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HOP production

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Hops were introduced into North America by the Massachusetts Company in 1629 and were grown for domestic use in New Netherlands as early as 1646. By 1648 production had spread to Virginia. Hops were not an important field crop in this country, however, until about 1800. The first commercial hopyard was established in New York about 1808, and by 1849 New York produced more than 1 million pounds annually. Total production along the eastern seaboard at that time amounted to 1,500,000 pounds annually.

Following the Civil War, the industry spread rapidly through Pennsylvania and into Wisconsin, where 5 million pounds were produced in 1869. The industry grew in New York during the same period, and more than 21 million pounds were produced in that State in 1879. The industry in New York was practically wiped out by downy mildew during the 1920's. It showed a small revival during the 1930's, but New York has not been an important hop-producing State since World War I.

The industry in the Pacific Northwest started between 1849 and 1869. Although New York led in production at the turn of the century, both Oregon and California outproduced it by 1909. Washington, California, and Oregon have been the major hop-producing States since the industry reached the Pacific Coast (fig. 1). Since 1950, Idaho has also become a major producer of hops. Production data for these four States are given in tables 1 and 2. The State of Washington is the largest hop producer, and since 1953 it has accounted for more than half of

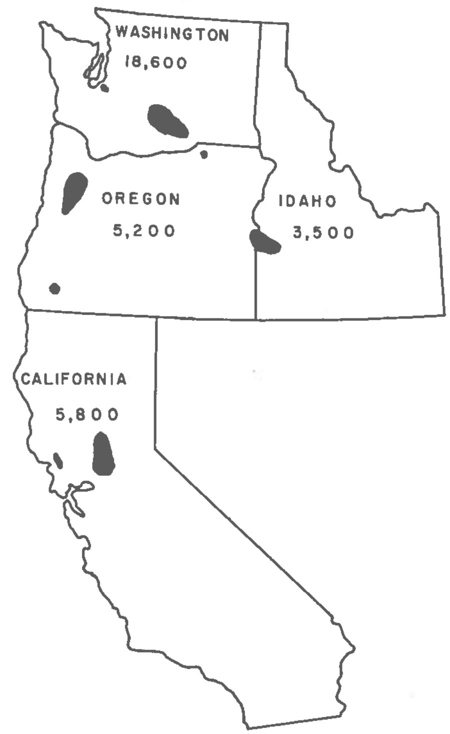


Figure 1.—The principal hop-producing districts of the United States and acres harvested by States in 1959.

TABLE 1.—*Average hop production by States, 1940–59, inclusive*

Period	Average production (million pounds)					Average production (percent of total)			
	Oreg.	Wash.	Calif.	Idaho	U.S.	Oreg.	Wash.	Calif.	Idaho
40–44	16. 387	13. 825	11. 314	[1] 0	41. 526	40	33	27	[1] 0
45–49	17. 283	20. 830	13. 860	0. 278	52. 251	33	40	26	1
50–54	13. 117	24. 493	13. 080	2. 907	53. 597	25	46	24	5
55–59	5. 459	25. 240	8. 093	4. 688	43. 480	12	58	19	11

[1]No production figures for Idaho were reported until 1949.

TABLE 2.—*Acreage, yield, and value of hops grown in the United States, 1948–59, inclusive* [1]

State	Acres harvested			Yield per acre			Total farm value	
	Average, 1948–57	1958	1959	Average, 1948–57	1958	1959	1958	1959
	Number	*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Thousand dollars*	*Thousand dollars*
reg.	9, 920	5, 000	5, 200	1, 150	1, 080	1, 340	2, 916	3, 205
Vash.	13, 880	19, 000	18, 600	1, 670	1, 490	1, 640	15, 854	14, 465
alif.	7, 490	5, 900	5, 800	1, 510	1, 530	1, 610	5, 416	5, 323
daho.	1, 447	3, 500	3, 500	1, 846	1, 620	1, 940	3, 062	3, 195
U.S.	32, 737	33, 400	33, 100	1, 490	1, 449	1, 619	27, 248	26, 188

[1]Taken from Oregon Crop and Livestock Reporting Service, U.S. Department of Agriculture, and Oregon State College, 1959.

he total U.S. production. California showed a decrease in production after 1952 but maintained its place as the second largest producer. Prior to World War II, Oregon produced almost 40 percent of the total crop in the United States; but it was in third place in 1959. On the other hand, Idaho produced less than 1 percent of the total crop in 1947 but 13 percent in 1959.

A 1957 survey showed that the hop acreage was 27,700. Hop acreages varied from small yards of 1 to 5 acres on diversified farms to 1,600 acres on specialized units growing hops in several yards. Most hop farms consisted of 25 to 75 acres.

From 1948 to 1957 the number of growers was reduced to approximately half, and the size of the individual units increased from about 42 acres per grower to about 63. During this period, the total U.S. acreage decreased from more than 40,000 acres to less than 30,000. These statistics indicate that the acreage reduction resulted from many small growers going out of the hop business. This was undoubtedly caused by an unfavorable market situation during the mid-1950's brought about by an unbalanced supply-disappearance ratio. While total acreage increased to more than 33,000 acres in 1958 and 1959, there was no indication that many small growers were going back into business.

Rather, this was mostly a reflection of increased acreage per holding.

The largest single use of hops today is in the manufacture of beer. Approximately 98 percent of the world hop production goes into the manufacture of that food beverage. Hops are used also as filtering agents, as medicinals and pharmaceuticals, and as food.

DESCRIPTION OF HOP PLANT

The commercial hop plant (*Humulus lupulus*) is a perennial that produces climbing annual stems from a perennial crown and rootstock. In a single season, stems may grow 20 to 25 feet; and they will die back to the crown after maturity. Stems twine around their support in a clockwise direction. They possess strong, hooked hairs, which help the plant cling to its support. Hop plants are remarkably vigorous, sometimes growing 6 to 12 inches in 24 hours. The leaves are dark green, hairy, somewhat heart shaped, and deeply lobed (3 to 5 lobes) with toothed edges. Leaves are borne in pairs, opposite each other on the stem. Long lateral branches (side-arms) bear most of the crop.

The perennial crown becomes woody with age, having heavy, rough, dark brown bark. Both fleshy storage roots and slender feeder roots are produced. An extensive root system may penetrate the soil to a depth of 15 feet or more. In addition to the true roots and aerial stems, the crown also produces underground rhizomes. Rhizomes possess numerous buds and are used for propagation.

Hop plants are generally unisexual, but occasionally male and female flowers may form on the same plant. Only the female plants produce the hops of commerce. The female flowers are borne in clusters on the upper part of the main stem and on the side-arms. As the female flowers mature, they form conelike structures (strobiles) composed of a central stem or strig that bears many bracts and bracteoles (petals). The mature hop cones are 1 to 4 inches long, oblong, yellowish green, and papery to the touch; and the petals and seeds bear numerous yellowish, glandular bodies called lupulin. These mature cones, after processing, constitute the hops of commerce. The medicinal properties and the characteristic aroma and bitter taste important in brewing are attributed to the essential oils and resins contained in the lupulin.

Hops are either seedless or seeded. Seeded hops result when the female flowers are fertilized by pollen from male flowers. Seedless hops result when pollination and subsequent seed formation are prevented by the elimination of all male plants in the area. In general, seeded hops are larger and heavier than seedless hops; but brewers feel that seeds in hops are undesirable. Seedless hops tend to shatter less during picking than do seeded hops. More seedless hops are grown today because growers usually receive a price premium for them.

CLIMATE AND SOILS

Hops are adapted to a wide range of climates and soils. They are grown commercially in the semiarid districts of the Yakima Valley of Washington and the Boise and Snake River Valleys of western Idaho and eastern Oregon, where the annual rainfall is less than 8 inches. They are also grown commercially in the Willamette Valley

Oregon, the Puyallup district western Washington, and the cramento and Sonoma districts California, where the annual infall is from 23 to 40 inches and curs mostly during the winter.

Average July temperatures range om 64° to 78° F. from one district another. Maximum temperares seldom exceed 100° in western regon and western Washington, it they may go as high as 110° 118° in the interior in Washingn, Idaho, and California.

Hops are produced successfully districts that sometimes expeence January temperatures of 35° F., but most hop-growing stricts are not subject to severe inter temperatures. The frostee period where hops are grown mmercially ranges from 136 days the Upper Yakima Valley to)0 days in the Sacramento Valley. [ops are grown commercially at evations from near sea level in ie Pacific Coast States to over 200 feet above sea level in Idaho. 'hey grow, though not commerally, at elevations near 7,000 feet the mountainous districts of Vestern United States.

Long, severe winters sometimes ill out many plants, particularly newly planted yards. Continued old, damp, or foggy weather in ie spring may delay normal field perations and may result in rerded, weakened growth of vines. 'hese conditions also favor the deelopment and spread of downy ildew, which is the most serious op disease in this country.

Excessive rainfall in August and September frequently results in eavy damage from aphids, molds, nd downy mildew. Extremely dry easons or prolonged hot, dry winds dversely affect normal crop develpment. Most of the hop crop is roduced under irrigation, even in hose districts that have heavy vinter rainfall.

Selection of the best soil for hops nvolves several factors—depth, fertility, texture, and drainage of the soil. In general, rich, alluvial soils or deep, sandy or gravelly loams are preferred. Soils with a high percentage of sand are more easily tilled. Heavy, wet soils and those that are strongly alkaline or saline should be avoided unless reclamation can be obtained by adequate drainage or proper soil treatment. Poorly drained soils are conducive to root rot and should be avoided. Because the roots of the hop plant may penetrate to a depth of 15 feet or more, a deep, well-drained subsoil is desirable. Soil maps are available for most hop-growing districts, and growers should consult them to determine the suitability of any particular site.

Most hops are produced in the medium and coarser textured soils of alluvial origin. These soils include the sandy loams and silt loams in river bottoms or along valley floors. Hops are grown with success, however, in finer textured silty clay and clay loam soils. Some hops are produced also in volcanic ash, particularly in the Yakima Valley and in western Idaho. In western Washington and Oregon, the pH value of the soil commonly varies from 6.0 to 7.0, but it may be as low as 5.3 in some yards. In the Yakima Valley of Washington, the pH value of the soil varies from 7.0 to 8.0 in most cases; but there are hop-producing soils that have a pH value greater than 8.0.

Topography of the land must also be considered. In general, gently sloping lands are best, since they lend themselves easily to irrigation and do not require undue expense for construction and upkeep of the trellises. Gently rolling lands are used in some areas, and they require the use of sprinkler irrigation systems. Rolling lands occasionally present problems in trellis construction that require irregularities in design.

VARIETIES

Three principal types of hops were grown in the United States in 1959: (1) The Cluster type, which includes the Late Cluster and Early Cluster varieties; (2) the so-called English type, which includes the Brewers Gold and Bullion varieties; and (3) the type characterized by the Fuggle variety. These three types of hops were introduced into this country during the early stages of the hop-growing industry in the United States, or else arose from an introduced variety either as a seedling or a bud sport. Except perhaps for the Cluster varieties, none of these is strictly of American origin.

Cluster Type

The two varieties included in this type are the most widely grown hop varieties in the United States. Late Cluster probably originated as a seedling of English Cluster during the early settlement of the eastern seaboard and was carried to the west coast by early settlers. Early Cluster probably originated in Oregon about 1908 as an early-maturing bud sport in a yard of Late Cluster.

These two varieties occupied approximately 88 percent of the total U.S. hop acreage in 1959. They are used extensively and almost interchangeably by the brewing industry and comprise the greatest bulk of the export market. Late Cluster is a medium-maturing variety that is grown throughout the Sacramento Valley of California, the Yakima Valley of Washington, and the Boise Valley of western Idaho. It occupies a small acreage in western Oregon. Early Cluster is grown in the same districts to a large extent. It is not grown in western Oregon and western Washington, nor in California to any extent.

Both varieties are vigorous, high yielding, and well adapted to picking by machine. They are susceptible to downy mildew, Early Cluster being more susceptible than Late Cluster. Early Cluster is similar to Late Cluster in quality and growth characteristics, but it matures approximately 10 to 14 days earlier. Each variety yields 2,000 pounds or more per acre, grown seedless under favorable conditions, and possesses approximately 5 to 7 percent alpha-acid at maturity.

English Type

Brewers Gold and Bullion varieties were developed at Wye College in England about 1919 as selections from a cross of a wild Manitoba female with an English male plant. They were introduced into this country during the 1930's, and they occupied somewhat more than 2 percent of the total hop acreage in 1959. They are medium to late maturing, with Bullion maturing approximately 10 days earlier than Brewers Gold. Neither variety is as resistant to downy mildew as Fuggle, but each can be grown successfully in the Willamette Valley of Oregon if effective downy mildew control measures are taken. Both are vigorous, yielding 2,500 pounds or more per acre when grown seeded; and they pick well by machine. They are very rich in alpha-acid, possessing 8 percent or more at maturity, a fact that at present limits their acceptance by some segments of the American brewing industry. They are also very high in essential oils, which makes them desirable to those brewers who use highly aromatic hops.

Fuggle Type

The Fuggle variety was selected as a chance seedling in England about 1861 and was introduced into this country during the latter half the 19th century. It is early ıturing and has considerable re- ıtance to downy mildew. Al- ough it is not a heavy yielding riety normally, it is grown to a ·ge extent in the Willamette Val- ý of Oregon and to a small ex- nt near Puyallup, Wash., where e growing of downy-mildew- sceptible varieties is difficult. ıggle occupied approximately 10 ·rcent of the total U.S. hop acre- ·e in 1959. It normally yields 200 to 1,400 pounds per acre of ɔps, grown seeded, and contains 5- to 5.5-percent alpha-acid at ma- rity. Fuggle is not grown so ex- nsively in this country as is the luster type. It is not well adapted machine picking because of its ndency to shatter, and it is sensi- ve to high temperatures.

Variety Improvement

None of the varieties mentioned ·presents the ultimate in desirable agronomic characteristics. The Cluster varieties are very suscepti- ble to downy mildew and root-rot organisms. Fuggle is not high yielding and often shatters badly. Brewers Gold and Bullion require low temperature storage for reten- tion of quality characteristics and require control for downy mil- dew. The U.S. Department of Ag- riculture; the Land-Grant Colleges of Oregon, Washington, Califor- nia, and Idaho; and the brewing industry are all actively engaged in developing improved varieties to correct these deficiencies.

Scores of crosses are made at Corvallis, Oreg., every year among many of the approximately 75 male plants and 300 female plants (fig. 2). Seed from the crosses is threshed and planted in greenhouse flats during the winter. When the resulting seedlings have reached the proper size (fig. 3), they are inocu- lated with a spore suspension of

ɪGURE 2.—Crossing block at Corvallis, Oreg. Technician is placing parchment bags over female flowers to exclude unwanted pollen. Pollen from desirable male plant will be used to pollinate the flowers at a later date.

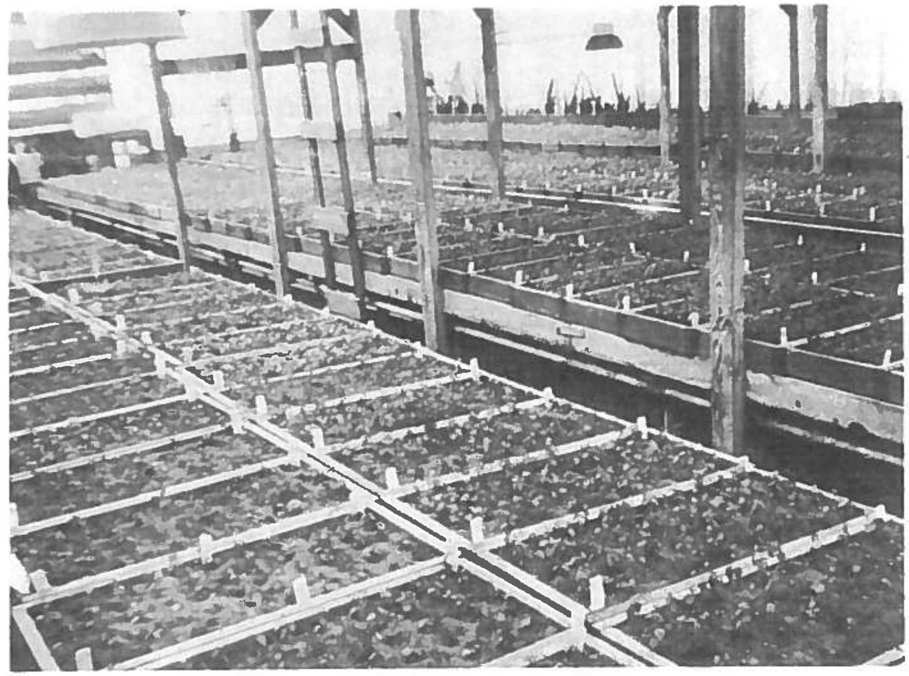


FIGURE 3.—Seedlings being grown in greenhouse flats. Thousands of seedlings are tested in this stage for resistance to downy mildew fungus.

downy mildew fungus. From 5,000 to 30,000 seedlings are treated an- nually in this manner. Seedlings that do not become infected by the fungus are saved and moved to the field for further testing. The re- maining plants undergo intensive testing for yield performance, re- action to diseases, and adaptability to machine picking. Quality is de- termined by both physical and chemical means (fig. 4).

The development of new and the improvement of existing varieties by selection merit the attention of every hop grower; however, such work is best undertaken by the plant breeder. Growers can, and do to some extent, take cuttings from plants of exceptional quality and vigor and increase the planting stock as an improved variety. Mixed varieties and light and

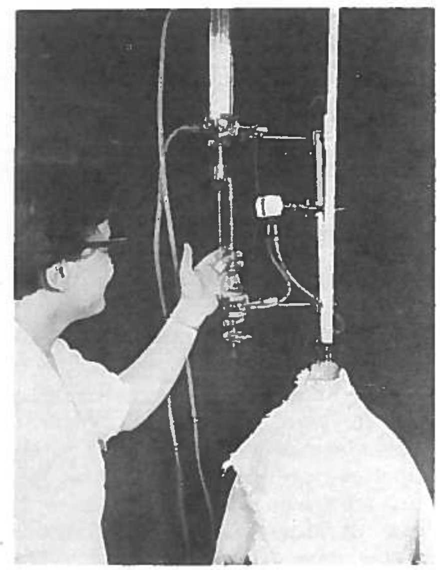


FIGURE 4.—Determination of essential oil content in hop samples by distillation. (Courtesy, Oregon State College.)

eavy producers occur in almost very field. Experiments at the)regon Agricultural Experiment tation have shown that a decided nprovement in production can ollow the careful selection of uniorm and highly productive plants or use as sources of planting stock. Because of the seasonal variability n production of individual plants, hey must be observed for more than ne season. Selection should be nade just before harvest when the lants can be staked, so that cuttings can be taken from them after they become dormant.

Some hop growers are more interested in introducing foreign varieties than they are in improving the planting stock at hand. Foreign introductions by growers must be cleared through official channels, where they are inspected to detect the presence of insect pests and diseases. Because of technical difficulties, the introduction, testing, and eventual distribution of the more promising foreign varieties are best undertaken by experiment stations.

ESTABLISHING THE HOPYARD

Trellises

Hops are grown on high wire rellises in this country (figs. 5, 9, 1). Since the crop is harvested lmost entirely by machinery, trelses are usually constructed to failitate this practice. Heights may ary from 16 to 22 feet, but the nost common are 17½ or 18 feet. A few yards in western Oregon nd western Washington still have rellises from 12 to 14 feet in height.

The type of pole used to support he trellises varies according to vailability, cost, and local tradiion. Untreated split cedar and awed redwood are used extenively. Split or whole-trunk pine nd Douglas-fir are also used videly. Pine or fir poles are usully treated with preservatives to nake them more durable. The oles are usually 4 to 8 inches in iameter and from 20 to 22 feet in ength, with the larger poles being sed in the anchor rows.

In the interior of the trellis, the oles are set upright in holes 1½ o 2 feet deep and extend about 18 eet in the air. Anchor poles round the edges of the yard are sually longer and are set at an ngle of about 70°, leaning outvard. Anchors commonly consist f sections of hardwood, cedar poles, or concrete blocks buried 4 feet in the ground. Some growers use manufactured spread anchors or auger-type metal anchors. A ⅜-inch cable or double-strand No. 00 wire is attached to bolts or wires coming from the buried anchors and extends to the tops of the anchor poles. No. 00 black annealed iron wire is extended in one direction across the tops of the poles or set in notches near the tops. No. 6 or No. 7 galvanized iron wire is extended along each row of hops in the other direction. The lighter wire, commonly called the stringing wire, is supported from the No. 00 main line wire by S-shaped wire hooks if the stringing wires are laid underneath. This type of construction was used widely in the past when the stringing wires were lowered for convenience in handpicking.

In the newer yards, which were established intentionally for machine harvest and in which the stringing wires are never lowered, the stringing wires are laid on top of the main line and need no other support. The ends of the stringing wires are attached to the tops of the anchor poles at the edges of the yard or to a main line wire extending the length of the yard. If the

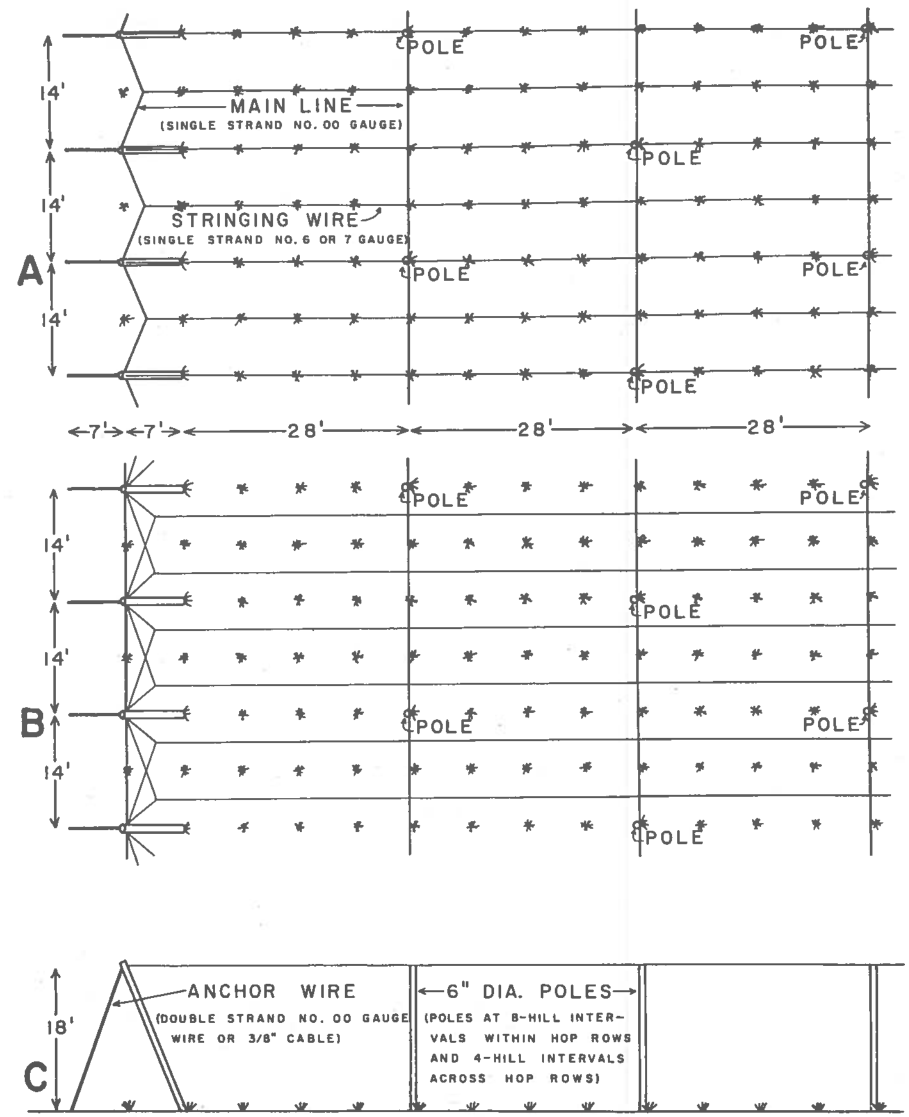


FIGURE 5.—Diagram showing common trellis designs on 7 foot by 7 foot spacing: (*A*), Stringing wires placed over rows; (*B*), stringing wires placed over centers; (*C*), side elevation showing system of anchoring used on edges of yard.

stringing wires are placed over the centers of the rows, these wires are forked at the edges of the yard and are attached to the anchor poles.

Trellises vary in design. In newer yards, poles are often set every fourth hill in one direction and every eighth hill in the other direction in a diamond lattice design (fig. 5). Such a design allows the rows of poles along the main lines to be four hills apart. Other common designs, particularly in the older hop-producing districts of western Oregon, have the rows of poles five or six hills apart along the main lines. In some of the heavier producing yards in the 'akima Valley district, poles are et at alternate hills along the main nes to give additional support.

Propagation

Hops are commonly propagated rom rhizome cuttings (usually alled "roots")—not from seeds. eedlings consist of a high percentge of male plants; show little niformity in the variety of hops roduced; and vary greatly in igor, quality, and time of ripenng. The cuttings consist of secions of the underground rhizomes fig. 6) that are cut into pieces 6 o 8 inches in length and bear at east 2 pairs of buds or eyes. Cuttings at least three-eighth inch in iameter are generally preferred. 'hey are usually obtained when the lants are pruned in the spring. f the cuttings are not planted imediately, they should be stored in a cool, moist, well-ventilated place to prevent drying out. Care should be taken, however, to prevent the development of molds or rots, premature sprouting, or freezing. Cuttings should be carefully inspected before planting; and those that are poorly developed, misshapen, damaged, or diseased should be rejected.

In some districts of the Pacific coast, a relatively good crop may be obtained from cuttings planted in the spring; but generally a full crop is not harvested until the second or third year. Varieties differ as to length of time required to mature. The Cluster and English varieties usually are vigorous the first year, but Fuggle requires 2 to 3 years to mature.

Many progressive hop growers establish a so-called nursery block (fig. 7), which they use to furnish planting stock. Cuttings are obtained in the usual way, but they are planted closely spaced in a separate area and allowed to grow for one season. The following fall or spring, the 1-year-old sets (fig. 8) are planted in place of cuttings. This practice allows some selection for superior planting stock, eliminates diseased cuttings before planting in the field, and usually results in a larger crop the first year after planting.

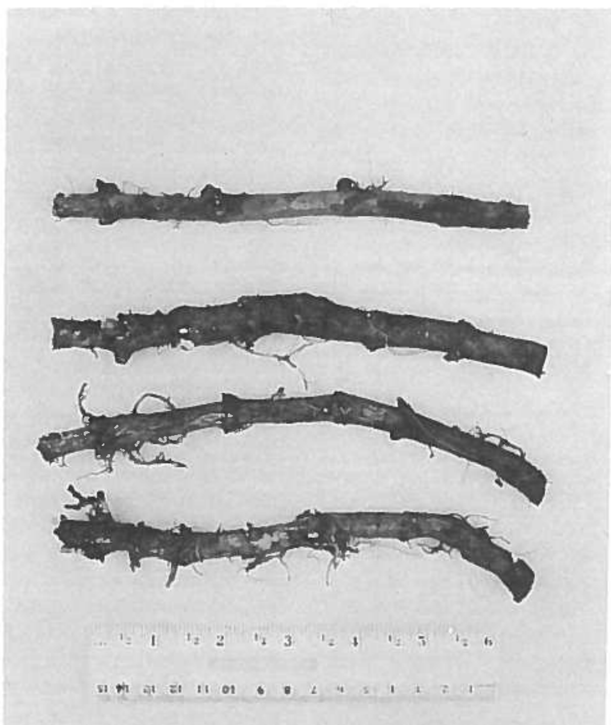


FIGURE 6.—Rhizome cuttings used for propagation.

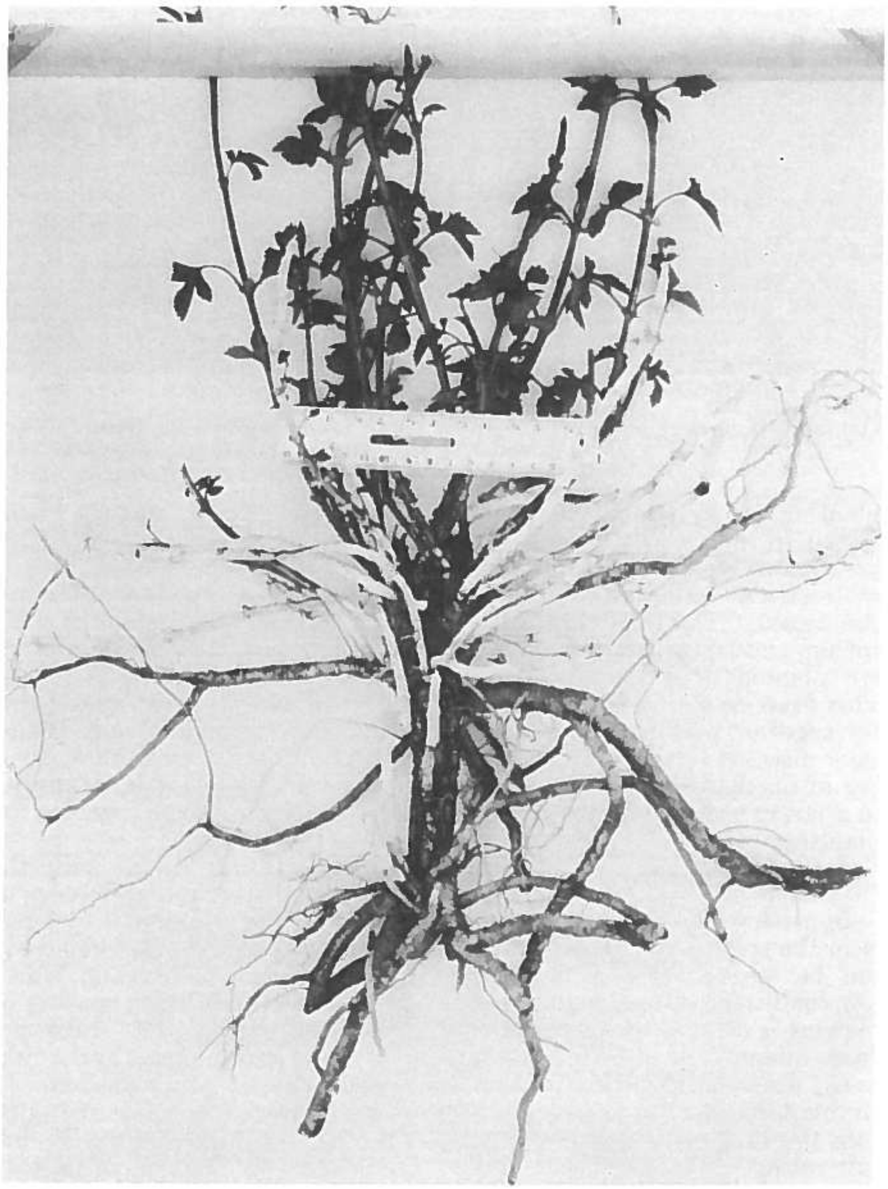
FIGURE 7.—A nursery block in Idaho used for furnishing crowns for replanting and establishing new yards.

Planting

In general, the best time to plant is in the spring as soon as the soil can be worked into a fine, mellow condition. Occasionally, when plowing is delayed by heavy rain or frost, plants are reset in missing, weak, diseased, or otherwise undesirable hills early in the spring before the first general pruning and cultivating. The common practice is to perform all three operations about the same time.

Successful plantings on lands not subject to winter flooding have been made in the fall after the fall rains have begun but before the soil becomes too wet to work. If the cuttings take root properly without undue loss from rotting, frost heaving, or desiccation, establishment of the plants is hastened; and reasonably high yields are obtained the first year. Spring is the more common planting time in western Oregon, California, and Washington; but in the drier, inland districts of Washington and Idaho, fall planting is sometimes done. Distribution of seasonal labor requirements has some bearing on time of planting.

Plant spacing varies with the district and with the preference of the grower. Spacing of 7 by 7 feet (889 hills per acre) is common in the districts of California, Washington, and Idaho; but spacing of 6½ by 6½ feet (1,031 hills per acre) is sometimes used in the Sacramento Valley of California. In western Oregon, spacing of 7½ by 7½ feet is used extensively; but there are a number of yards with a spacing of 7¾ by 7¾ feet, and 8 by 8 feet (680 hills per acre). In some areas, spacing of 7 by 3½ feet (1,778 hills per acre) is used, which is similar to the close spacing of the European hop-producing regions. This last spacing is not common in this country except in establishing



GURE 8.—One-year-old Fuggle nursery set used for propagation. Long sprouts and ends of some roots will be trimmed off before planting.

new plantings; alternate hills are dug the second year and used for replants.

There are two methods of placing the rows with respect to the stringing wires (fig. 5). In Washington, California, and Idaho, and in the more recently established yards in Oregon, the rows are generally placed between the stringing wires. In many yards in western Oregon, the hills are placed directly under the stringing wires; but this is more common in the older yards. Placing the stringing wires over the centers of the rows rather than directly over the plants allows a wider spread between the vines in a single hill. This exposes more leaves to direct sunlight and reduces tangling along the wires.

The number of cuttings planted in each hill varies considerably. In most districts, two to four cuttings per hill are planted. In western Oregon, however, only one and sometimes two cuttings are planted; and in other districts as many as six cuttings are planted. Planting a larger number is expensive when there is a shortage of cuttings because of expanded acreage or when few cuttings have been collected, but it assures a more satisfactory stand. In seasons of scarcity, some cuttings may sell for as much as $50 a thousand.

Cuttings are planted vertically in holes made in the hill. The soil is then firmed-in around the cuttings, and 1/4 to 1 inch of loose soil is left over their tops. Air holes around the cuttings allow drying out, and a compacted layer on top of the cuttings prevents normal emergence of the shoots. New plantings should be cultivated so that excessive soil is not heaped over the hills, thus delaying emergence or killing the cuttings. Emergence is also delayed if the cuttings are planted with the buds pointing downward.

CULTURE

The culture of hops is complex and highly specialized, and hop growers take pride in mastering the complexities of production. In all hop-producing regions, cultural practices and equipment become traditional within a locality; but they vary from one area to another. On the whole, however, both are somewhat standard, although there is leeway for individual preferences.

Fertilizers

Careful consideration of soil type and cropping history serves as a basis for developing a fertilizer program. Soil samples should be submitted to local colleges or universities for analyses, and fertilizer programs should be established on the basis of these analyses. Consult your local county agent for correct sampling procedures.

Hops require large amounts of nitrogen, phosphorus, potash, and calcium for full development; and they deplete the soil of these elements. Adequate amounts of sulfur, zinc, boron, and other elements must be available for normal plant growth.

In general, nitrogen is the main element found deficient in most hop-growing soils. The amount of nitrogen that needs to be added varies from one district to another, and specific recommendations should be obtained from local institutions. It is estimated that a full crop of hops removes up to 90 pounds of nitrogen per acre each year.

In the Willamette Valley of Oregon, applications of 80 to 140 pounds of nitrogen per acre are recommended. Because of the heavy vinter precipitation and the dan- ;er of flooding, nitrogen should be pplied from early spring to early ummer in order to keep leaching osses to a minimum. In the Yak- ma Valley of Washington and he other inland districts, it may e necessary to apply 100 to 160 ounds of nitrogen per acre each eason. Since the rainfall in these reas is low, nitrogen can be applied vhenever climatic or labor condi- ions permit.

A full crop of hops removes an stimated 25 to 30 pounds of P_2O_5 er acre each season, and this mount should be replaced if the lants are to grow normally. Be- ause of the fixation of phosphorus n the soil and other factors that end to make it unavailable to the lants, soil applications should ex- eed 25 pounds of P_2O_5 per acre. Response to phosphorus varies, and 10 general recommendations for ts application can be made. It is 10t uncommon for growers to sup- ly 50 to 100 pounds of P_2O_5 per cre in a season regardless of the esults of the soil analyses.

The hop-growing soils in this ountry, except for some of the andy soils, generally contain ade- uate amounts of potash. A full rop of hops will remove up to 100 ounds per acre of K_2O in a season. Hops respond only occasionally to dditional potash fertilization, but gain soil analyses should be used s a guide.

Some soils in the Yakima Valley f Washington and the Boise Val- ey of Idaho are deficient in sulfur, inc, or boron. Applications every ifth year of 30 pounds of zinc per cre in the form of zinc sulfate, zinc xide, or zinc ammonia sulfate are ecommended for the zinc-deficient soils in the Yakima Valley. Sulfur s deficient in the Willamette Valley f Oregon. Applications of 400 ounds per acre of gypsum every 3 to 5 years will counteract his deficiency. Usually, sufficient amounts of sulfur are applied in fertilizer materials such as ammo- nium sulfate and superphosphate and in mixed fertilizers, as well as in some sulfur-containing fungi- cides. Boron-deficient soils are not clearly defined, and a general rec- ommendation cannot be made. Consult your experiment station or county agent for advice concerning this deficiency. Boron in excessive amounts is toxic to the plants.

Fertilizers can be applied to the soil in several ways. Some growers apply them by hand, making a ring around each hill that is covered up by subsequent tillage operations. This method is more commonly used on new plantings that have not developed extensive root systems. Placing some fertilizer materials such as nitrogen, potash, and boron too close to the hill causes the plants to burn. On established plantings, broadcasting the fertilizers between the rows followed by disking, or placing the fertilizers by means of an attachment on a grain drill, is recommended. Broadcasting or drilling should be done early in the spring in order to avoid injuring the feeder roots. Banding ferti- lizers, particularly liquid carriers of nitrogen, alongside the rows is coming into use; but this should be done early in the spring to avoid cutting the feeder roots. Water- soluble nutrients are sometimes added to the irrigation water during the growing season.

Because of the relatively high temperatures in the hop-growing districts, most soils are compara- tively low in organic matter. For this reason, organic matter should be replaced by applications of barn- yard manure, machine-picking resi- dues, and other organic materials; by growing winter cover crops; or by a combination of these cultural practices. When properly decayed, organic matter increases soil fertil- ity, tends to increase availability of inorganic chemical nutrients in the soil, increases soil moisture in- filtration rates, improves the gen- eral tilth and structure of the soil, and increases soil aeration.

In the inland hop-growing dis- tricts, growers often apply 10 to 20 tons per acre of barnyard manure each season; and in some seasons as much as 50 tons per acre is ap- plied. An application of 20 tons per acre of barnyard manure, in addition to furnishing organic mat- ter, will supply an average of 200 pounds of N, 100 pounds of P_2O_5, and 200 pounds of K_2O per acre. Not all of these amounts will be- come available to the plants the first season. Other organic mate- rials such as waste legume hay or grain straws are sometimes cheaper and more readily available for fer- tilizing. All fertilizer materials should be incorporated into the soil as soon after applying as possible.

Cover or green manure crops to protect the soil against erosion and to supply organic matter are highly recommended. Cover crops are particularly desirable in lowland areas that are subject to flooding or to considerable leaching of the soluble plant nutrients during the winter.

Some growers use a mixture of legumes and winter grains, but others depend entirely on winter grains for cover crops. In certain Pacific coast districts, natural wild growth of weeds is sufficient to pro- vide a cover crop; but it usually will not provide large supplies of organic matter. The more com- monly used cover crops in western Oregon are mixed winter barley and hairy vetch, Austrian winter peas, crimson clover, or winter bar- ley or rye grown alone. Horse- beans and barley grown alone are commonly used in the Sacramento district of California. Vetch or mixed vetch and rye are used in Washington. Cover crops are seeded just prior to harvest or as soon thereafter as possible, irri- gated if necessary, and plowed un- der as soon as soil conditions permit in the spring. For this reason, the cover crop must produce abundant growth by March.

Pruning

Excessive shoots from the root- stock of the hop plant must be removed by pruning. Pruning con- fines the crowns to a reasonable area, removes diseased portions, shapes the rootstock to an accept- able form at a suitable depth below the soil surface, and keeps runners to a minimum. In general, plants are pruned early in the spring. Two to five furrows are plowed on each side of the row, and the earth is turned away from the hill (fig. 9). The yard is often cross plowed in a similar manner, leaving each hill a small, undisturbed cube. The earth is then hoed and grubbed away from the roots; and the su- perfluous roots and runners, to- gether with 1 or 2 inches at the top of the root crown, are sliced off (figs. 10, 11). After pruning, some soil is hoed back on the hill, and the rootstock is covered with 2 or 3 inches of earth. Occasionally the hills are left open after pruning and are covered when next culti- vated.

Machines with whirling blades or knives to prune off the tops of the crowns have been developed and are coming into use. These machines are pulled along the hop rows, and the whirling blades slice off the tops of the crowns along with 1 or 2 inches of topsoil. If the blades are kept sharp and mov- ing at sufficient speed, pruning can be done without mutilating the crowns.

Severe pruning by any method often results in root rots, and un- even pruning frequently causes late development of overpruned vines. Each plant should receive individ- ual treatment according to its con-

URE 9.—First plowing in spring. Yards are often cross plowed, which leaves each hill an undisturbed cube ready for hand pruning.

ion and state of development. ə number and strength of the es produced after pruning are best evidence of correct prun- and of the soundness and vigor the rootstock. If plants are efully pruned, much injury can avoided, the amount of annual lanting reduced, and the yield the crop increased substantially.

Stringing

ince most of the hop crop is duced on high trellises, a strong ne must be used to support the es. Coir yarn, a twisted palm- r twine imported mainly from ia and Ceylon, is used generally this country because of its ngth and relatively low cost. satisfactory paper twine has been developed and is coming into general use, particularly in the Willamette Valley of Oregon. In addition to supporting the vines, the twine must not bind in the picking machines and must deteriorate in the field after harvest.

A high cart pulled by tractor power is commonly used in stringing (fig. 12). Two to six workers ride the high cart, and each worker ties one or two twines to each wire as the cart is pulled crosswise to the stringing wires. The twines are tied 20 to 24 inches apart over the centers between the hills. Most growers use two twines for each hill; some, however, use three twines, the third being tied directly in line with the hills.

After the twines have been attached to the stringing wires, other

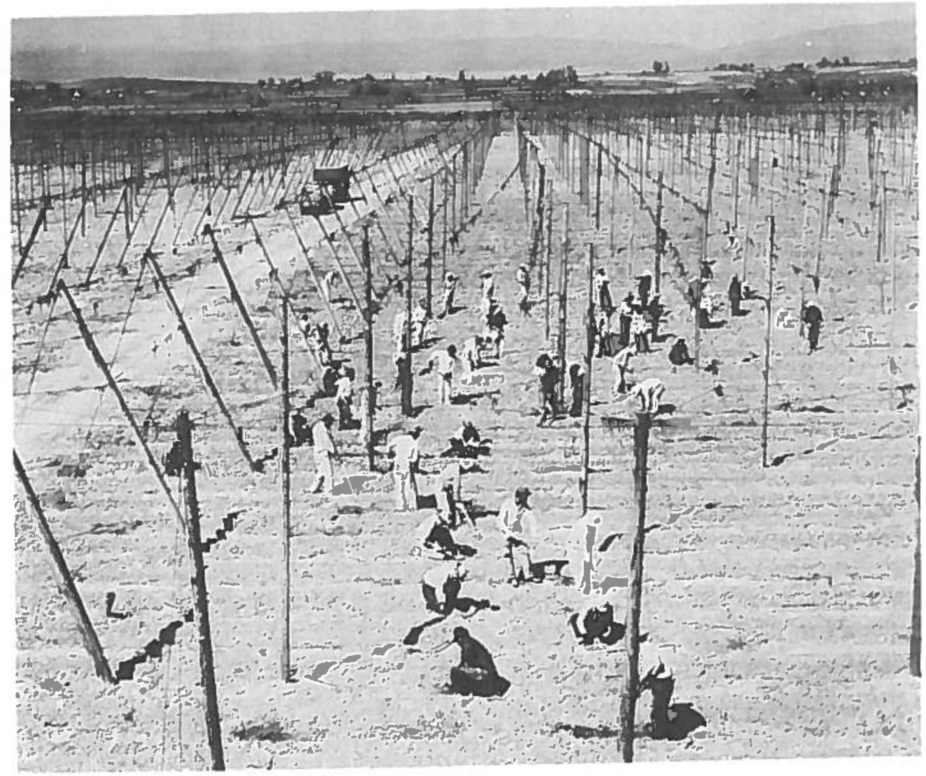


FIGURE 10.—Large crew hoeing and pruning in early spring.

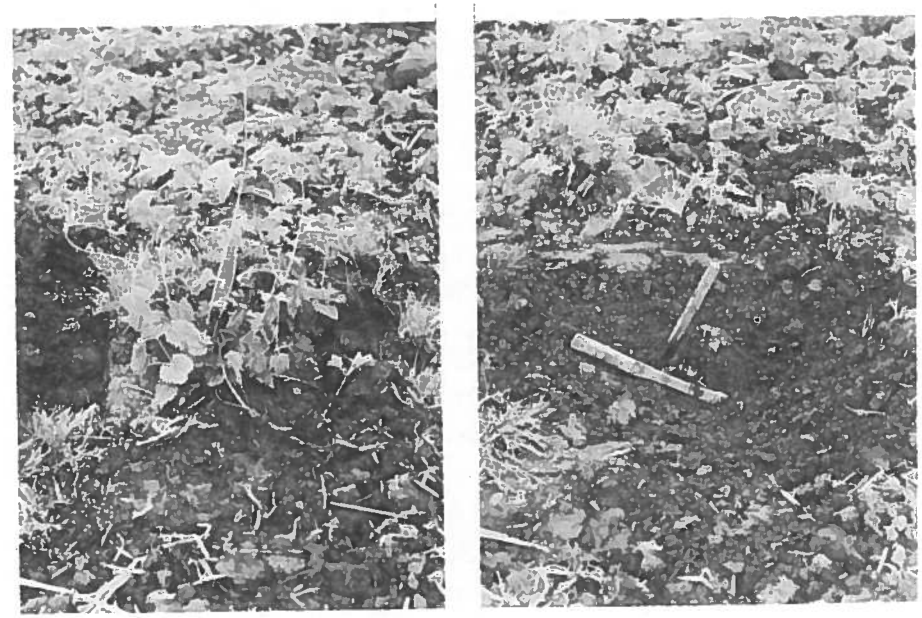


FIGURE 11.—Hill on left before pruning; hill on right after pruning.

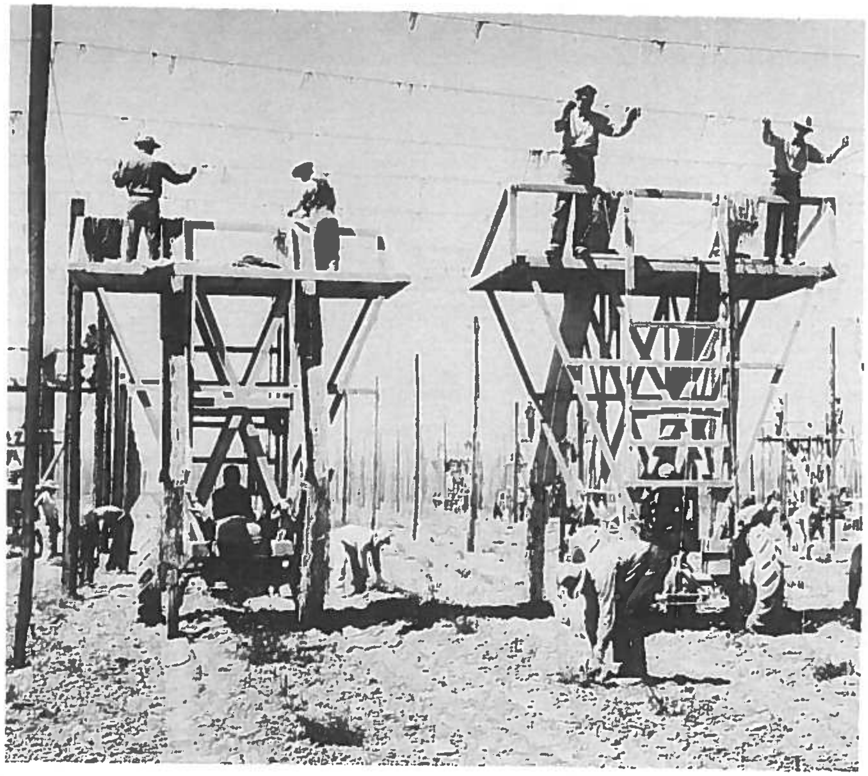


FIGURE 12.—Stringing crews at work showing use of high carts.

FIGURE 13.—Training crew at work.

rkers tie the twine ends to oden stakes or wire pegs at each l. Some California growers tie › twine ends directly to the ›wns, while others punch the led twine ends into the soil. e latter practice provides an›rage until the vines have been ined.

Where the stringing wires are ced over the centers of the rows, › string is generally led from one e on one side of the hill and anıer from the opposite wire. ıce this system produces a V-pe in two directions, the vines 'e a greater spread after train; and are more open to direct ılight. Where the stringing es are placed over the rows, two ings are led to each hill so as to m a V-shape above each hill in › direction only.

Training

When the young vines are about 2 feet long, training is begun. After the desired vines are selected in each hill, the remaining vines are cut off. One to three vines are trained up each string, depending on variety and grower preference. Care should be taken to twine them in a clockwise direction to insure their climbing and to prevent them from unwinding (fig. 13). With some varieties, the yield per hill is proportional to the number of vines trained. Except for closely spaced planting, better results should follow when at least six vines are trained to each hill. This is true particularly of the Fuggle variety. Where downy mildew is a factor, infections may be reduced by training the vines during weather less favorable to the development and spread of the disease.

When the vines have nearly reached the stringing wires, the strings are tied together (arched over) about 4 feet from the ground to provide clearance for the tractors and implements between the rows. It is usually necessary to train the vines at least twice a season; the second and any subsequent trainings are used to replace fallen or missing vines. It is often necessary to remove a downy-mildew-infected or otherwise damaged vine and train another vine or lateral in its place.

Stripping and Suckering

As soon as the vines are trained, the lower leaves should be removed to prevent the spread of downy mildew and insect pests. When the vines have reached the stringing wires, all side-arms and leaves should be removed from the vines below the point at which the strings are tied together. This practice, known as "stripping," should be employed with care. Many young vines are checked in growth by too severe stripping. If the vines are stripped too high, a "top crop" results, and yields are reduced. Stripping wounds at the bases of the vines may serve as points of entry for certain diseases and often weaken the vines so that they crack or break off in midseason in windy localities.

Excessive shoots are usually removed from around the bases of the plants early in the season. This practice is known as "suckering" and is primarily employed to rid the plants of diseased vegetative material and to force the growth into the selected vines.

Iany growers believe that cut-
g the vines at harvest time re-
·es the vigor of the rootstocks
ess some basal growth is pres-
. Experiments at Oregon State
lege showed that complete
pping and suckering up until
·vest time reduced the yield of
ɔs the following year. If suck-
are allowed to grow during the
·er part of the growing season,
y provide live leaf tissue that
nufactures food for the root-
ɔk. Stripping and suckering
ıuld be done early in the season,
vever, since these practices elim-
te much downy-mildew-infected
terial and retard the spread of
ect pests, particularly spider
·es. Many growers who neglect
s practice for an entire season
faced with a serious incidence
downy mildew or spider mites,
ich weakens the rootstock.

Cultivating

Cultivation practices in different
ɔ-growing districts vary accord-
; to seasonal needs, and the im-
ments employed are largely a
tter of individual preference.
e first cultivation operations in
spring are usually those em-
ɔyed in connection with pruning.
rious types of disk harrows, roll-
, drags, and cultivator sweeps or
ınks are used to develop and
intain a satisfactory soil condi-
n as soon as possible after culti-
ion begins. Thorough cultiva-
n is important; it should begin
·ly and continue until the lateral
unches are well developed. This
ɔps down the weeds and prevents
topsoil from forming a crust.
Most hop growers cultivate to
pths of 6 to 10 inches early in the
ıson in order to incorporate sur-
e organic matter into the soil;
d, as the season advances, they
ltivate at shallower depths.
ɔst growers do not cultivate
eper than 2 to 4 inches during
e latter part of the growing season. If the small feeder roots are destroyed or seriously injured by late cultivation, growth will be checked and early ripening favored. Deep cultivation, particularly during the growing season, reduces yields. Existing soil conditions must determine the advisability of cultivation after the appearance of the feeder roots. If weeds are under control and the soil is not crusted, further cultivation is unnecessary and may be harmful.

Careless use of machinery causes much needless injury to crowns. Mechanically injured crowns are subject to root rots, which often shorten the life of the plantings. This damage, in turn, necessitates much annual replanting and increases the cost of production.

Irrigating

Most hops in this country are produced under irrigation. Irrigation is essential in the inland areas of California, Oregon, Washington, and Idaho; and it greatly improves production in the higher rainfall areas in the western districts of the coastal States. Both gravity and sprinkler irrigation systems are used.

Gravity irrigation is by far the more common type. Water is diverted from adjacent streams or pumped from adjoining streams or wells and carried along canals to the highest areas of the fields. It is then directed down furrows alongside the rows of hops or allowed to flood between rows to the lowest levels. Usually, with both the border flood and the furrow method, excessive water is applied at the upper ends of the system before sufficient water reaches the lower ends. Although furrow irrigation (figs. 14, 15) requires more labor and land preparation, it is more desirable, since it encourages better control of the water and does not tend to crust the soil.

FIGURE 14.—Furrowing hopyard in preparation for irrigation.

Border flood irrigation is not used extensively except in the Sacramento Valley of California, the oldest inland hop-producing district on the west coast. With either method of gravity irrigation, the equivalent of up to 3 acre-feet of water is required during a season. The number of irrigations per season varies from 4 to 10 in the Yakima and Boise Valleys and from 2 to 4 in the Sacramento Valley.

Sprinkler irrigation is practiced almost exclusively in the Willamette Valley of Oregon and on the uneven lands in the Sacramento Valley of California. With sprinkler irrigation, pipes are laid on top of the ground throughout the field. They must be removed after each irrigation before any other tillage can be done. The source of irrigation water may be an adjacent stream or a well. Water is distributed to the sprinkler laterals by portable mains or by permanent, underground mains having riser-valves located at strategic positions in the field.

Sprinkler irrigation has an advantage over gravity irrigation in that better control can be kept over the amounts of water applied, thus

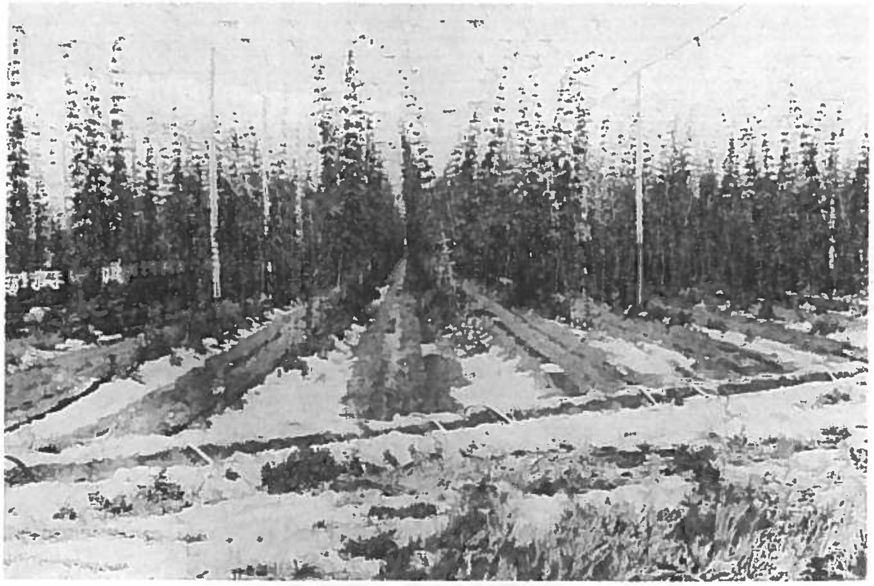


FIGURE 15.—Furrow irrigation of hops.

-creasing efficiency of water use d reducing the hazards of over-igation. Most sprinkler systems common use are designed to ap-y approximately 3 acre-inches of ater in a 6- to 8-hour set.

Disadvantages of sprinkler irrigation are the relatively high initial cost, the necessity of upkeep of equipment, and the amount of labor required to set up and take down the system at each irrigation.

DISEASES AND THEIR CONTROL

Hops are subject to relatively w diseases, but some diseases are great economic importance. In asons favorable for disease de-lopment, losses may be very large. 1957, California growers esti-ated their losses from hop downy ldew to be 30 percent of the total op. In the same year, disease sses for the entire U.S. hop crop re estimated to be 12 percent.

In addition to direct losses, costs control measures may be high; ality of the hops may be af-cted; and returns to the grower ay be substantially reduced.

The diseases of greatest impor-nce to hop producers are downy ildew, sooty mold, root rot, and several virus diseases. Knowledge of hop diseases and how to combat them is necessary for successful hop production.

Downy Mildew

All varieties of hops grown in the United States are subject to damage from downy mildew caused by the fungus *Pseudoperonospora humuli* (Miy. & Tak.) G. W. Wils. There are, however, differences in susceptibility among the commercially grown varieties. Early Cluster is the most susceptible variety, but Late Cluster is also susceptible. The English varieties Brewers Gold and Bullion are

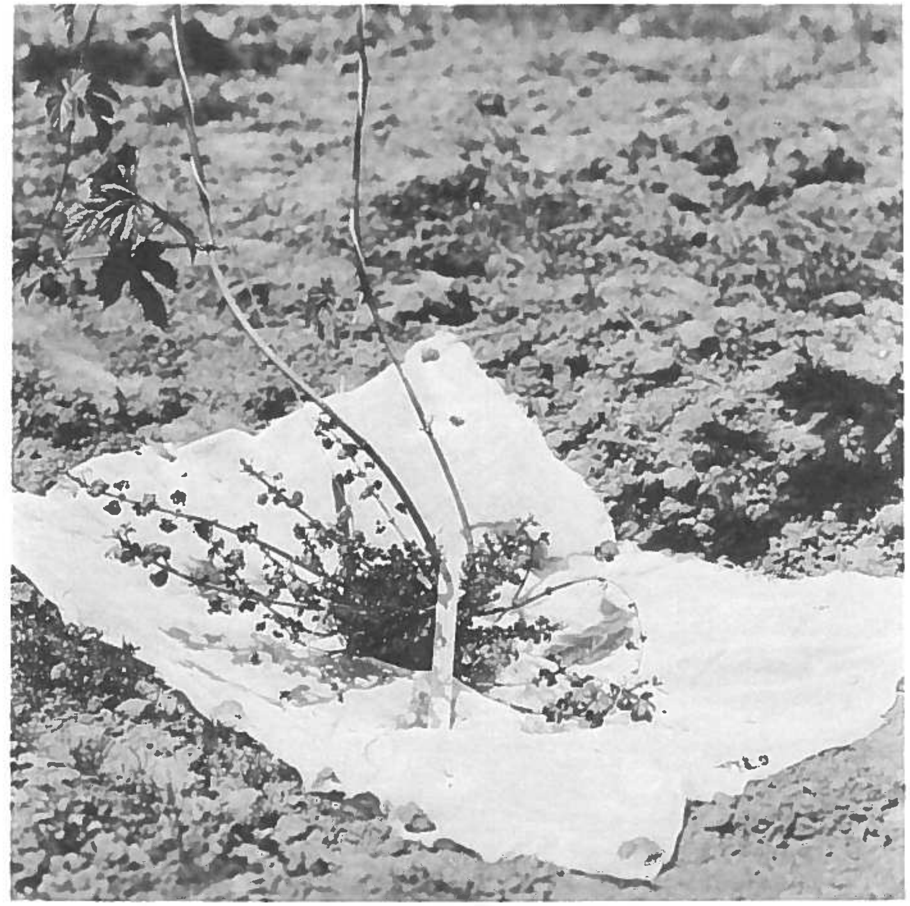


FIGURE 16.—Hop hill with numerous stunted downy-mildew-infected vines at base. Such infected "spikes" serve as sources of new infection.

somewhat susceptible and can be severely damaged in seasons favorable for downy mildew development. Fuggle is resistant but may be damaged by especially severe outbreaks.

Downy mildew is found in all the commercial hop-growing areas in the United States. It is most severe in areas of heavy spring rainfall but has become firmly established in drier areas. Even in the Yakima Valley of Washington, where annual rainfall may be 7 inches or less, downy mildew has become a serious problem.

The first symptoms of downy mildew appear in early spring when a part or all of the new shoots arising from a hill may be infected. Badly infected shoots are unable to climb and are stunted, brittle, and lighter colored than healthy shoots (fig. 16). They are infected internally by the downy mildew fungus and are called "spikes" by growers. Millions of spores are produced on infected spikes, and these spores are carried by wind or water to other shoots, which they may infect. The tips of healthy shoots or lateral branches may become infected and grow into spikes

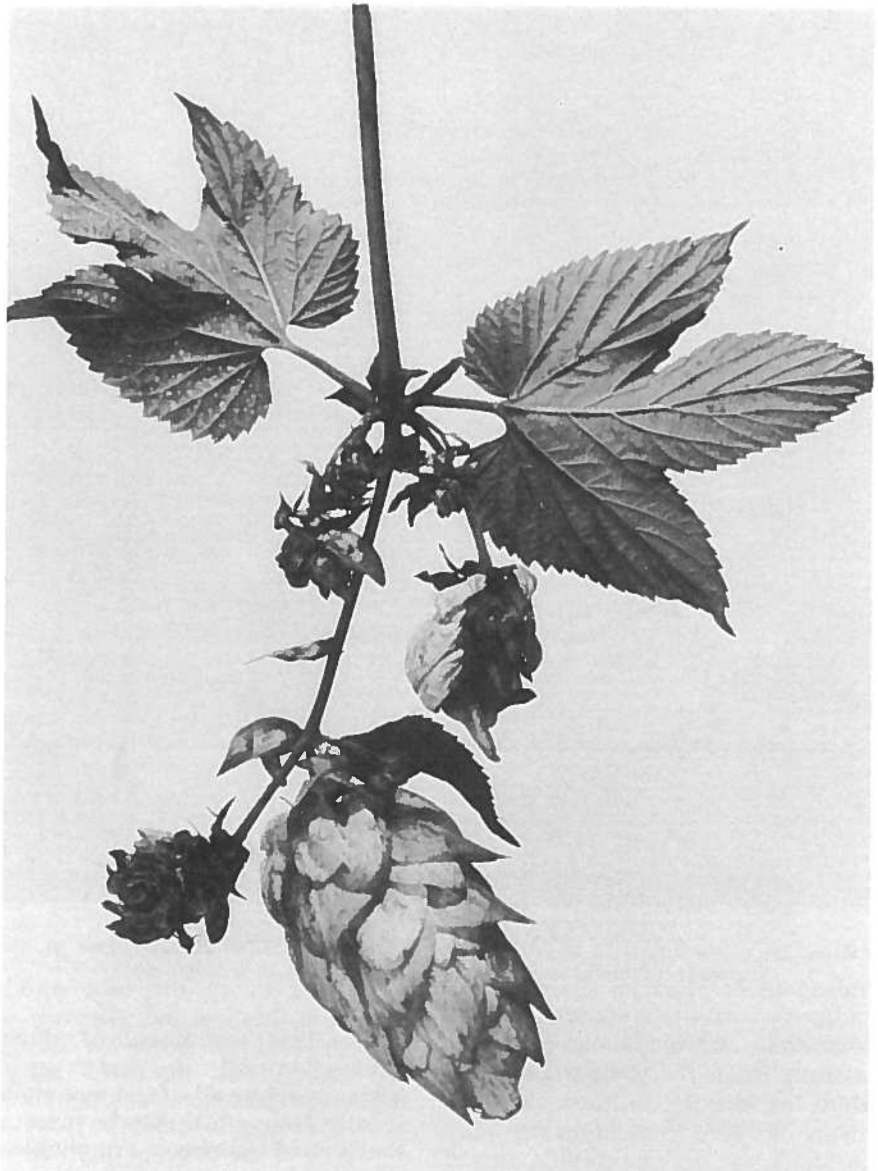


FIGURE 17.—Downy mildew blight of hop cones.

nilar to those arising from the own.

Flowers are frequently infected ıen blooming occurs during wet humid weather. Infected ›wers turn brown, shrivel, and equently drop. When young nes are attacked, they cease to grow and turn brown. When older cones are infected, part or all of the petals turn brown and the cones fail to develop properly, as shown in figure 17. More spores may be produced by the fungus on any of the infected organs, including leaves.

The hop downy mildew fungus lives through the winter either as weather-resistant winter spores, which are formed in infected plants and overwinter in crop debris, or as systemic perennial fungus strands in infected roots and crowns. Systemic crown infection is the most important method of overwintering. When crowns are infected, some of the first shoots that appear in the spring may be infected when they emerge from the soil.

The Early and Late Cluster varieties are particularly susceptible to root and crown infection. Early Cluster in particular may be severely damaged by crown infection. Infected roots and crowns show streaks or pockets of reddish-brown discolored tissue when cut (fig. 18). Such infected hills may die during winter or may produce weak plants the following season. In Washington, root and crown infection have caused extensive hill "die-out" in recent years.

Moisture, either as dew, rain, or irrigation water, is necessary for downy mildew infection. Temperatures of 60° to 70° F. are most favorable for infection and disease development. Rains, fogs, dews, cloudy days, and high humidity favor spore production and infection. When such conditions occur frequently, especially during May and June, dusting or spraying with fungicides may be necessary to prevent serious losses (fig. 19).

Effective fungicides for both dusts and sprays are available that act as chemical barriers to spores present on the plant. Full coverage sprays requiring high volumes per acre for adequate coverage must be applied by ground sprayers. When weather conditions are good, dust may be applied by air. Foliage should be covered completely when sprayed or dusted.

Control measures should be applied in early spring before the disease becomes widespread. Spiked shoots should be removed from the

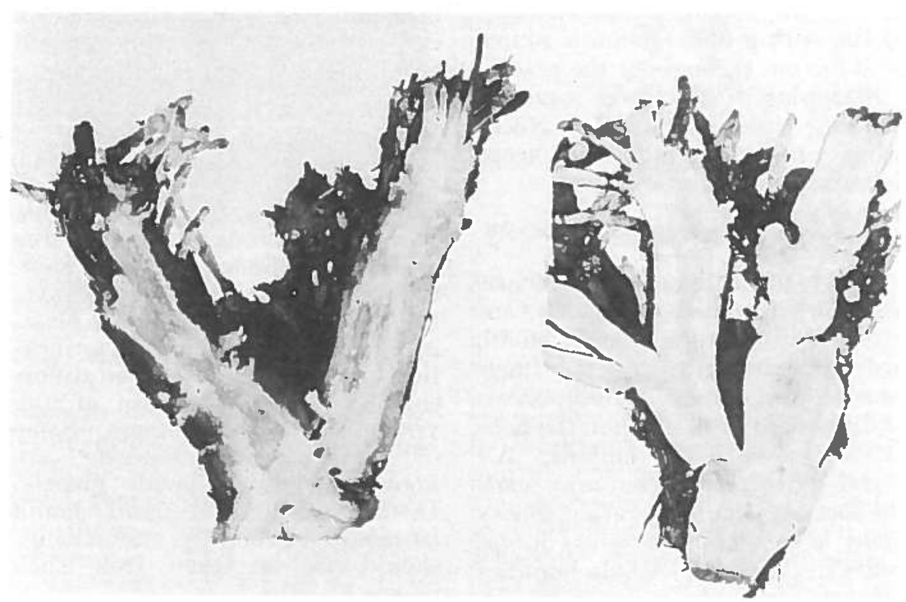


FIGURE 18.—Crown infection by hop downy mildew. Infected crown on left shows brown, dead, outer tissue. Crown on right is healthy.

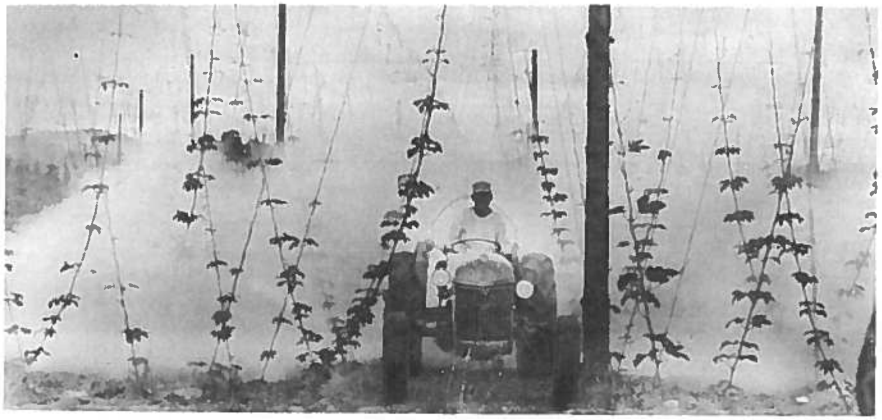


FIGURE 19.—Dusting hops for downy mildew control.

ants, carried from the field, and ırned as soon as they appear and ;gularly thereafter so long as they 'e prevalent. When the incidence ' crown infection is low, infected ants should be dug and removed 'om the field. Escaped hops 'owing on anchor wires, in fence ›ws, or on ditchbanks near cultiıted yards should be eradicated, ; they may become diseased early . the spring and remain a source ' infection throughout the season. Stripping of the lower leaves at 'aining time is desirable. Suck'ing and stripping also keeps ›wn serious infection.

Sooty Mold

Sooty mold may cause serious sses when aphids, which are inırectly responsible for the mold, 'e not controlled. The fungi ıusing sooty mold, *Cladosporium* ıd *Fumago* spp., grow on the hon'dew excreted by aphids. All ›rial parts of the vine may show ıe sooty-black discoloration. Sooty old is most serious when it ap›ars in the cones. Moldy hops are .ferior in quality and may be dif›ult to sell. Sooty mold can be ›ntrolled by following an effecve aphid control program.

Root Rots and Root Die-out

Root rots result in loss of both newly planted cuttings and established hills. They are characterized by a brown or black discoloration and rot of the infected parts. No direct control measures have been developed, but care should be taken to use only healthy cuttings for propagation. Downy mildew infection contributes to root rot and root die-out. Rot and die-out are frequently severe following a serious downy mildew outbreak.

Virus Diseases

Several abnormal conditions of hop vines are due to virus infection. Symptoms include leaf and tip distortion, tip die-back, yellow spotting of the leaves, stunted growth, failure to climb, and flower blasting. Information on identification, distribution, effects on different varieties, and control of hop virus diseases is incomplete. Some of these diseases, however, are known to reduce yields greatly. Distinctly abnormal plants should be removed promptly, and cuttings should not be taken from such plants.

Other Diseases

A bacterial canker sometimes forms on vines and young shoots but has not been widespread or serious. Crown gall, another bacterial disease, is present in all hop-growing districts but is not of major economic importance.

Verticillium wilt is present in some west coast hop-production districts. This disease, caused by the fungus *Verticillium albo-atrum* Reinke & Berth., is of great economic importance to the hop industry in England. New hopyards should not be established in sites known to be infested with Verticillium wilt resulting from previous cropping to potatoes, tomatoes, strawberries, or peppermint.

HOP INSECTS AND RELATED INSECTS [1]

Hops are subject to attack by a large number of insects and other pests. Hop aphids (fig. 20) and spider mites (fig. 21) are the most important hop insect pests. Wireworms, root weevils, the omnivorous leaf tier, the western spotted cucumber beetle, the corn earworm, and several species of cutworms may require control measures in some years. Symphylans have recently become of economic importance in some Oregon hopyards. White grubs (larvae of the June beetle and of the Prionus beetle) in recent years have become a problem in the Sacramento district.

FIGURE 20.—Heavy infestation of aphids on underside of hop leaf. (Courtesy, Oregon State College.)

Profitable hop production requires knowledge of the important insect pests and their control. Fortunately, excellent control measures have been developed for the most serious insect pests.

Use of Pesticides on Hops

Hop pest control is based on the use of chemicals as sprays or dusts,

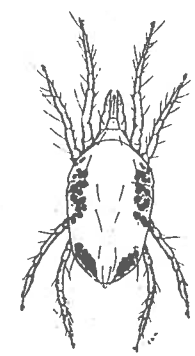


FIGURE 21.—Adult female spider mite.

or as soil treatments. Local regulations and recommendations for the use of insecticides on hops may vary. Recommendations may also change rapidly as new materials are tested and old ones reevaluated. In addition, insecticides used to control hop pests have different characteristics that growers should understand in order to use them properly. Specific recommendations should be obtained from your local county agent or experiment station before using insecticides on hops.

[1] Acknowledgment is made to H. E. Morrison and E. C. Klostermeyer of the Oregon and Washington Agricultural Experiment Stations for much of the material in this section.

Hop Aphids

The hop aphid (*Phorodon humuli*) is a serious insect pest that requires annual control measures in most hop-producing districts of the United States. Heavy aphid populations devitalize hop plants and reduce yields. More important, during hot weather aphids move into hop cones where they secrete honeydew upon which sooty mold develops. Sooty mold discolors the hops and lowers their market value.

Hop aphids overwinter as eggs on prune, plum, and related trees. Normally these eggs hatch in April or May, and the aphids produce several generations on the tree foliage. In May and June, aphids migrate to hop foliage and begin to reproduce. Rapid development is favored by cool, moist weather. Hot weather during July and August suppresses development, but cooler weather before or during harvest usually results in heavy aphid populations that require control. Aphids should be controlled either before or during the period hops are in the bloom or burr stage, to prevent them from entering the young cones.

Spider Mites

Spider mites (*Tetranychus* spp.) are serious pests in all hop-growing areas. They feed by puncturing the lower leaf surfaces and withdrawing sap. Each puncture produces a small, light-colored spot. As the mites increase and feeding continues, the leaves become bronzed, shrivel, and die. The mites also attack the cones, turn them reddish, and reduce their quality. Heavily infested plants become devitalized and produce a light crop. Unlike aphids, spider mites are favored by warm, dry weather and usually do not become abundant until summer.

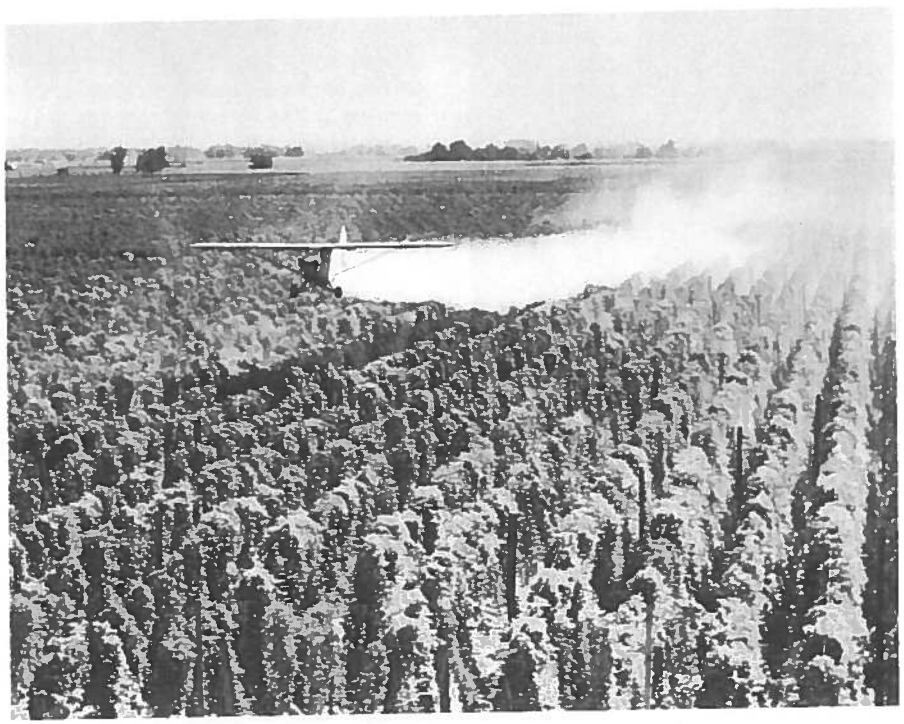


FIGURE 22.—Dusting by airplane for insect control.

Adult female mites overwinter on grasses and other plants. In mild regions, they may overwinter as minute reddish-orange masses in the cracks and under the bark of poles. Eggs are deposited on grasses and other plants during April and May; and, when these plants begin to dry or become unpalatable, the mites move to hops and other crop plants. Movement to hops usually occurs in June or July but may be earlier in warm, dry areas and seasons. Spider mites reproduce rapidly on hops, and control measures are generally necessary to prevent plant and cone damage before harvest. Control measures should be employed early in the season, as soon as the first mites appear. Delay in applying controls permits a buildup of mite populations, and frequent treatments are often necessary.

Cutworms

Cutworms are the caterpillarlike larvae of dull-colored moths. They spend the winter in the soil either as larvae or pupae. The adult moths emerge in late spring and lay eggs. After the eggs hatch, the larvae feed on hop stems and leaves. Feeding is usually done at night, and the larvae burrow into the soil during the day. Cutworms are voracious feeders and may cause considerable damage when numerous. Consult local agricultural advisors for control recommendations.

Omnivorous Leaf Tier

Larvae of the omnivorous leaf tier (*Cnephasia longana*) feed on the growing tips of vines. They may destroy the tips, and this results in stimulating the lateral shoots. This injury does not appear to reduce yields, but the time spent in training new shoots increases labor costs.

Western Spotted Cucumber Beetle

The yellowish-green western spotted cucumber beetle (*Diabrotica undecimpunctata*) sometimes damages hops by feeding on the tender, rapidly growing young shoots. Adult beetles emerge in the spring and feed on hops and many other plants. This insect is limited in distribution to western Oregon and the Sacramento Valley of California.

Garden Symphylan

The garden symphylan (*Scutigerella immaculata*) is a small, pearly white, centipedelike animal that feeds on roots of many plants. In recent years, it has become troublesome in some hopyards, especially on new plantings. When numerous, the adults and young cause stunted, unthrifty plants. Because it can move deeply into the soil, the garden symphylan is difficult to control, especially in established plantings of perennial crops like hops. Consult your local agricultural authorities before attempting control.

Other Pests

The corn earworm, some species of wireworms, loopers, white grubs, and nematodes are sometimes important pests in different areas. Consult your local county agents or State agricultural experiment stations for identification and control recommendations.

HARVESTING

Hop harvest usually begins in the middle of August and is over by mid-September. Actual picking is regulated by date of ripening and by the capacities of the picking machine, drier, and storage bins. If the tonnage of a variety is particularly large with respect to these facilities, picking may begin when the hops are on the immature side.

[arvesting should be scheduled so ıat it is continuous from one field › another throughout the harvest ·ason in order to keep the full com-lement of experienced workers. It often difficult to recover the full ·ew after a few days' layoff. ight harvesting is often practical fig. 23).

Time to Pick

Hops are in their prime condition nly a few days. During this time 5 to 10 days) they contain their ıaximum brewing value, maintain ıeir attractive appearance, and do ot shatter extensively. Premature arvest results in losses to the rower by excessive dry-down weight loss in drying), and the onsumer is denied full brewing alue. After a crop has reached ull ripeness, brewing value does not leteriorate for several days; but hattering increases, and discolora-ion rapidly becomes more apparent.

Usually the size of a grower's rop and the facilities for picking are such that he must extend his harvest for a period of 3 or 4 weeks; consequently, some compromises on maturity and quality must be made. To insure the most uniform quality over the entire harvest period, advantage can be taken of the range of ripeness, which results from variable soil and moisture conditions. Frequent examinations will reveal the areas that are ready first and those that are later maturing; and the maturity of selected fields can be delayed slightly by late pruning. Also, two varieties whose average maturities are 10 to 15 days apart can be grown. In Oregon, these are Fuggle and Late Cluster; in Washington and Idaho, Early Cluster and Late Cluster may be grown.

Methods of Picking

Handpicking of hops has been replaced almost entirely by machine picking. Hops picked by machine are generally cleaner than are handpicked hops, but there is consider-

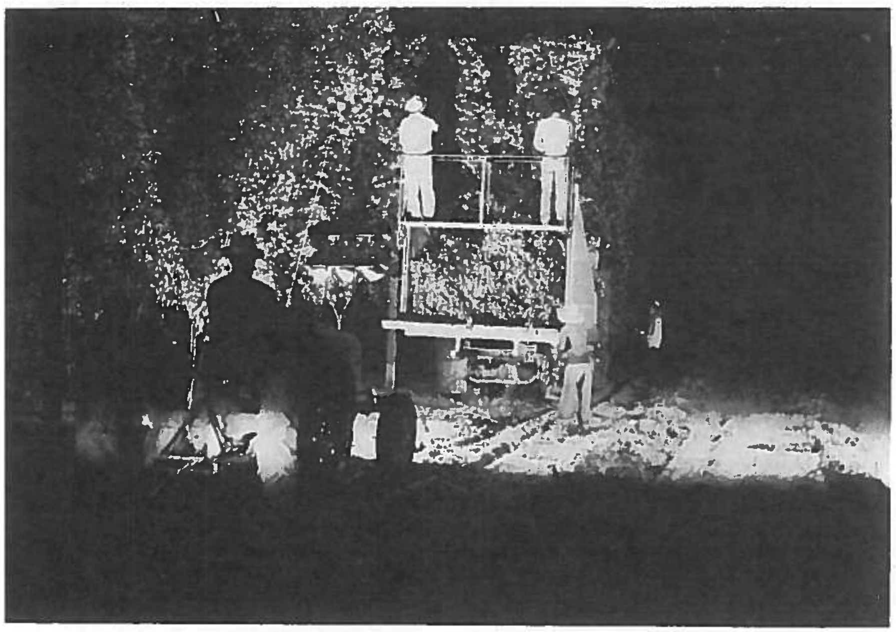


FIGURE 23.—Cutting vines at night for picking by stationary machine.

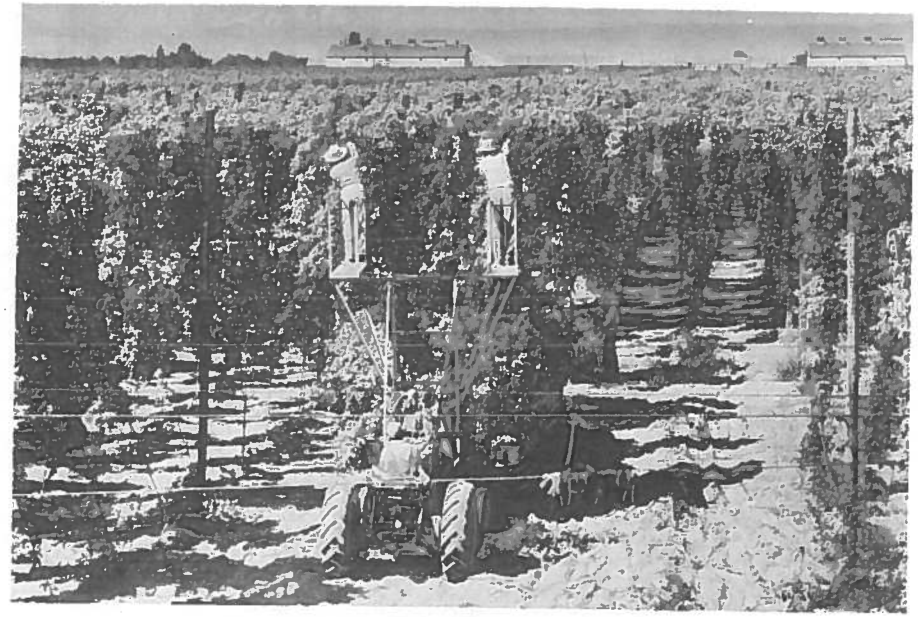


FIGURE 24.—Cutting hop vines for hauling to stationary picker.

able waste from shattered cones. It is estimated that half a bale per acre is frequently lost in this manner. The amount of waste varies with variety, degree of ripeness, seasonal conditions, and individual machines.

There are three general types of picking machines in common use in the United States: The stationary horizontal, the stationary vertical, and the portable. Of these, the stationary horizontal machine is the most popular. Both types of stationary machines are installed in large buildings, and the unpicked hop vines are transported to them. The portable machine can be pulled into the fields, where it makes a preliminary separation of the hop cones from the vines.

The stationary horizontal picking machine.—With this type of machine, the vines are cut loose from the hill about 4 feet from the ground and from the overhead wires. This operation is performed by two men in elevated platforms called "crows' nests" mounted on trucks or tractor-drawn carts that travel between the rows (fig. 24). After being cut, the vines are lowered onto flatbed trucks and laced into "combs," or narrow vertical V's, mounted on the truck beds to prevent tangling and unnecessary breakage. When the trucks or carts are loaded with vines from 60 to 90 hills, they return to the picking machine.

The vines are removed from the combs, or V's, and clamped into a "grasper bar" (fig. 25) attached to an endless chain that travels through the machine. The vines, thus secured, pass over a series of picking finger drums about 3 feet in total diameter that have 20 picking finger bars attached to each. The drums rotate 40 to 50 r.p.m. in a direction opposite that of the vines' travel through the machine. After the vines have traveled over the full series of drums, they pass in the opposite direction below the fingers of the upper drums. The vines then pass over the bottom bank of finger-studded drums, which again

URE 25.—Unloading vines from V's at picking machine and clamping them into grasper bar.

rotating in a direction opposite travel of the vines. The vines ıs have been picked on both sides, l nearly all the hop cones have n removed. After traveling the gth of the machine during the ond picking, the spent vines are charged as waste.

Iop cones, petals, leaves, and ken side-arms fall into a diand wire mesh belt where leaves l partially picked side-arms are ined and delivered to a side-arm ker. Cones, petals, and small sh pass through the wire mesh t and fall on to drapers (canvas ts inclined at approximately '), which discharge toward the e of the machine (fig. 26). The ole hop cones, which are round, l down the draper onto a conor belt to continue through the cleaning process. The leaves and stems have small spines and are of different shape and density from the cones. They adhere to the draper canvas and are carried over the top of the draper to be discharged as waste.

Hops from the machine are sent on through a series of recleaning operations similar to the drapers but smaller. They often have the added refinement of a steep, fine wire mesh conveyor onto which a stream of air is directed. The hops fall through the air stream while leaves, stems, and petals are held to the belt and discharged as waste.

After the hops have passed completely through the picking and recleaning operation, they are inspected by four to eight persons (fig. 27) who remove remaining

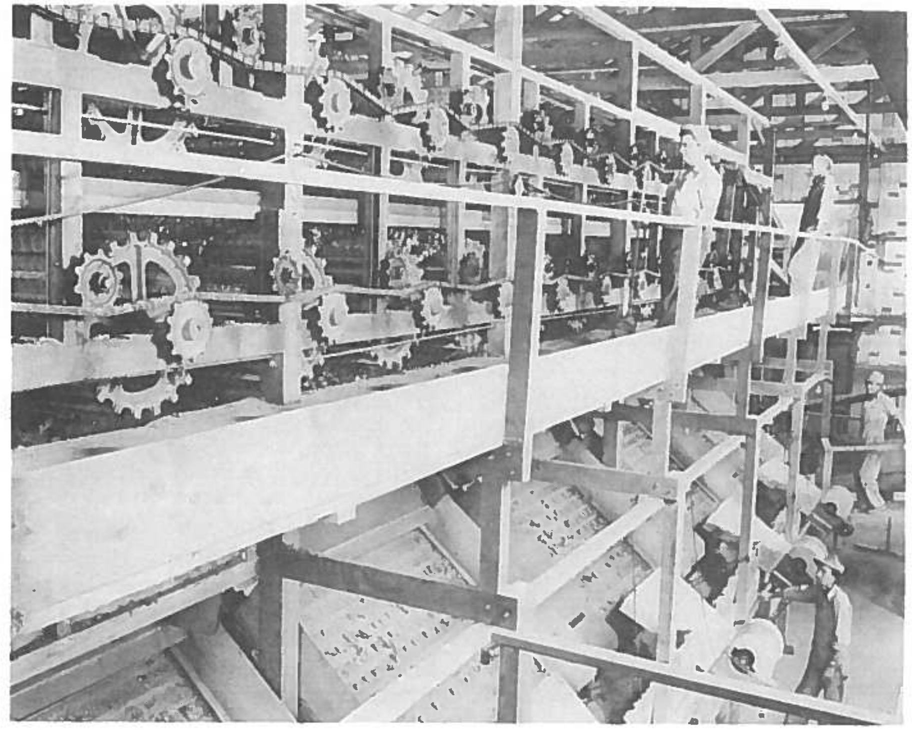


FIGURE 26.—Portion of stationary horizontal picking machine. View shows picking drums above and drapers below.

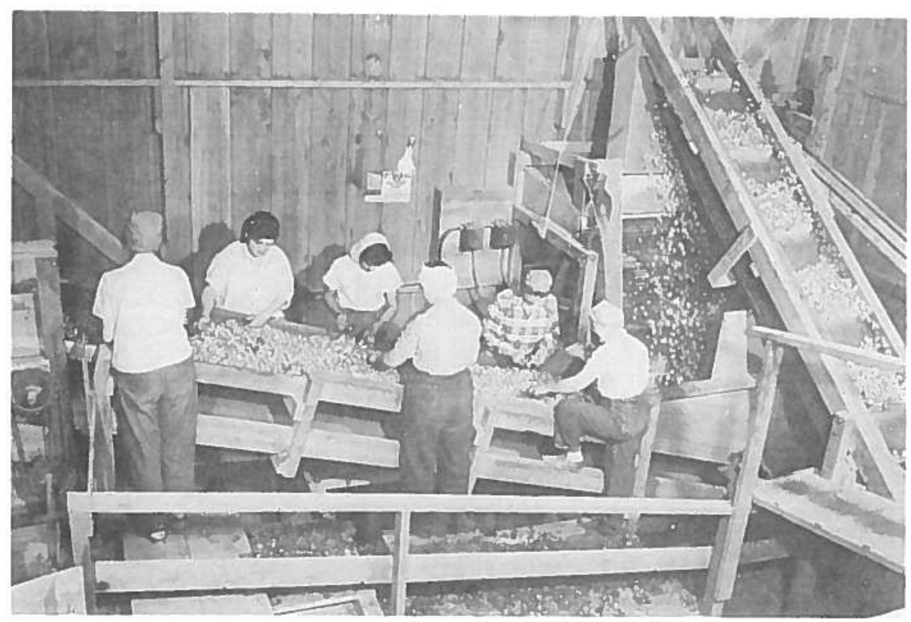


FIGURE 27.—Final hand-cleaning operation just before hops are sent to the drier.

portions of leaves and stems. The hops are then either sacked for transport to the drier or fed into a conveyor leading directly to it.

Several modifications of the horizontal picker described here are in use; however, all follow the same principles. These machines require the attendance of 10 to 20 persons and can pick from 3,000 to 4,000 pounds of green hops per hour (3 to 4.5 bales, dry). The output varies according to variety and yield.

The stationary vertical picking machine.—With this machine vines are cut in the field and hauled to the vertical picker in the same manner as that described for the horizontal picker. They are then fed into the machine while they hang inverted from an overhead trolley that carries them between the banks of picking fingers. Vertical machines employ endless chain belts mounted with banks of picking fingers rather than the revolving drums of the horizontal machines. The picking fingers strip the hops downward, and the hops are then conveyed to recleaners and side-arm pickers. Operations other than stripping the vines are very similar to those described for the horizontal pickers.

The portable picking machine.—With this machine, the vines are cut loose from the hills and the wires in the same manner as that of other machines, except that the elevated platforms are mounted on the picking machines (fig. 28). The picker itself is pulled down the hop rows, and the vines are fed directly into it.

Although the portable picker employs the same picking principles as the stationary machines, it must of necessity be much smaller. Consequently, a less thorough separation of cones from the leaves and stems can be made, and further recleaning is often required. The hops are sacked as they are picked and are then transported directly to the drier or to stationary recleaning machines. Portable machines are being replaced by stationary machines because of the larger capacity and superior performance of the latter.

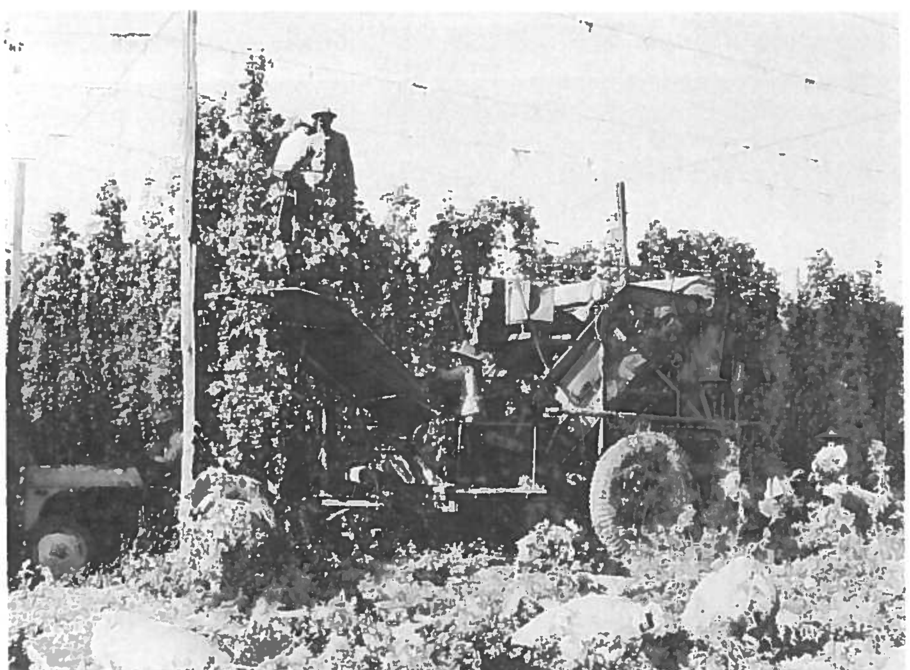


FIGURE 28.—Portable hop-picking machine.

DRYING

Drying is one of the most important steps in the processing of high-quality hops. When received from the picker, hops contain 70 to 80 percent of moisture, which must be reduced to 8 or 10 percent before the hops can be stored safely for future use.

As currently practiced, commercial hop drying is a batch process. Green hops arrive at the drying chamber on the second floor of the drier building either in sacks of about 60 pounds each or on a conveyor belt. They are loaded to a depth of from 20 to 40 inches into a chamber with a slatted floor covered with burlap sheeting (fig. 29). Beneath this floor is a chamber from 7 to 20 feet high into which warm air is fed and forced upward through the bed. While the air is in transit, moisture is picked up from the hops; and the temperature of the air is lowered. The cooler, moisture-laden air is then forced out through ventilation openings in a cupola above the drying chamber. After the hops have been dried to approximately 10-percent moisture content, they are transferred to a cooling chamber where moisture differences are allowed to equalize. At this time a new batch of green hops can be loaded into the drying chamber and the cycle repeated.

FIGURE 29.—Loading a kiln with fresh hops. Hops are carefully forked to prevent uneven packing.

Construction of Hop Driers

Newer hop driers are usually con- ·te and sheet-metal-covered frame ·uctures large enough to accom- ·date at least two kilns of from) to 1,000 square feet each (fig.). A slatted floor of 1- by 2-inch ards on edge is built 7 to 10 feet ·m the ground. This is covered th burlap and forms the kiln or. The area above the floor then comes the kiln, and the chamber low the floor is known as the ·num chamber. The roof rises about a 45° angle, starting ap- oximately 8 feet up on the kiln ·lls, until an opening of about feet remains. This opening, ·ich runs the length of the dry- ; house, is topped by a cupola to 8 feet high. Cupolas are ·ally slatted so as to prevent back ·fts during strong winds.

A loading deck runs the length the drier at the same level as · kiln floor. A door leads from · loading deck into the kiln, and the opposite wall a second door ens to either a ramp or a con- yor belt leading to the cooling ·ambers.

All new driers are provided with ·ced-air systems. These are powered by 10- to 15-horsepower electric motors driving centrifugal or blade-type blowers. Air thus set into motion is forced through an oil- or gas-fired furnace and into the plenum chamber beneath the kiln floor. Heat exchangers can be used to heat the air that comes in contact with the hops, thus eliminating possible contamination by combustion products. Some driers depend on natural equalization of pressures in this chamber, while others contain a series of ducts that open into different sections of the room, thus providing a more uniform pressure distribution. This is highly important in order to avoid uneven drying or blowing holes in sections of the hop bed.

These forced-air systems are capable of delivering up to 50,000 cubic feet of air per minute against a static pressure of 1.5 inches of water. Provisions are made for baffling the air intake in order to reduce this air volume when necessary.

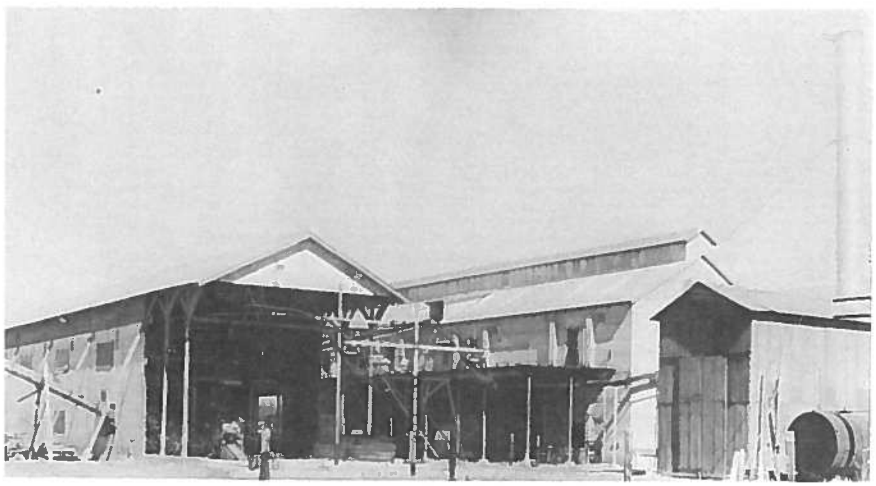


FIGURE 30.—Picking and drying center.

Drying Process

Temperatures and air velocities are the most critical factors in drying hops. Both high temperatures and high velocities tend to shorten drying periods. However, temperatures in excess of 160° F. will bring about unfavorable changes in the resinous constituents of the hops and give them a burned, disagreeable aroma. Thermometers are placed 6 to 12 inches below the floors, and automatic recorders provide a permanent record of temperatures used throughout the drying process.

At natural draft, kilns create an air velocity of 10 to 25 linear feet of air per minute.[2] By use of fans, these air velocities can be increased to 50 to 60 linear feet per minute. Velocities above this tend to lift the hops from the floor and often blow holes in the bed. These holes must be repaired immediately to maintain a uniform flow of air through the hops.

Growers commonly dry their hops at 140° to 150° F. with air velocities of 40 to 50 feet of air per minute. Under these conditions, a 30- to 36-inch bed of hops is usually dried within 8 to 12 hours. Variations in drying time occur as a result of differences among varieties, degrees of ripeness, and weather conditions. Drying time for a 36-inch bed of hops can be shortened to 7 or 8 hours by utilizing high velocities and high temperatures. Modern driers have controls for both temperature and air velocity that can be adjusted to meet scheduling requirements of the harvesting operation.

Use of high air velocities requires that the hop bed be laid evenly and uniformly. Most growers accomplish this by starting along one wall and working toward the door of the drier, carefully laying the bed to the desired depth. A pitchfork is used to loosen and spread the hops in order to insure a uniform degree of packing. Furthermore, in order to use maximum air velocities of 50 to 60 feet per minute, it is necessary that the pressure beneath the bed be uniform across the entire floor area. A plenum chamber pressure equivalent to a head of about 1.5 inches of water at the start will be reduced to a little over 0.5 inch at the end of the drying process.

As drying proceeds, the lower layers of hops become dry before the upper layers. The moisture content may be as low as 1 percent at the bottom, while the upper layer of hops still has 18 to 20 percent of moisture. With high air velocities, this gradient is much smaller; and this permits shorter equalization times in the cooling bins. In some installations, provisions are made for reversal of the direction of airflow during the drying process. This results in a more uniform moisture gradient within any given batch of hops at the end of the drying period.

There is at present no satisfactory substitute for experience in determining when hops have reached a sufficient degree of dryness. In general, when cones from near the middle of the bed have brittle, easily shattered petals but still have tough, pliable strigs, the moisture content will be 8 to 10 percent. "Fat" strigs that have not begun to shrivel indicate that drying is incomplete, while strigs that are brittle indicate overdrying. When a batch of hops has been overdried, it is usually mixed with properly dried hops so that the final blend will have a satisfactory moisture content. Some growers have mechanical means for humidifying overdried hops.

Sulfuring

Sulfuring is a process commonly used for bleaching. It is done by burning 1 to 4 ounces of sulfur per

[2] "Linear feet of air per minute" is equal to cubic feet of air per square foot each minute.

100 pounds of green hops (20 to 22 cubic feet) and allowing the fumes to pass through the hops. This process makes the hops lighter and more uniform in color and gives them a soft silkiness that makes them more appealing to the eye and to the touch. According to a recent survey, about half of the Washington growers, and even more of the Oregon and California growers, use sulfur for bleaching. Very little, if any, sulfur is used in Idaho.

CURING

After the hops have reached the proper degree of dryness, they are carefully scooped from the kilns and moved to the cooling bins (fig. 31). If the cooler is attached to the drier, the hops are taken over ramps directly to the cooling bins. However, if the cooler is located in a separate building, the hops are scooped into conveyor belts or carts mounted on a tramway and transported to the bins.

The moisture content, which is not always uniform in each batch removed from the kiln, is equalized during the curing period. The hops become tough and pliable and acquire a finer aroma and better appearance. They should be handled as little as possible to prevent undue breakage, which affects their appearance and results in a loss of lupulin and storage quality.

Hops may be left in bulk for several weeks and suffer little injury if the cooler is tightly closed to exclude atmospheric moisture. The length of time they are left in bulk depends largely on the amount of storage space available and the size of the crop harvested. Most growers prefer to leave their hops in storage at least 5 to 7 days prior to baling. Where storage space is limited, some growers find it necessary to bale a particular lot of hops the same day it is removed from the kiln. When this is necessary, there is more damage from shattering and breakage.

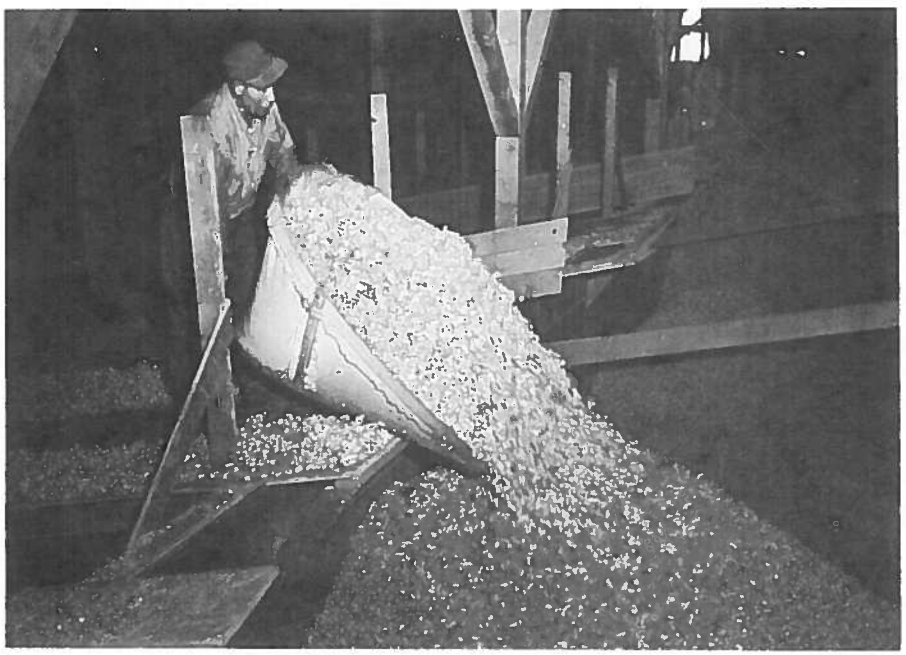


FIGURE 31.—Dry hops being transferred from kiln floor to cooling bin.

BALING AND STORING

After the hops have been properly cured and have become sufficiently pliable to prevent undue breakage in handling, they are ready to be compressed into bales. The hops should be carefully examined before baling to determine if they contain excessive moisture. The strig to which the bracts are attached contains most of the moisture and should be pliable and tough but not noticeably moist. If too moist, hops will mold in the bale, and both color and aroma will be damaged.

Balers of various designs are in use, but all are constructed on essentially the same general principle—the use of a plunger that fits inside a vertical rectangular chute approximately 1½ by 4½ feet in cross-sectional dimensions. The chute is constructed of steel or polished hardwood. The plunger travels up and down in the chute when activated by a system of gears and cables attached to a winch drum.

The most common type of power used to operate hop balers is the electric motor. In some installations, the downward stroke of the plunger is limited by microswitches; and the electric motor is designed so that it will stall if the microswitches fail to function. One or two teeth are sometimes removed from the drive shaft of the plunger to make overcompression less likely. Gasoline-powered tractors are also used as a source of power, and some balers are still operated by horsepower.

The baling process is carried out in a series of operations. First, a burlap or Hessian cloth is laid on the chute floor and the gates are clamped shut. The chute is then filled with loose hops from above, and the plunger is brought down to compress them. The plunger is then raised and the chute is again filled with loose hops, after which a second cloth is laid across the top. The plunger is again lowered, compressing the hops in the bottom of the chute. The hops are held in this position for a few seconds, then the bottom gates are opened and swung upward, and the bale is ready to be sewed (fig. 32).

Starting at the ends of the bale and using a lock stitch about 3 inches long, the needle is run through the cloth over the twine. The twine is then looped over the needle (half hitch) and pulled tight. Properly sewed bales should not expose any hops at the seams. After the sides have been sewed, the plunger is raised and the bale is expelled from the chute. It is weighed, and the ends of the cloth are pulled over and sewed in place. Another cloth is then laid in the bottom of the chute, the doors are clamped shut, and the process is ready to be repeated.

Because of the sticky nature of the lupulin, the inside walls of the chute must be wiped frequently with a cloth soaked in mineral oil.

Most balers are made to form a standard sized bale with two fillings of the chute. Some balers, however, require three fillings and some only one. When the bales have first been formed, they are approximately 4½ feet by 1½ feet by 2 feet. However, on expansion against the cloth, the finished bale is approximately 4½ feet by 1⅔ feet by 2½ feet.

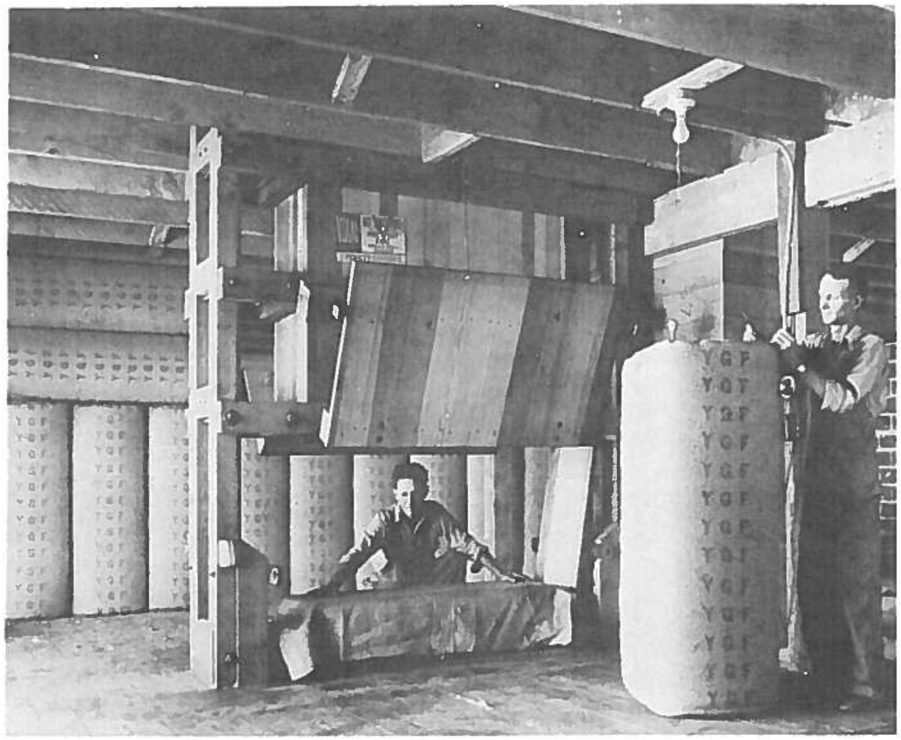


FIGURE 32.—Baling hops. One bale has just been completed, and the baler is being prepared for the next.

Bales should weigh between 185 and 205 pounds. Hops that have been baled in this manner weigh approximately 15 pounds per cubic foot, but after expansion they weigh approximately 10.5 pounds per cubic foot.

Hops are baled in jute bagging or burlap having 16 threads or less to the inch. About 5 running yards of cloth 45 inches wide is required for each bale. Because the baled hops are usually handled by hooks while being stored and transported, it is important that the bales be properly and securely sewed to prevent damage. Eight- or ten-ply linen twine is generally used for this purpose. Some growers use heavy paper or polyethylene film in addition to the burlap to form an inner wrapper as a dust and moisture barrier.

The baling operation is usually carried out by a crew entirely separate from the drying crew. In most districts, a baling crew consists of four laborers. This allows two men to be on the upper floor, one to gather the loose hops and load the chute, and the other to assist in this operation and to operate the controls to the source of power. Two men are required on the lower floor to sew and weigh the bales. The baling crew contracts to do the baling either on a piecework or an hourly basis. An experienced crew can complete a bale every 4 or 5 minutes.

Hop constituents undergo gradual changes while in the bale, the degree depending on the variety and conditions of storage. Because of the cost of cold storage or the lack of such facilities, growers often store their hops for long periods at temperatures that fluctuate with the season. Under such conditions, the desirable hop acids are oxidized to hard resins, the essential oils are volatilized, and the hops often acquire a disagreeable aroma. These changes result in a decline in their market value.

Experiments have shown that cold storage is the best practical means of protecting hops against deterioration, and many dealers and most breweries are equipped with this facility. Hops should be stored and transported at temperatures kept below 40° F. and as constant as possible. Proper baling and storage are necessary to protect hop quality and will benefit the grower and consumer alike.

QUALITY

Hop quality can be judged by physical evaluation, which is the standard used by most growers and dealers; and by chemical analysis, which is more generally used by the brewing industry and research groups.

Physical Evaluation

Nearly all hop purchases are made on the basis of physical evaluation of color, aroma, and lupulin content, and the measurement of leaf and stem, seed, and broken cone content. Experienced members of the industry are able to judge hop quality with a considerable degree of accuracy, even without the refinements of laboratory apparatus. Some of the tests do not have a direct bearing on brewing quality, but they nevertheless affect the salability of the crop.

Federal regulations require that each lot of hops bears a certificate of inspection by State or Federal inspectors. Samples drawn from random bales are evaluated for leaf and stem content and for seed content. A summary report of the inspections is issued periodically by the U.S. Department of Agriculture.

Color.—Hops should be light yellowish green. If they have been damaged by insects or diseases, the color will be blotched or spotted. Prematurely harvested hops are green in color without the yellowish tint. When hops are overripe, some petals will have an undesirable rust color.

Aroma.—Hops picked at the peak of maturity have a full, pleasant aroma. Samples that come from prematurely harvested hops may have a haylike aroma and be generally unsatisfactory. Hops picked after full maturity may have a slight harshness in addition to the full aroma. The aromatic qualities of hops are closely associated with their essential oils.

Lupulin.—The resins and essential oils are contained in the tiny, yellow lupulin granules located at the bases of the petals. The hand-evaluation test for lupulin is to rub a few cones and note the degree of stickiness. A sample exceptionally sticky when tested in this fashion is referred to as "rich." The resinous constituents in hops are extremely important because they provide the hop bitterness necessary for flavoring fermented malt beverages.

Leaf and stem.—The extractable material in leaves and stems is considered undesirable by brewers. Dealers currently pay a bonus of 1 cent for each percent under 6 percent leaf and stem content. Above 6 percent, the buyer has the option of imposing a penalty or rejecting the particular lot.

Seed.—Seedless hops are generally preferred by the brewing industry, and a price premium is paid for them.

Broken cones.—Experiments at Oregon State College have shown that broken or shattered cones are lower in alpha-acid content and possess significantly poorer keeping qualities than do whole cones. Consequently, the percentage of broken cones is considered in the physical evaluation of hops.

Evaluation by Chemical Analysis

While the chemical analysis of hops is precise, it is confined to only a few components. It can make no evaluation of physical appearance, insect and disease damage, or extent of broken cones. Chemical analysis is concerned primarily with the alpha-acid content, but the essential oil content and the tannin content may also be evaluated.

Alpha-acid.—Alpha-acids are the most important bitter principles of the hops. Alpha-acid content is a varietal characteristic that appears to be affected only slightly by soil variation or cultural practice. The seasonal influence, however, is noticeable.

The Fuggle variety is one of the milder hops with respect to alpha-acid content and averages between 4.5 and 5.5 percent.

The Cluster varieties (Early and Late) are somewhat richer in alpha-acid, as they range from 5 to 7 percent. The English varieties Brewers Gold and Bullion range from 8 to 12 percent of alpha-acid.

Once hops are removed from the vines, alpha-acid is sensitive to processing and handling. Hops must be carefully dried to prevent oxidation of the alpha-acid, and caution must be exercised to prevent shattering of the cones. Hops should be dried to the proper moisture content (8 to 10 percent) and stored under as cool conditions as possible to prevent undue deterioration. Storage temperatures vary with the weather and with the construction of the warehouse; however, they usually remain under 70° F.

Essential oils.—A close relationship exists between the aroma and flavor of the brewed beverages and the essential oils of the hops used in their manufacture. However, it is not possible to define these delicate qualities in terms of the essential oils alone. For this reason, chemical analysis for essential oil content is not so popular for evaluating aroma and flavor as is the physical method of rubbing and smelling.

Like alpha-acids, hop oils are subject to deterioration and loss. To maintain a high oil content, the same post-harvest precautions must be taken as in the case of alpha-acid; and even further attention to drying temperatures is necessary. Temperatures under 130° F. are desirable. Hops with a high oil content, which are used almost exclusively in the brewing of ales, have a limited market.

Tannins.—Hop tannins make a real contribution to the brewing process by aiding in protein coagulation; however, there has been little interest in the routine evaluation of hops for their tannin content.

PRODUCTION AND MARKETING

Hops are grown in almost every temperate region of the world. In 1959, the major producing countries were the United States, West Germany, the United Kingdom, the U.S.S.R., Czechoslovakia, Yugoslavia, France, Belgium, Australia, Poland, Japan, East Germany, and Canada, each of which produced over 1 million pounds. The United States, West Germany, and the United Kingdom are the largest producers; together, they produced over 65 percent of the world total in 1959.

The United States leads all countries in the production of hops. Figure 33 shows the world and U.S. production from 1934 (following the repeal of prohibition in the United States) to 1959, except for the war years 1939 to 1944. World production has fluctuated throughout this period, reaching a high level during the period 1950–54. World production in 1958 amounted to 179,485,000 pounds, an alltime high.

Production in the United States has followed essentially the same pattern, reaching a peak of more than 53 million pounds annually during the period 1950–54. This was followed by curtailed production, and somewhat less than 37 million pounds was produced in the United States in 1955. Since that time, there has been a steady increase in total production, with over 53 million pounds again being produced in 1959.

World production of beer is slowly increasing because of the growing population, better and more widespread transportation facilities which have expanded world markets, and the more general acceptance of beer as a food beverage. The demand for hops is more or less fixed, since it is regulated by a single industry whose requirements are relatively inelastic. As a result, rising and falling production levels cause great fluctuation in the prices that hop growers obtain for their crop.

Figure 34 shows how production in the United States is curtailed following periods of oversupply. During the periods 1934–38 and 1945–49, total annual supplies were only slightly more than total annual disappearance, with a 6- to 8-month supply carried over. During the period 1950–54, total supplies, including annual production, annual carryover, and imports, greatly exceeded annual disappearance brought about by domestic consumption and exports. As a result, production was greatl reduced in 1953, 1954, and 1955 Since 1955, there has been a steady increase in production as well as ir

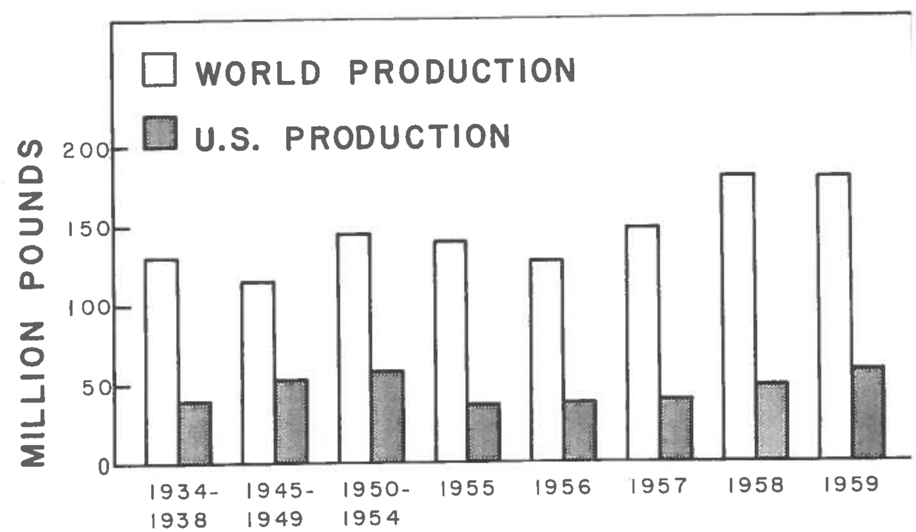


Figure 33.—Average annual world and U.S. hop production during stated period Crop harvested in Southern Hemisphere is included with crop of preceding calei dar year in Northern Hemisphere. (Compiled from AMS and FAS reports.)

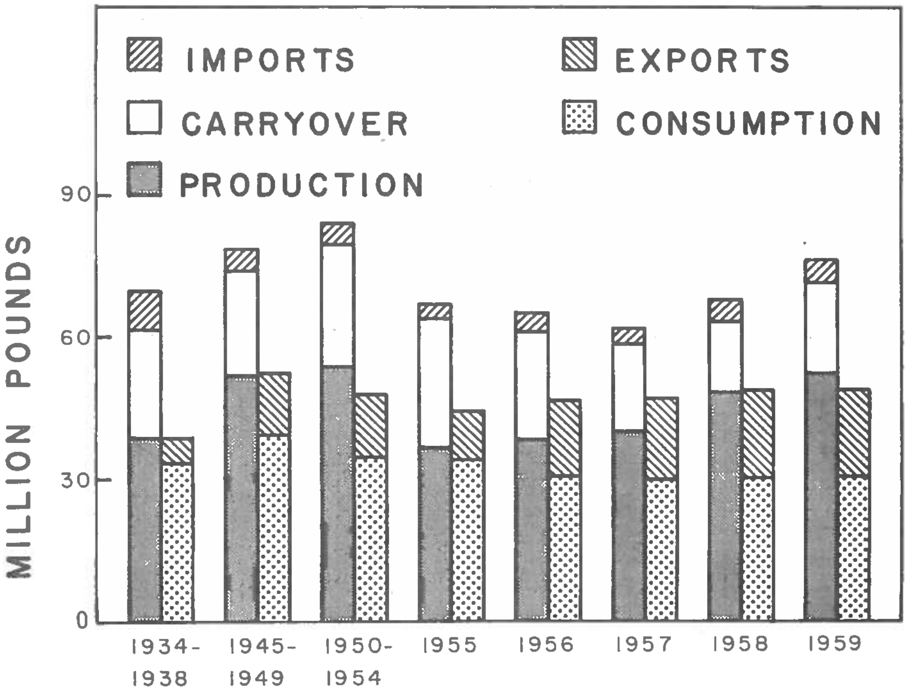


FIGURE 34.—Average annual U.S. hop supplies and disappearance during stated periods. Supplies include total annual production (harvested), total imports from September 1 to August 30, and total carryover as of September 1. Disappearance includes total domestic consumption and exports from September 1 to August 30. (Compiled from AMS and FAS reports.)

exports. Exports have not kept pace with increased production, and American hop growers again faced an unfavorable market situation in 1960.

Although beer consumption is rising, domestic consumption of hops has declined steadily for the past several years. This has been caused by a decrease in the amount of hops used per keg of beer that has more than offset the increase in the amount of beer manufactured.

American-grown hops compete favorably in most world markets with regard to quality. In addition, efficient U.S. production methods make American hops cheaper than those grown in most competing countries. Because of these factors, American-grown hops have found increasing favor in foreign brewing centers since 1955. With the continued upward trend in world beer consumption, the export demand should continue at high levels. In 1959–60, a record amount of 18,590,000 pounds was exported to foreign markets. Market price and the availability of American dollars in overseas markets have a definite influence on the export market.

Hop imports have been decreasing steadily for many years, but the competition of foreign hops with domestic hops is still significant. Certain U.S. breweries prefer foreign hops and import them from Europe even when the domestic supply is plentiful.

The most important problem that confronts the hop grower is the sale of his crop at a price that will give him a fair return on his investment and labor. Owing in part to great fluctuations in price, hop growing is an extremely uncertain enterprise from the business point of view. The state of the market is determined largely by the probable demand as judged by prospects at home and abroad during the current year and by stocks held in storage from the previous years. Since hops are a perennial crop requiring considerable expense for establishment, it is difficult for growers to adjust production according to supplies on hand at the beginning of each season. The market is influenced also by the activities of the dealers or merchants who stand between the producer and consumer.

Hop dealers form the distributing organization and the economic buffer for the trade. They contract with the grower for specific tonnages from specific fields. They maintain a cash reserve from which a grower can obtain advances, if necessary, to produce his crop. They relieve the grower of his crop immediately after harvest and provide warehouse facilities for the hops until the consumers are prepared to receive them.

After harvest, hops are hauled directly to local warehouses where they are held in common storage. During the following month or two, most of them are distributed to the consumer. Portions of the crop sold for domestic use are normally transported by rail as soon as the breweries are prepared to receive them. Upon arrival, they are held at temperatures of 35° F. or lower until they are used. The part of the crop that is sold to foreign markets is sent to special dealer-owned plants or to special companies who prepare it for export. Preparation usually consists of recompressing two bales into the volume occupied by one. Bales are then wrapped and sealed in waterproofed, laminated paper and crated in wooden boxes. Some recompressed hops are sealed in metal drums for export.

A small portion of hops intended for specialized uses is placed in cold storage within hours after baling and is shipped directly to the consumer in refrigerated boxcars. Interest in shipping some lots by rail in iced boxcars is increasing. This trend may eventually include a considerable portion of each crop.

Experiments have been made tc explore the possibility of protecting the hop acids and essential oils while in transit by vacuum packing in metal drums, by sealing undei nonoxidizing atmospheres such as nitrogen or carbon dioxide, or by wrapping and sealing with polyethylene film. While these methods are helpful, they have not beei used to any appreciable extent ii the United States.

COST OF PRODUCTION

The complexity and specialization of hop production necessitate large investments in trellises, land, equipment, and buildings. Many man-hours of labor are required for manual jobs as well as for operating the special equipment. Large amounts of materials such as fertilizers, burner fuel, baling cloth, fungicides, and insecticides, as well as considerable expenses for machine operation, are involved.

The dependence of hop producer on transient labor presents additional problems. Considerabl time and effort are spent in recruiting labor crews for the hoeing an training operations in the sprin and for harvest in late summer. I is not until the helpers have become experienced that they can d an efficient and satisfactory jol Often growers find it necessary t teach an inexperienced crew o seasonal helpers every spring. In addition, most hop producers must provide housing or camping facilities, including upkeep and maintenance of buildings and drinking and sanitation facilities, for the seasonal helpers and their families.

Many items that must be considered in determining the cost of producing hops differ with the season, locality, and size of operation and are difficult to estimate or predict. Expenditures for labor and materials are often reduced to a minimum in years of unfavorable market conditions, and this materially reduces the cost of production. Unusually low yields caused by unfavorable weather conditions or by unexpected losses from disease or insect pests increase production costs. On the other hand, conditions unfavorable to the development of diseases and insects tend to decrease production costs by reducing the expenses involved in control programs.

Independent studies made by the Extension Service of the University of California and the Oregon Agricultural Experiment Station for the years 1934–36 showed that preharvest costs, under normal conditions, remained essentially fixed. Harvesting, drying, and baling costs increased because of higher yields; but the cost of production per pound decreased progressively as the yield increased. This does not necessarily mean that hops are produced most economically in those districts that consistently produce the highest average yields.

Production requirements differ among districts. For example, the consistent need for a greater number of irrigations in the drier inland districts where yields may average 1,500 to 1,900 pounds per acre brings about an increased cost per pound compared to the cost in the more humid districts where yields may average 1,000 to 1,500 pounds per acre. This increased cost may or may not be offset by the expense involved in the more humid districts where more attention to disease control is sometimes necessary.

Cost-of-production figures are generally considered unreliable, since they represent variation in individual efficiencies and judgments. They can be obtained only by consultation with individual operators, who are often understandably reluctant to discuss their personal managerial affairs. Cost estimates have been obtained indicating that, at normal yield levels, the average cost of producing a pound of hops in 1957 was approximately 40 to 45 cents. This estimate included all seasonal investments in labor, equipment, materials, interest, insurance, and depreciation, plus a reasonable return on investments. It represented the thinking of hopgrowers, and it corresponded favorably with estimates based on earlier economic studies adjusted for present-day prices.

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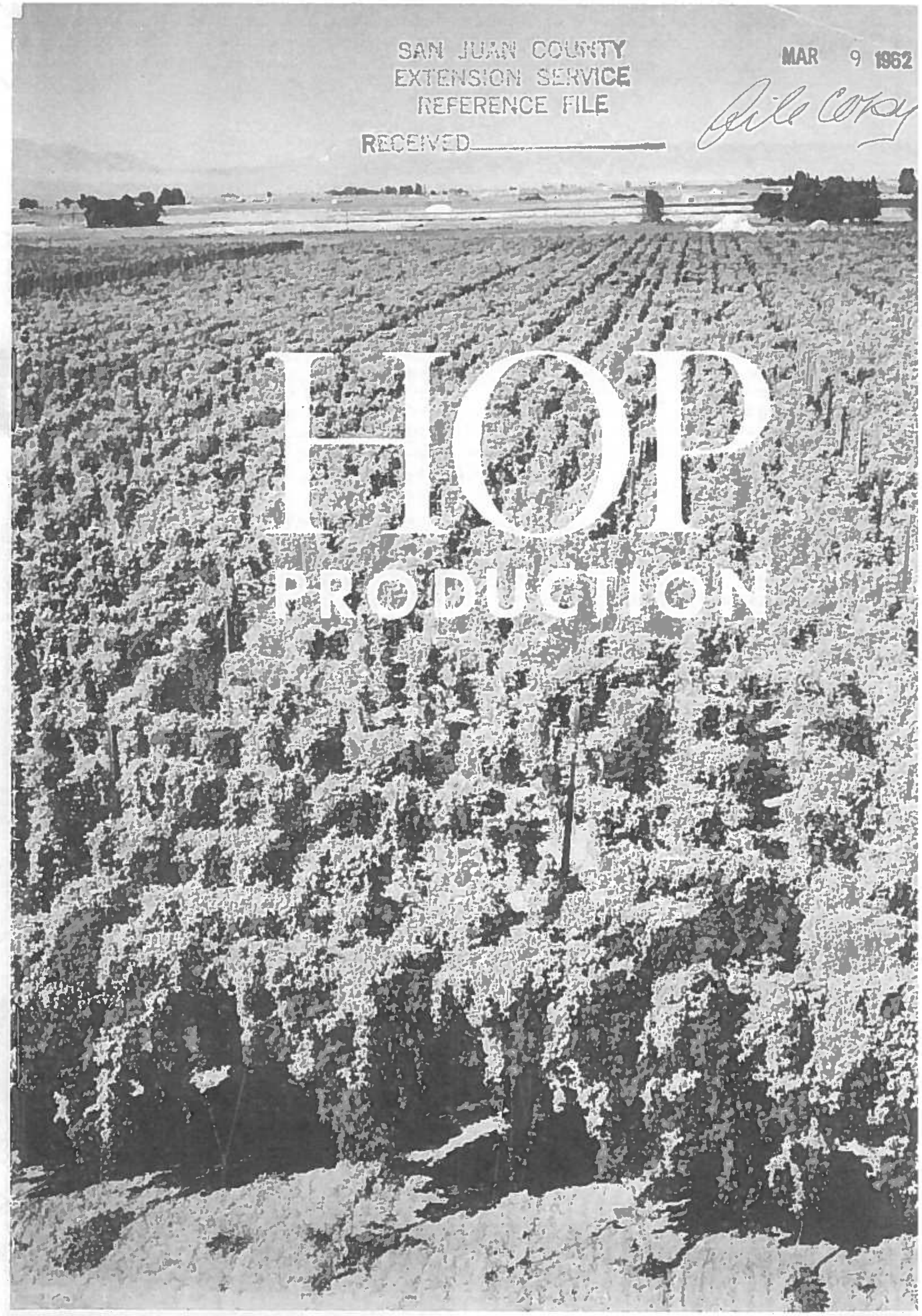
Growth Through Agricultural Progress



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