover crops in mature orchards very little benefit was obtained. It takes about twice as much commercial fertilizer on cover crops in mature orchards as it would on the same crops in an open field. Only the full amounts given have been used on trees directly so it is not known what the effects on trees might be if lesser amounts were used.

Quickly available fertilizers like nitrate of soda are of little value applied in the fall as they leach out so quickly that plants obtain only a small part of the nutrient. Applied in late winter or early spring they have been more successful. Ammoniated phosphate 16-20-0 and ammonium sulphate as sources of nitrogen applied either in the fall or late winter have been most satisfactory, and when combined with the other necessary materials listed above have given the best returns. Regardless of the exact materials used, however, amounts have been adjusted so that approximately 100 pounds of nitrogen have been applied per acre, with 135 pounds of phosphorus as P₂O₅, 50 pounds of sulphur, and 100 pounds of potassium as K₂O. Varying a few pounds according to the materials used.

Barnyard manure, seldom obtainable in any large quantity, is the best material to use in fertilizing cover crops and filbert trees. With some soils it has been necessary to top dress with manure before a satisfactory cover crop growth could be obtained. Where barnyard manure is not available, many types of strawy material have been used successfully. Residues of leguminous crops like vetches, alfalfa, or any such legume material are superior to grain straw, because of their higher nitrogen content. Decomposition or breaking down of strawy material to render plant nutrients of this organic matter available for plant use is done by soil bacteria. These soil bacteria require a supply of nitrogen and if insufficient nitrogen is present in the strawy material to satisfy their needs, nitrogen will be withdrawn from the soil. This deprives the trees of needed nitrogen. To overcome this, about 100 to 150 pounds of ammonium sulphate should be applied for each ton of dry straw applied to the soil. Apparently the straw should not be plowed under in early spring just as growth is starting, as even the use of ammonium sulphate does not prevent a temporary depletion of nitrogen.

Lime added to the soil is of value only for leguminous crops and only in a few districts having high soil acidity. As a soil amendment or fertilizer for filbert trees themselves, it is of questionable value.

**Intercrops with Filberts**

Intercrops have not been commonly grown in filbert orchards. Operators who have grown intercrops generally have had small farms and could not afford the loss of income from the land during the development of filbert orchards. With filbert trees planted 20 to 25 feet apart, the area that can be advantageously devoted to intercrops is limited. Practicing intercropping
usually means growing a high-income-producing crop requiring considerable labor. Truck crops and berries have been profitably used as intercrops especially by growers who already were producing them as a regular practice. As most orchards have been planted by tree-fruit growers, however, or by general farmers who have not been equipped, located, or inclined to handle such intensive crops, filberts usually have been raised without intercrops.

Annual crops are more satisfactory for intercrops than perennial crops, as space required by filbert trees can be

**Bearing Age**

A few nuts may be produced by any filbert variety the first or second year after planting. This is especially true when trees have been grown in the nursery for a year or more after rooting. Nevertheless, the average orchard cannot be expected to return a profit on cultural operations before it is 5 or 6 years old. After that age each additional year should produce an increase in crop until the orchard is 10 to 12 years of age, when, with most orchards, fluctuating annual yields will begin.

From limited available records, it is impossible to determine when an orchard should reach maximum production. This depends on many factors such as variety, fertility, soil, planting distance, and so forth; but apparently many orchards have reached that point at 15 to 25 years of age. There are no data to indicate how long an orchard will remain in profitable production.

**Harvesting, Drying, and Marketing**

Filberts are picked up after they are fully mature and have dropped to the ground. Varieties that do not naturally free themselves from their husks must be husked out by hand or machinery.

Many different types of field harvesting machines are now in use and the cost of harvesting has been drastically reduced by the use of these machines. There are some machines that pick nuts up off the ground; hull them; remove blanks, dirt, and stones; and pour them into sacks. The most commonly used machines, however, are really field cleaners. Nuts are hand raked into piles or windrowed by a side delivery type sweeper—then nuts, leaves, and litter are dumped by hand into a hopper on the machine and the cleaned nuts are run into the sacks. The blanks, leaves, twigs, dirt, and stones are discarded by the machine.

Prompt harvesting of the filbert crop, although desirable, is not as essential as with soft fruits. Nuts should be gathered two or three times during the season. Filberts lying on the
ground for any length of time gradually darken. Rainy weather increases the discoloration of shells.

Damp or undried filberts should not be stored in a sack or large container 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 as they will not mold as easily when spread out on the ground. Delay in harvesting, however, does not produce the best product. Since present market requirements demand that nuts must be clean, washing is a general practice. Only under exceptional seasonal conditions will nuts be clean enough to market when brought in from the field without being washed. Various types of washing machines and equipment are used for this purpose.

Artificial drying at temperatures of 90° to 100° F. is used in practically all cases. It is only with small crops or in very dry seasons that filbert nuts can be dried without artificial heat by being spread out in a thin layer. As nearly all filberts are shipped to out-of-state markets, if too much moisture remains there will be loss in weight and spoilage before they are consumed. To avoid any possibility of this loss, nuts should be dried until their moisture content is reduced to 8 to 10%. Kernels containing 8 to 10% moisture snap if bitten when cold.

Driers of various types are in use—prune driers, hop driers, and bin driers. 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 to be handled.

Many inexpensive, fairly efficient driers have been made by remodeling old buildings already on the ranch. The heating unit should be placed 8 to 10 feet below the floor on which filberts are spread and sufficient openings made in the lower side walls to allow entrance of cold air. The drying floor is made of wire cloth laid on strips 1 by 2 inches or 2 by 3 inches, so that at least 50% of the floor space is open, allowing air to pass upward. Outlets in the roof of sufficient size to allow free upward movement of air should be provided. Few growers maintain drying temperatures continuously for 24 hours a day. Aid in designing new driers 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, those containing no kernels can be separated from the good ones by pouring all of them into water and then picking out the ones that float high. This is a slow process but with a little experience can be well done.

Filberts are marketed by grades established by the Oregon State Department of Agriculture. There are numerous grower cooperative associations as well as independent buyers scattered throughout the state.