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# SWEET CHERRIES: Production, Marketing, and Processing

Agriculture Handbook No. 442

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## PRECAUTION

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State Extension specialist to be sure the intended use is still registered.

This handbook updates information on cherry production that formerly appeared in Farmers' Bulletin 2185, "Growing Cherries East of the Rocky Mountains," and its predecessor, Farmers' Bulletin 776, of the same title.



# SWEET CHERRIES: Production, Marketing, and Processing

By H. W. FOGLE, J. C. SNYDER, H. BAKER, H. R. CAMERON,  
L. C. COCHRAN, H. A. SCHOMER, and H. Y. YANG

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# CONTENTS

	<i>Page</i>		<i>Page</i>
Introduction .....	1	Fungal and bacterial diseases .....	49
Botanical classification .....	2	Brown rot .....	50
Areas of adaptation .....	3	Armillaria root rot .....	52
Importance of crop .....	3	Verticillium wilt .....	53
Responses to climate .....	5	Collar rot or crown rot .....	53
Winter- and frost- hardiness .....	5	Cherry leaf spot .....	53
Rain cracking of fruit .....	5	Coryneum blight .....	54
Fruit doubles .....	7	Witch's broom .....	54
Soil requirements .....	7	Black knot .....	54
Cultivars (Varieties) .....	8	Powdery mildew .....	55
Main cultivars .....	8	Perennial canker .....	55
Special-purpose cultivars .....	11	Bacterial canker .....	55
New and promising cultivars .....	13	Crown gall .....	57
Pollination requirements .....	18	Virus and viruslike diseases .....	57
Propagation .....	19	X-disease .....	58
Rootstocks .....	20	Little cherry .....	59
Interstocks .....	21	Albino .....	61
Topworking .....	22	Prunus ringspot .....	62
Orchard planting .....	22	Mottle leaf .....	62
Site .....	22	Rusty mottles .....	63
Selection of nursery stock .....	22	Rasp leaf .....	64
Soil preparation .....	23	Twisted leaf .....	64
Time of planting .....	24	Black canker .....	64
Tree spacing .....	24	Spur-inducing virosis .....	65
Transplanting .....	25	Short-stem virosis .....	65
Tree heading and training .....	25	Virus diseases of lesser importance .....	65
Care of young trees .....	26	Cherry boron rosette .....	66
Orchard management .....	26	Other disease problems .....	66
Cultivation .....	26	Harvesting and marketing .....	67
Fertilizers .....	26	Picking maturity .....	68
Irrigation .....	28	Indices of maturity .....	68
Cover crops and intercrops .....	28	Fruit handling .....	69
Weed control .....	29	Packaging .....	69
Pruning and thinning .....	31	Pretransit holding and shipping .....	72
Pruning .....	31	Processing .....	74
Thinning fruit .....	35	Brining .....	74
Protection against birds .....	36	Maraschino .....	81
Insects and mites .....	37	Glacé .....	84
Cherry fruit flies .....	38	Canning .....	84
Black cherry aphid .....	40	Freezing .....	85
Mites .....	41	Dehydrating .....	85
Pear slug .....	44	Pickling .....	85
Plum curculio .....	45	Other uses .....	85
San Jose scale .....	46	Literature cited .....	85
Shot-hole borer .....	46	Additional selected references .....	91
Lepidopterous larvae .....	47		

# Sweet Cherries: Production, Marketing, and Processing

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## INTRODUCTION

Climatic conditions in the Pacific Coast States are very different from those in the Great Lakes cherry areas. Cultivars (varieties developed under cultivation) grown are different in the western and eastern growing regions. Utilization varies widely, even among the Pacific Coast States. Many western cherries are grown under irrigation, while those in eastern orchards are grown mostly under natural rainfall. The western shipper requires cultivars firm enough to withstand transportation for 3,000 miles and several days on the grocer's shelf, whereas the eastern grower uses soft-fleshed cultivars because of their greater rain-cracking resistance.

Despite these variations between growing regions, it appeared desirable to have a publication combining such recent developments as new cultivars and new harvesting and handling methods with the considerable, but widely dispersed, published material on sweet cherries. Since about 80 percent of the sweet cherries are produced in the Western States, it appeared

logical to prepare such a publication primarily for western conditions, with variations noted as appropriate for eastern producing areas.

The sweet cherry is considered to be native to the Caspian-Black Sea region (30)<sup>8</sup> and perhaps to parts of Asia as far east as northern India (58). From these areas, men and birds apparently spread seeds to all of continental Europe.

Early colonists brought sweet-cherry seeds to America and established orchards. Natural spread occurred in the eastern United States, and large specimen trees were often found in open pastures or forests. Propagation of trees by grafting in America started about 1767, some 140 years after the first records of cherry culture in America (71).

Settlers brought sweet cherries with them to Michigan, Indiana, Illinois, and Missouri in the period from 1700 to 1750.

Franciscan monks were cultivating sweet cherries in California missions by the end of the Revolutionary War. A few of the "forty-niner" gold miners began cultivation of cherries and other fruits. However, modern cherry growing in the West began with Henderson Lewelling, who in 1847 transported nursery stock from Iowa to western Oregon by oxcart and established orchards. Later, lacking suitable understocks, the Lewelling nursery, then headed by Henderson's brother, Seth Lewelling, grew large numbers of cherry trees from seeds. From these, the cultivars 'Bing' and 'Republican', and later, 'Lambert' originated.

'Napoleon' was renamed "Royal Ann" by the Lewelling brothers after its label was lost en-

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<sup>8</sup> Italic numbers in parentheses refer to Literature Cited, p. 85.

route during the overland journey. These four cultivars have comprised nearly all of the commercial acreage in the West until the present time.

## BOTANICAL CLASSIFICATION

The sweet cherry (*Prunus avium* L.) is a drupe or stone fruit belonging to the family Rosaceae. It has a basic chromosome number (n) of 8. Nearly all sweet cherries are diploid ( $2n=16$ ), although occasional tetraploids ( $4n=32$ ), which bloom sparsely and are unproductive, occur from the union of unreduced gametes. Rarely, triploids have been found. Duke cherries, *P. Gondouini* (Poit. and Turp.) Rehder, [*P. effusa* (Host.) Schneid.], arise from the cross of tetraploid *P. cerasus* L. (commonly known as sour cherry, tart cherry, pie cherry, or red cherry) and unreduced pollen ( $2n$ ) of the sweet cherry. The tetraploid duke cherries are productive in varying intermediate degrees between the two species.

Numerous attempts have been made to separate sweet cherries into distinct subspecies. Although some rather distinct botanical differences are evident in the wild state, hybridization of the cultivated forms confuse any such attempt at classification. Therefore, it is more practical to separate cultivars into two rather distinct pomological groups:

1. The bigarreus, which have firm-fleshed fruits, and
2. The Guigne, Gean, or Heart group, which have soft, tender flesh.

Only bigarreau-type cherries are firm enough to withstand commercial handling. Heart-type cherries often are satisfactory for backyard use, however.

Both of these groups can be further divided on the basis of skin color into dark and light types. The so-called "black" cherries are actually reddish-purple or mahogany, and the so-called "white" ones are actually yellow, usually with pink blush.

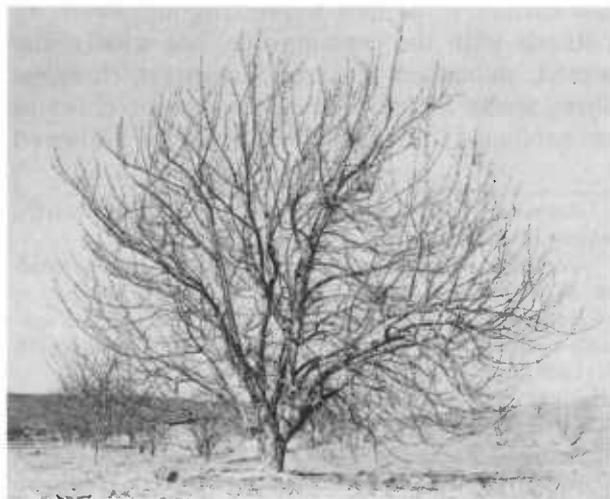
Botanically, cherries are more closely related to plums than to peaches or apricots. Some borderline *Prunus* species are difficult to classify definitely into one or the other group. Cherries generally differ from plums in that

leaves emerging from buds are folded lengthwise in contrast to being rolled in plums. Also, in cherries, the stone is more globular, the fruit and stone are smaller, and the flowers occur in corymbose, rather than umbelliferous, clusters.

Sweet-cherry trees that are untrained and unpruned form a large tree with strong central leaders. Generally, they are long-lived trees, which will attain greater height and breadth than can be handled economically in commercial practice (fig. 1). Hence, some care in training the young tree, pruning to produce and maintain wide-angled limbs, and forcing early fruiting are helpful in controlled growth and mature tree size. When fully hardened, sweet-cherry trees are hardier than peaches but more tender than most apple varieties. However, trunks, crotches, and terminal wood of sweet-cherry trees are susceptible to early fall freezes.

Leaves and fruits of sweet cherries are larger in general than those of other cherry species. Petioles may be glabrous or may have sparse to dense pubescence. Large, prominent glands, often bright red, occur at the base of leaf blades and on the petiole.

Flowers are white-petaled and usually single, although double-flowered types occur. In-



PN-3042

FIGURE 1.—A large bearing sweet-cherry tree. Note the natural spread of the tree as a result of ample space. This tree regularly produced more than 1,000 lb. of fruit each year.

florescence buds contain 1 to 5 flowers, usually 2 or 3, forming a shortened corymb upon opening.

Fruits vary from round through ovate to long heart shapes. The styler scar often is conspicuous. The stem cavity ranges from very shallow with symmetrical shoulders in the oval shapes to deep, abrupt ones with prominent shoulders in the heart shapes. Sutures are usually inconspicuous. Flesh color ranges from yellow to dark purplish-red, almost black, and is controlled by one genetic factor (26, 41). Skin color varies from yellow, to yellow with a pink blush, through shades of mahogany, to almost black. Although quantitative inheritance of skin color first seemed probable, one major factor and a hypostatic one appear to explain the segregation classes that occur (41). Additional modifying factors may operate. Stem length may vary from about an inch to nearly 3 inches. The stone is elliptical to roundish, smooth, and free to semiclinging to the flesh. Pits are distinctive morphologically and thus are useful in identifying cultivars.

For rootstocks, seeds are used of mazzard, a term used to denote small-fruited, usually uncultivated, *P. avium*, or of the St. Lucie cherry, *P. mahaleb* L. The 'Stockton Morello', *P. cerasus*, is a preferred rootstock where soils are too wet for mazzard rootstocks. Other rootstocks that have been used to a limited extent are *P. fruticosa* Pall., (the European ground cherry), *P. fontanesiana* Schneid. (a mazzard x mahaleb hybrid), *P. pensylvanica* L., *P. serotula* Lindl., *P. "dropmoreana"*, *P. incisa* Thunb., *P. nipponica* var. *kurilensis* (Miy.) Wils., and other *P. cerasus* cultivars.

## AREAS OF ADAPTATION

Sweet cherries are not well adapted to most areas of the United States. Despite the fact that it has been a favored home garden fruit and tried in every part of the country, the sweet cherry is limited in commercial production principally to seven western and four Great Lakes States. In the last 2 decades, California, Oregon, Washington, and Michigan accounted for about 80 percent of the trees and more than 85 percent of the U.S. production. The following compilation (table 1) from US-

DA Agricultural Statistics and U.S. Census data shows the distribution of sweet-cherry production and reveals possible trends in the United States.

## IMPORTANCE OF CROP

The annual U.S. production of sweet cherries averaged more than 90,000 tons in the years 1951 through 1970, and more than 113,000 tons in the last 5 years of this period. In the second of these decades, more than 100,000 tons were produced each year except 1963, 1965, and 1968. Peak production of 136,390 tons occurred in 1949, and a similar yield occurred in 1971. The 1970 crop of 121,650 tons had a farm value of more than 40 million dollars, about an average return from crops in the past decade. Crop prices are affected by unusually heavy or light crops, and total value tends to fluctuate less than production.

Almost 3.9 million trees, 37 percent of which were nonbearing, were reported in the 1964 census, as compared to less than 2.3 million in 1959. Approximately 4.1 million sweet-cherry trees were reported in the 1969 census. Twenty-eight percent of these were nonbearing trees.

Each of the eight top-producing States showed increases in the number of nonbearing trees in 1959 as compared with 1954 (table 1). Continued expansion of sweet-cherry plantings was evident in the 1964 trees census, particularly in Washington, Oregon, Montana, Michigan, and Colorado, but expansion had ceased in California, New York, and Pennsylvania. Other producing States were about maintaining their planting rate. In the Pacific Northwest, part of the increase was accounted for by replacement of trees lost in the severe fall freeze of 1955. Most of the rest represent substantial new plantings in all major sweet-cherry areas, reflecting the relatively favorable returns of recent years.

About 35 percent of marketable sweet cherries was sold on the fresh market each year from 1960 to 1969. Previously about 40 percent and as high as 48 percent were marketed fresh. During the period 1955-70, between 10 and 20 percent of the crop was canned, and less than 1 percent was frozen each year. The remaining

TABLE 1.—Percent of total U.S. sweet-cherry production for a 22-year period, percent of total U.S. trees bearing and non-bearing from 1959 and 1964 censuses, and percent change in number of nonbearing trees from 1954 to 1959 and from 1959 to 1964, by producing States

State	Percent of total U.S. production <sup>1</sup>									Percent of total U.S. trees <sup>2</sup>				Change in percent of nonbearing trees	
										Bearing		Nonbearing			
	1950-59	1960	1961	1962-66 <sup>3</sup>	1967	1968	1969	1970	1971 <sup>4</sup>	1959	1964	1959	1964	1959/1954 <sup>5</sup>	1964/1959
Calif ..	30	34	27	26	15	28	24	21	24	28	25	28	18	+27	-14
Oreg ..	24	18	25	25	35	17	28	33	24	23	21	19	23	+192	+57
Wash ..	19	16	21	18	21	13	19	20	24	11	14	11	22	+127	+159
Mich ..	11	20	14	18	16	24	17	17	15	19	23	29	26	+157	+12
N.Y ...	5	5	4	5	4	6	6	3	5	6	5	4	3	+33	-15
Utah ...	4	2	2	2	3	8	2	2	3	5	5	4	3	+33	+5
Idaho ...	3	2	2	2	2	1	2	1	1	2	2	2	1	+20	+6
Mont ...	2	2	2	1	2	1	<1	1	2	2	2	2	2	+223	+32
Pa ....	1	1	1	1	1	1	1	1	<1	2	2	1	1	-31	-6
Colo ...	1	1	1	1	1	1	<1	<1	<1	1	1	1	1	-34	+44
Ohio ...	1	1	1	-----	-----	-----	-----	-----	-----	1	<1	1	<1	-31	-22

<sup>1</sup> From Crop Production, Annual Summaries (CR-FR-2-1) and Fruits, Non-Citrus, by States (FR-NT-2-1), prepared by USDA Statistical Reporting Service, Crops Reporting Board, Washington, D.C. Reporting for Ohio ended in 1961.

<sup>2</sup> From Census of Agriculture, Vol. II General Report 1959:926-927 and 1964:468-469.

<sup>3</sup> Average for 5-year period used because of extremely atypical distribution of the crops in 1963, 1965 and 1966.

<sup>4</sup> Indicated crop, from Crop Production (CrPR 2-2) release dated July 9, 1971, USDA Statistical Reporting Service.

<sup>5</sup> (Total nonbearing trees in 1959 ÷ total nonbearing trees in 1954) x 100 - 100.

percentage, as high as 50 percent, was brined during this same period for manufacture of maraschino, glacé, and candied cherries.

Use of sweet cherries varies widely in different producing areas. Oregon and the Great Lake States market about 15 percent of their production fresh and brine about two-thirds. California markets about one-third of its production fresh and brines about half. Washington (90) and the remaining western States market more than two-thirds of their production fresh. Washington divides the remainder between canned and brined products, while

Montana, Idaho, Colorado, and Utah brine all of their remainder.

The canning industry uses from 15 to 25 percent of the marketed volume in California, Oregon, Washington, and the Great Lake States. Favorable fresh-market prices, unusually large fruit size, and freedom from rain-cracking reduce the volume for processing, particularly in the Pacific Northwest States. Washington is the only State reporting freezing of sweet cherries for market. About 2½ percent of the cherries sold in Washington are frozen.

## RESPONSES TO CLIMATE

### WINTER- AND FROST-HARDINESS

When fully dormant, sweet-cherry trees withstand minimum temperatures that kill peach fruit buds and severely damage peach trees. However, cherry trees are very susceptible to freezes before the hardening process is completed. In 1955, many cherry trees in the Pacific Northwest were killed or severely damaged in the trunk and crotches by temperatures around 0° F. in mid-November (fig. 2). These temperatures would not injure a dormant cherry tree, but they had not been preceded by a killing frost in most areas. Thus the hardening process was incomplete. Therefore, it is advisable to avoid late flushes of growth and to promote early tree hardening by withholding late summer or early fall applications of nitrogen, by avoiding heavy irrigation in the early fall, and by the use of fall-seeded cover crops.

Sweet-cherry fruit buds sometimes are killed during the dormant period. 'Bing' buds tend to withstand 2° to 4° lower temperatures than do those of peach. Occasionally the difference may be more than 4° because cherry fruit buds respond to below-freezing temperatures more rapidly than do peach buds in Washington State tests.

Fruit buds are very sensitive to spring frosts just preceding and during the opening of flower cluster buds. Whereas a temperature of 28° F. is considered critical for cherries

during the tight-cluster stage of flower opening, the other stone fruits may endure 25° F. or lower. During the bloom and after-bloom periods, however, cherries will withstand about as much cold as the other fruits at equivalent stages of development.

### RAIN CRACKING OF FRUIT

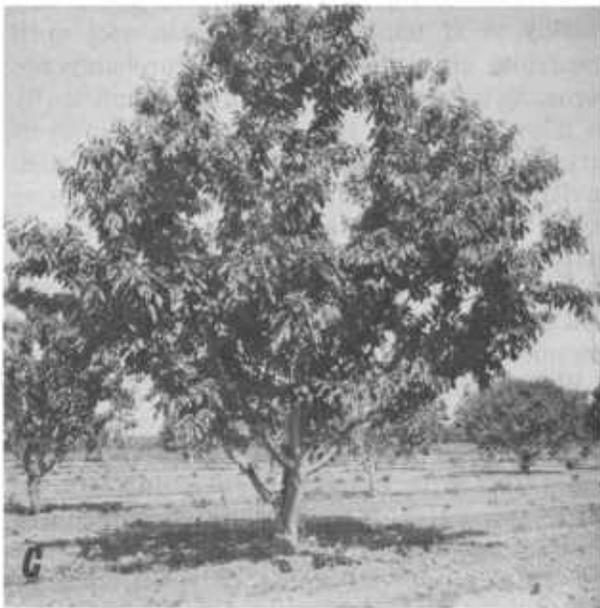
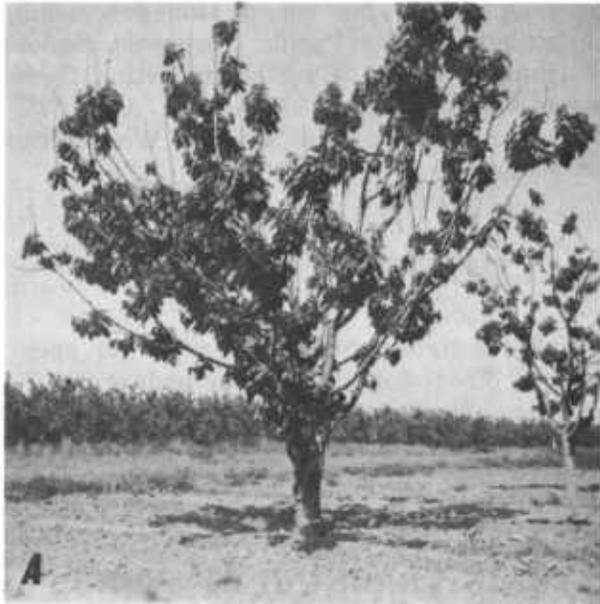
Rain during, or just preceding, harvest may result in cracking of fruits. If the fruits dry quickly or if temperatures remain cool until the fruits are dry, cracking will probably not occur. Often small cracks will heal sufficiently to allow the fruit to be marketed. However, large concentric ring splits around the stem cavity or longitudinal splits across the sides or styler end permit the entrance of molds and extraneous material. The cracked fruit requires culling during the picking and handling operations, often to the extent that picking costs are not returned.

Warm rains followed immediately by sunshine are the conditions most favorable for cracking. Soil moisture content apparently is not a factor in cracking (126). Instead, osmotic absorption of water through the skin of the fruit appears to be responsible for cracking. Higher soluble solids (sugars), greater turgidity of the fruit, warmer water temperatures, and greater skin permeability all favor cracking.

Cracking of fruits as a result of rains dur-

ing harvest is a major factor limiting the distribution of sweet-cherry production. While large differences in rain-cracking resistance between cultivars do not exist, this hazard can be somewhat reduced by selection of cultivars. The 'Bing' cultivar is quite susceptible to crack-

ing and is not adapted to many fruit-growing areas for that reason. On the other hand, 'Bing' is the leading cultivar in the western States, where its firmness for long-distance shipping overshadows the cracking hazard. 'Lambert' appears susceptible to fruit cracking in the



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FIGURE 2.—Recovery of cherry trees by May 1956 from the fall 1955 freeze in the Pacific Northwest. Progressively less damage and greater recovery are shown by trees of A, 'Bing', B, 'Lambert', C, 'Sam', and D, 'Van'.

“green” stages, but less so than ‘Bing’ in riper stages. ‘Van’, ‘Sam’, and ‘Hedelfingen’ under field conditions have appeared more crack-resistant than other firm-fleshed cultivars.

A number of preventive sprays have been tried to reduce rain-cracking of fruit. Among these were rosin, fish-oil soap, casein solution, casein and tannin mixtures, and lime sprays (127). Each of these under certain conditions somewhat reduced fruit cracking but left undesirable residues. Cracking was reduced 50 to 60 percent on trees with full crops and somewhat less on trees with light crops when 1 p.p.m. naphthalene acetic acid (NAA) sprays (13) were applied midway between blossoming and harvest (or about 30 days after full bloom). Oregon tests (134) confirm the effectiveness of NAA sprays and show reduction of fruit cracking from sprays of hydrated lime (5 to 8 lb. per 100 gal.) two weeks before harvest. These lime sprays are suggested only for fruit to be brined.

## FRUIT DOUBLES

Fruit doubles reflect the occurrence of two pistils on a single pedicel. If the ovaries of both pistils are fertilized and normal development progresses, two fleshy fruits ripen on the same fruit stem. If one of the ovaries is not fertilized, a normal fruit will develop. If one developing ovary aborts, a fleshy cherry with an attached dry fruit occurs. If neither pistil is fertilized or both ovaries abort, the pedicel drops.

Seasonal differences are found in the occurrence of fruit doubles or twin fruits. These occur as more or less equally developed cherries, or one member of the twin may not develop

fully, forming a fleshy or dry, hard protuberance on the side of the normal cherry. Usually the undeveloped fruit cannot be separated from the normal one without tearing the skin of the latter, rendering it unmarketable. If this type of fruit is not culled during harvest, the undeveloped twin punctures good fruit in the picking container. Excessive doubles may make sorting impractical, and the whole crop becomes unmarketable. Normally a few doubles are not discriminated against in the market, providing both cherries of most twins are fleshy.

Multiple pistils form because of one or occasionally two additional cell divisions during the fruit bud initiation period. Unusually warm weather during the fruit bud initiation period, late May or early June of the season preceding blossoming, influences the occurrence of doubles. Hot periods in July and August are thought to produce 20 to 30 percent fruit doubles in the ‘Bing’ and ‘Napoleon’ cultivars in the Sacramento Valley of California (86). Doubles rarely occur, however, in the cooler coastal valleys of California. Most doubles tend to occur on the southwest side of the tree and in the terminal 3 feet of the branches.

Some control over the occurrence of doubles can be exercised by the choice of orchard site. Areas or sites particularly subject to high temperatures (90° F. or over) during late spring and early summer can be avoided. It should be remembered, however, that warm, irrigated areas are generally less subject to rain-cracking and diseases. A dense cover crop, if compatible with the cultural system used, may help to moderate temperatures in the orchard during this period of flower bud formation.

## SOIL REQUIREMENTS

Sweet cherries on mazzard (*Prunus avium*) rootstocks are not tolerant of clay or poorly drained soils. Trees grow best on sandy loams, particularly those that do not have clay or caliche layer subsoils. Heavier soils often are satisfactory if surface and subsoil water drainage is good. Shallow sandy soils, particularly

those where irrigation is not available, are not suited to sweet-cherry production.

Trees on mahaleb rootstocks (*P. mahaleb* L.) are more tolerant of sandy soils, soil-moisture deficiencies, and high alkalinity than trees on mazzard stocks. Trees on ‘Stockton Morello’ sour-cherry rootstock (*P. cerasus*), on the

other hand, are less susceptible to damage from wet soils than trees on either mahaleb or mazzard stocks. In Oregon, 'Napoleon' trees on morello rootstocks have tended to be short lived.

Soils that recently have been planted to crops susceptible to the *Verticillium* wilt fungus should be avoided. Sweet cherries are subject to attack by the same species (*Verticillium albo-atrum* Reinke & Berth.) as are apricots, almonds, potatoes, tomatoes, eggplant, melons, mint, cotton, tobacco, the brambles, and some orchard weeds and cover crops. Before planting a sweet-cherry orchard, a grower should

determine whether any of these crops have been used on the proposed orchard site in the previous 10 to 15 years. Land previously used for potatoes particularly should be avoided. The fungus is known to persist in the soil even though nonhosts have intervened for several years. Fumigation may be feasible if a particularly desirable site is known to have grown susceptible crops.

On old apple land with high content of arsenic, it is desirable to haul in soil to replace the contaminated soil in each tree hole.

## CULTIVARS (VARIETIES)

Selection of main cultivars best suited to the environmental, cultural, and marketing factors that affect his operation is probably one of the most important decisions a grower makes. Successful sweet-cherry production requires that the cultivars be adapted to the environment. The grower must consider the cold-hardiness of wood and fruit buds; resistance to rain-cracking, diseases, and insects; and compatibility with the rootstock dictated by climate and soil type.

Other important considerations include time of fruit maturity, rainfall hazard during ripening and harvest, and the availability of facilities and labor at harvesttime. Available market outlets should be investigated to determine the marketing arrangement most advantageous to the grower. In selecting cultivars, the grower should exploit advantages such as large fruit size, earliness, and closeness to markets. Consumer preferences in the available markets should be considered.

About 1,150 cultivars of cherries, almost half of them sweet cherries, have been described (58). A listing by the American Pomological Society (44) contains almost 300 cultivars under cultivation at United States and Canadian experiment stations. Numerous selections of known hybrid origin or unknown parentage also are under test. A few mutants, notably 'Rainbow Stripe', which mutated from 'Lambert', and a similar light-colored mutant from 'Bing', have occurred naturally. Both mu-

nants have fruits of 'Napoleon' type but with dark suture lines.

Despite the large number of cultivars available, only 'Bing', 'Lambert', 'Napoleon' (Royal Ann), and 'Black Tartarian' were used to any extent for commercial production in the West until interest in new varieties intensified about 1940. 'Republican', 'Deacon', 'Van', 'Sam', 'Centennial', 'Waterhouse', mazzard seedlings, and others were used primarily as pollinizers. 'Schmidt', 'Windsor', 'Lambert', 'Napoleon', 'Victor', and 'Black Tartarian' have been the favored cultivars in the East.

Increased interest in cultivars has led to the use of newer ones as main cultivars rather than as pollinizers only. Objectives have been to spread the harvest season and to take advantage of the hardiness and rain-cracking resistance available in some of the newer cultivars.

Descriptions of main commercial, special-purpose, and promising new cultivars follow. The new cultivars should be planted with standard cultivars to determine their performance in the environment and the cultural management system of the individual grower. Some are described only briefly because of limited data on their performance.

### MAIN CULTIVARS

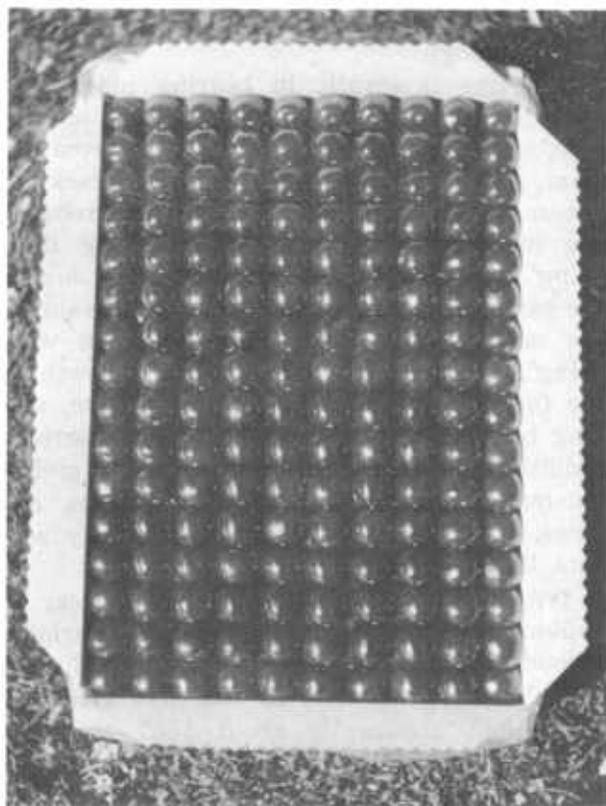
'BING', with its large, firm, reddish-purple (mahogany) fruit is the principal cultivar of

the sweet-cherry industry. The 'Bing' cultivar originated from a seed of 'Republican' grown by Seth Lewelling of Milwaukie, Oreg., in 1875. It was named after a Chinese workman (58). The fruit, as it is grown in the Pacific Northwest, represents about the ideal type desired by handlers. The fruit is firm enough for long-distance shipping—up to 3,000 miles. Fruit size, under careful management, often averages  $1\frac{1}{8}$  inches in diameter or larger, giving the handler a high percentage of 9- to 11-row<sup>9</sup> boxes (fig. 3). The fruit color is very desirable, and it remains lustrous until the fruit is over-ripe. The stem length is average,  $1\frac{1}{2}$  to 2 inches, permitting easy picking. The high sugar content of 'Bing' fruits is balanced by a relatively high acid content, resulting in a distinctive, tangy flavor. The stone is relatively small, and the flesh is thick, crisp, red, and juicy. On the other hand, the fruit is susceptible to rain-cracking, doubling, and brown rot. Fruit ripens in early midseason. It is round to heart-shaped, with a prominent styler scar and an inconspicuous suture line. The stone is semiclinging to almost free, oval, and smooth.

The tree, while reasonably vigorous in the West, lacks winter-hardiness and is susceptible to a number of virus and viruslike disorders. Trees of 'Bing' are upright-spreading in growth habit. Crotches usually are wide-angled and strong. Bark is reddish-brown and smooth, with gray scarfskin. Bark lenticels are large and conspicuous. Leaves generally are oblong ovate, coarsely crenate, and dark green. Leaf petioles are glabrous; this characteristic is used for nursery identification of nonbearing trees.

The cultivar is self-incompatible and incompatible with 'Lambert', 'Napoleon', and 'Emperor Francis'. Other cultivars generally pollinize 'Bing' adequately, providing they overlap its blossom period. 'Van', 'Deacon', 'Republican', and 'Sam' (where this cultivar does not bloom too late) have been particularly useful as pollinizers for 'Bing'.

<sup>9</sup> Row-size number refers to the number of cherries of uniform size required to fill the width of a standard cherry lug (11.5 inches). This requires an average diameter of  $1\frac{3}{32}$  inch for 9-row,  $1\frac{5}{32}$  inch for 10-row, and  $1\frac{3}{4}$  inch for 11-row cherries.



PN-3047

FIGURE 3.—A packed box of 10-row sweet cherries—'Chinook' cultivar.

'LAMBERT', with its large, medium firm, dark fruit is more widely adapted than 'Bing'. Trees are more vigorous and hardier than 'Bing'. The growth habit is more upright than 'Bing', and crotch angles tend to be narrower.

'Lambert' originated as a seedling of 'Napoleon' on the Henderson Lewelling farm at Milwaukie, Oreg., about 1880. The pollen parent was thought to be 'Black Heart'. It was introduced by J. H. Lambert in 1895 (58).

Fruits of 'Lambert' are moderately firm, slightly lighter in color than 'Bing', and more lustrous, juicier, milder in flavor, and lower in soluble solids than those of 'Bing'. The cavity is deep and flaring. The styler scar is depressed. The fruit ripens on an average of a week later than 'Bing'. The fruit shape is longer and more pointed than 'Bing'. It is firm enough for distant shipping and suitable for processing. The stem is longer and slender. The stone clings

and is large and slightly flattened. The skin is thin but tough.

The tree is erratic in bearing in eastern areas. The fruit does not hold well on the tree, and, in fact, sometimes shatters from the stem. The fruit is subject to rain-cracking. Green fruits and very ripe fruits probably are more susceptible to rain-cracking than 'Bing', but 'Bing' is more susceptible during the early harvest period. Pruning and training are more difficult with 'Lambert' than with 'Bing', because of the more upright growth of the former. Narrow angles tend to form, and long barren branches may occur. The bark is reddish-brown, with numerous lenticels, giving an overall grayish appearance. Leaves are large, oblong-oval to obovate, and finely serrate. Petioles have numerous hairs.

'NAPOLEON' (Royal Ann) has a clear to yellow flesh, with yellow skin and a variable amount of pink blush. It originated in Europe of unknown parentage. It was first described in France, apparently about 1667, under a different name. Seth Lewelling renamed it Royal Ann following loss of the label during the wagon trek of the Lewelling brothers to Oregon (58). This name persists in the western States.

The tree is somewhat more spreading than 'Bing'. Although the tree and fruit buds are relatively hardy when dormant, the cultivar appears particularly susceptible to early fall freeze damage. Young trees are vigorous, but there is a tendency for older trees to become slow growing and overproductive. Branches usually are wide-angled with strong crotches. The bark is reddish-brown and often is covered by gray scarfskin. Lenticels are large and prominent. Leaves are long, tapering to a fine point, finely serrate, and semifolded.

'Napoleon' fruit ripens a few days earlier than that of 'Bing'. It is moderately firm fleshed, juicy, lower in soluble solids, and similar in acidity to 'Bing'. It is very susceptible to doubling in warm climates. The overall flavor is mild but slightly acid. The fruit is particularly well adapted to canning and brining. However, it is not adapted to long-distance shipping because of its tendency to

show brown skin bruises from handling or preharvest wind damage.

'SCHMIDT' is the preferred cultivar in areas where 'Bing' is not successfully grown because of excessive rain-cracking or lack of vigor. It is a main cultivar in eastern orchards, but is not considered productive enough in the West.

'Schmidt' originated about 1841 as a seedling of an old German cultivar and was raised by a forester named Schmidt at Casekaw, Prussia, Germany. It was introduced into England by Thomas Rivers and then to America, but the details are unknown (58). The name appeared on the American Pomological Society list in 1897.

The fruit is large, dark mahogany, roundish cordate, and flattened on the ventral side, with a slight swelling along the suture. The stem is medium long, up to  $1\frac{3}{4}$  inches, and moderately slender. The stem cavity is deep and flaring. The suture is a black line. The stylar scar is small and dark. The skin is thick and tough. The flesh is firm, wine red in color, and meaty. The flavor is sweet and rich but rather astringent. The stone is clinging and large sized. The cultivar usually ripens a few days before 'Bing'.

The tree is large, vigorous, and upright-spreading. The bark is purplish-brown and often covered with scarfskin. Lenticels are numerous, large, prominent, and brown, which gives the tree a characteristic striped and rough appearance. Fruit buds and blossoms are relatively tender, but the tree is hardy. Leaves are very large, oblong-ovate, and finely serrate. Rain-cracking of fruit is less serious than in 'Bing' or 'Lambert'. 'Schmidt' is a good pollinizer for 'Bing', 'Lambert', and 'Napoleon'.

'WINDSOR' is the standard late-ripening, dark cherry in eastern areas. Generally in the West this cultivar is not used because of its small size and also because it is softer and has lighter-colored flesh than either 'Bing' or 'Lambert'. In the East its bud hardiness and regular, heavy productivity have generally outweighed the usual discount in the price of this cultivar in comparison to the larger, firmer 'Bing' fruits. It should be considered

for home-orchard plantings, particularly in districts subject to low winter temperatures.

'Windsor' originated on the farm of James Dougall of Windsor, Ontario, Canada (58). It was first propagated in 1881.

The fruit is medium to large, round to round-ovate, and laterally compressed. The flesh is relatively softer than 'Lambert'. It ripens late, usually after 'Lambert'. The stem cavity is deep, wide, and flaring. The suture is indistinct. The styler scar is a medium-sized russet dot which is slightly depressed. The skin is red, becoming purplish-black when fully ripe. The flesh is tender, red to purple, meaty, and subacid to sweet. The quality is fair to good. The stem is short to medium, 1 to 1½ inches, and adherent to flesh until fully ripe.

The 'Windsor' tree is medium-sized, vigorous, spreading, hardy, and very productive. The bark is reddish brown, and on older branches it is covered with gray scarfskin. Lenticels are small, oval, and scattered. Leaves are medium sized, oblong, and coarsely serrate.

## SPECIAL-PURPOSE CULTIVARS

Although the five cultivars described in the preceding section represent nearly all the commercial acreage, several other cultivars are important to provide the necessary pollination of the main cultivars or for special-purpose use. Some of these are gaining limited favor as main cultivars in some areas. These are described in the approximate order of ripening.

'SENECA' is distinctive because it ripens 2 to 3 weeks ahead of 'Black Tartarian'. The fruits are of 'Black Tartarian' type, but are too small and soft for commercial use. It is a good pollinizer and has backyard possibilities. The term "bird cherry" is used colloquially for this cultivar, because the fruit ripens earlier than other varieties and birds harvest most of the crop.

'Seneca' originated from a cross in 1910 of Early Purple and an unknown red-skinned sweet cherry. It was introduced about 1922 by the New York State Agricultural Experiment Station (12). The tree is tall, spreading,

and very vigorous. It is relatively hardy, precocious, and productive. Leaves are narrow, crenulate, and coarsely serrate.

The fruit is small and somewhat truncate. The stem cavity is moderately deep and flaring. The skin is thin and tender, and the flesh is dark red, juicy, soft, and slightly stringy.

'EARLY RIVERS' and 'EARLY PURPLE' (Guigne) are very early cultivars ripening between 'Seneca' and 'Black Tartarian' seasons. 'Early Purple', which was first mentioned in 1688, apparently originated in England as a result of a cross of May Duke and Spanish Yellow. 'Early Rivers' is a more recent English introduction (58). Both are of 'Black Tartarian' type but earlier than that cultivar. 'Early Rivers' has firmer fruit than does 'Black Tartarian'.

'BIGARREAU DE SCHRECKEN' is a dark-fleshed cherry that ripens about 2 days before 'Black Tartarian'. It is a German cultivar tracing back at least to 1876 (58). The fruit flesh is firmer than that of 'Black Tartarian', and therefore the fruit is better adapted to shipping. Fruit size tends to be small, flavor is relatively poor, and excessive doubling may occur.

'LYONS' originated near Lyons, France, in 1822 (58). It is an early, medium-large, dark cherry with tender flesh. The tree tends to have a weeping habit.

'BLACK TARTARIAN', the standard cultivar for the early season, was introduced into England from Circassia, Russia, under the name of Ronald's Large Black Heart. It was first introduced into America by William Prince of Flushing, N.Y., early in the nineteenth century (58). It is probably the most widely disseminated sweet-cherry cultivar in the world.

The tree is vigorous, productive, and upright. Crotches tend to be narrow, crowded, and weak. The tree is not very hardy, particularly to early fall freezes, but fruit buds are fairly hardy. The bark is reddish-brown and smooth. Lenticels are large, numerous, conspicuous, raised, and sharply pointed. Leaves are large, lanceolate, with coarsely serrate margins. Glands, usually 2 to 4, occur

on the petiole below attachment to the leaf blade.

The medium to small fruits ripen early and hang in good condition for some time. The skin is thin, separates readily from the flesh, and becomes very dark, almost black. The flesh is soft, dark red, juicy, highly flavored, and sweet. The juice is dark and abundant. The stone is free, smooth, and slightly compressed laterally.

'VICTOR', a 'Windsor' seedling, was introduced in 1925 by the Horticultural Experiment Station, Vineland, Ontario, Canada (12). This light-colored cherry ripens 3 to 4 days before 'Napoleon'. The tree is large and vigorous but is not productive in all areas. The fruit is medium large, relatively firm fleshed, and of good quality. Usually this cultivar has more pink blush on the fruit than 'Napoleon' has, and it is sometimes preferred for this reason.

'SPATE BRAUNE' is a dark-skinned, light-fleshed cultivar of unknown European origin, which ripens a few days before 'Bing'. The fruit is firm and of good quality and has a long stem. The tree is very productive.

'VAN' was selected in 1942 by A. J. Mann at the Research Station, Summerland, B. C., Canada. It is an open-pollinated seedling of 'Empress Eugenie', a Duke cherry. It is named in honor of J. R. Van Haarlem, former pomologist at the Horticultural Experiment Station at Vineland, Ont. (12). This dark cherry has numerous good characteristics. It has proved one of the most satisfactory pollinizers for 'Bing', 'Lambert', 'Napoleon', and many other cultivars. It showed outstanding tree hardiness to the 1955 fall freeze in central Washington. 'Van' appears to have some rain-cracking resistance. The tree makes vigorous nursery growth. The tree is precocious, bearing commercial crops after 4 or 5 years in the orchard, or 1 to 3 years before the 'Bing' cultivar. The fruit colors early and retains a bright lustrous color over a long picking period (7 to 10 days). The fruit is high in soluble solids and retains its high quality and firmness into 'Lambert' season. It is adapted to canning, although the flesh tends to be a lighter color than 'Bing' unless harvesting is delayed until 'Lambert' season. Picking for fresh market

may be done in 'Bing' season or slightly earlier because of Van's early coloring and high soluble solids. Increased size and darker flesh color, without substantial loss of the bright luster, favors picking after 'Bing', however.

'Van', perhaps more than any other cherry cultivar, responds favorably to special cultural practices. The tree should be maintained in high vigor and pruned more selectively than normally is practiced to assure continued production of large fruit. Its tendency to over-produce should be recognized. It has special merit as a filler<sup>10</sup> cultivar because of its heavy production during the early years of the orchard. There are indications of possible incompatibility with the *P. mahaleb* rootstock (43). The cultivar does not grow satisfactorily in areas where bacterial canker is severe. The fruit stem is short, and fruits tend to form a tight cylinder around the branch. Both factors may contribute to difficult picking. The fruit shape is blocky (short linear axis) as contrasted to the heart shape of 'Bing'; consequently, it requires more fruits of 'Van' than of 'Bing' of comparable row size (shoulder diameter) to fill a box. The framework of 'Van' trees is less upright than that of 'Bing', and crotch angles usually are wide and strong.

'NOBLE' (St. Margaret, Tradescant Heart) is an old, dark-fleshed, English cultivar of unknown origin (12). It was introduced into the United States in 1943. The fruit ripens between 'Schmidt' and 'Hedelfingen' seasons. It is heart-shaped, large, firm, and sweet. It rain-cracks less than most late cultivars. The tree is large and vigorous.

'DEACON' is a dark-colored cultivar that originated near Olympia, Wash., around 1925 from unknown parentage. It proved to be a good pollinizing cultivar for 'Bing' and 'Lambert' and was planted in the Pacific Northwest for that purpose. The fruit exterior closely resembles that of 'Bing', but the flesh is lighter red, has lower acidity, and has a milder flavor. Also, the tree has proved rather slow growing

<sup>10</sup> Fillers are temporary trees planted between permanent trees to make better use of orchard space. These should be removed before they crowd the permanent trees.

and particularly susceptible to disease and to rain-cracking. The canned product of 'Deacon' harvested at maturity comparable to 'Bing' has a considerably lighter color and less flavor.

'HEDELINGEN' is an old German cultivar. Conflicting reports on the rain-cracking resistance of this cultivar arise from the existence of two strains in Germany, only one of which has rain-cracking resistance. The collection of this cultivar grown at the Irrigated Agricultural Research and Extension Center near Prosser, Wash., showed fairly good resistance to rain-cracking. It lacked sufficient hardiness, however, to survive the severe fall freeze of 1955.

The fruit is firm, dark mahogany, and of good quality. It ripens between 'Bing' and 'Lambert' seasons. Flavor is slightly astringent, similar to 'Republican', and fairly strong. The tree is spreading and has slender, slightly drooping terminals and branches.

'VERNON' is a dark-fleshed, open-pollinated seedling of 'Windsor' selected in 1925 and introduced in 1937 by the Horticultural Experiment Station at Vineland, Ontario (12). The fruit is similar to 'Windsor' in appearance, but larger, firmer, and of higher quality. It ripens a few days before 'Bing'. It appears to be more susceptible to rain-cracking than is 'Windsor'. The tree is large, vigorous, and precocious.

'REPUBLICAN' (Black Republican, Lewelling, Oregon Black) is a dark-colored, highly flavored sweet cherry originating about 1850 as a seedling in the orchard of Seth Lewelling at Milwaukie, Oreg. (58). Although the parentage is unknown, it is thought by some to be a cross of 'Napoleon' and 'Black Tartarian' and by others to be a seedling of 'Eagle'. 'Republican' is a dependable pollinizer. Its tendency to overbear usually results in small, unprofitable fruit sizes. Skin color becomes a dull, very dark mahogany, detracting from the market attractiveness of the fruit. The flesh is very firm, dark red, and slightly astringent. The tree is more spreading than 'Bing'. 'Republican', topworked at 30 inches on mahaleb rootstock at the Irrigated Agriculture Research and Extension Center, Prosser, Wash., overgrew the rootstock within 5 years

and started overbearing, with resultant loss of commercial fruit size. The mahaleb portions of the trunks were killed by the 1955 fall freeze.

'GIANT' was originated in 1900 by Luther Burbank and introduced in 1914 (58). It is a large-fruited, Bing-type cherry, which ripens after 'Bing'. The fruit is dark, glossy red, and of good quality. The tree is vigorous and upright, but it is not as productive as most cultivars. The trees is slow to start bearing.

'BADACSONY' (Badacsoner Reisenkirsche) is a large-fruited, firm cherry. It originated near Balston Lake, Hungary, probably about 100 years ago (58). The fruit is mild flavored and has light red flesh and a long slender stem. It ripens about the same time as 'Bing'. The tree is vigorous, fast growing, and precocious. It tends to be a shy bearer in California.

## NEW AND PROMISING CULTIVARS

Several cultivars originating within the last 30 years are relatively untested under commercial conditions. These are suggested for commercial trial, but not for large-scale plantings until their commercial characteristics have been determined. Some have special merit as pollinizers for present cultivars.

'LAMIDA', a 'Lambert' seedling, was one of three dark cherries introduced by the Idaho Agricultural Experiment Station in 1946 (128). It was released because of its resistance to rain-cracking. The fruit is somewhat more pointed than that of 'Lambert', softer fleshed, and usually larger. The fruit stem often is attached to the fruit at an oblique angle. Soluble solids in this cultivar are relatively low, and the flesh tends to be light red. The tree does not set as heavy crops as does 'Lambert'. It is somewhat less hardy, although it is relatively vigorous. This cultivar is very susceptible to fruit doubling.

'EBONY', another Idaho introduction, closely resembles 'Republican', but is somewhat larger-fruited. It is a seedling of 'Lambert'. 'Republican' is probably the pollen parent. The name is derived from the very

dark skin color. The fruit ripens in 'Bing' season or slightly earlier. Fruit quality is good, with considerable astringency. Rain-cracking susceptibility is similar to that of 'Bing', and probably worse during early years of production when the crops may be small. The tree is fairly productive, but slow to start bearing. The cultivar is susceptible to fruit doubling and to deep suture. The tree is only moderately hardy.

'SPALDING', the third Idaho introduction, was selected from a progeny of 'Bing'. 'Deacon' was the probable pollen parent. It is a crisp-fleshed, large-fruited cultivar, which ripens in 'Lambert' season or later. The cultivar is named after a missionary who introduced fruit growing in northern Idaho. The fruit has a good finish and retains its luster after picking. The quality is fair, and the soluble solids are low. The tree is vigorous, moderate in hardiness, and slow to start bearing. The light crops on young trees rain-crack easily. With comparable crop, 'Spalding' appears about as susceptible as 'Bing' to rain-cracking.

'SAM' is a dark-colored cultivar introduced by the Research Station, Canada Department of Agriculture, at Summerland, British Columbia (70). The name is derived from the initials of Summerland and Arthur Mann, a station fruit breeder who made the selection. 'Sam' resulted from open pollination of a 'Windsor' seedling.

'Sam' fruit ripens about a week earlier than that of 'Bing'. It is large and conic to heart shaped. It has dark mahogany skin, firm flesh, good texture, and some rain-cracking resistance, but relatively low soluble solids and acid contents. It cans well, producing a syrup about as dark as 'Bing' with a milder flavor than that of 'Bing'.

The tree is vigorous, upright-spreading, and hardier than 'Bing'. In the 1955 fall freeze in Washington, 'Sam' ranked second only to 'Van' in cold-hardiness. It is a good pollinizer for 'Bing', 'Lambert', and 'Napoleon' in northern areas where 'Sam' blooms early enough to overlap the blossoming period of these cultivars. In one year, however, in the Yakima Valley of Washington, 'Sam' bloomed too

late to pollinize 'Bing' because blossoms in the lower part of the trees were damaged by frost.

'STAR' is a dark-fleshed introduction from the Research Station, Canada Department of Agriculture, at Summerland, British Columbia. It is an open-pollinated seedling of 'Deacon', selected by A. J. Mann and introduced in 1949 (12). 'Star' is similar to 'Sam' but appears to be slightly earlier and of better quality. It has the disadvantage of being unfruitful with the 'Bing', 'Lambert', and 'Napoleon' cultivars, and therefore is unsuited as a pollinizer in the main western plantings. It pollinizes 'Van' satisfactorily. It blooms very late and may not overlap blossoming of main cultivars sufficiently.

The fruit tends to be Lambert-shaped, but otherwise it resembles 'Bing' in size, firmness, and quality. The tree is moderately vigorous, productive, and moderately hardy. Excessive fruit doubling and rain-cracking occur in this cultivar in California.

'LAMBERT COMPACT', tested as Summerland 2B-17-4, was selected from seedlings grown from irradiated dormant scions of 'Lambert' in 1959. It was introduced in 1964 by K. O. Lapins (65). The fruit is reported to be almost identical to that of 'Lambert', except for slightly shorter and thinner stems and 2 to 5 days later ripening. The salient feature of this induced mutant is the compact growth habit, characterized by short internodes and closely spaced fruit spurs. The tree is estimated to attain about one-half the size of 'Lambert' trees.

'STELLA', tested as Summerland 2C-27-19, is the first self-fertile sweet cherry named. It originated from the cross in 1956 of 'Lambert' x John Innes seedling 2420. It was selected in 1964 and named in 1970 by K. O. Lapins. The tree is very vigorous, precocious, and moderately hardy. Fruit is a dark, moderately firm, large 'Lambert' type. It ripens a week before that of 'Lambert'. Tests indicate that 'Stella' is self-fertile and a universal pollinizer (66).

'STARKING HARDY GIANT' (Meyer) was discovered in 1925 as a seedling of unknown parentage near Cedarburg, Wis., by

Mrs. O. R. Meyer (12). It was granted plant patent 764 in 1947, introduced as Meyer in 1948, and renamed in 1949 because of its apparent hardiness and consistent productiveness. The fruit ripens between 'Bing' and 'Lambert' seasons, and closely resembles the latter cultivar. Skin color is dark but lustrous and attractive. Flesh color is lighter than that of 'Bing'. Fruit size often is small because of the heavy bearing characteristic of this cultivar. With comparable crops, fruit size of 'Starking Hardy Giant' is almost equal to well-grown fruits of the 'Bing' and larger in areas where 'Bing' is not well adapted. Soluble solids and acidity are lower than in 'Bing', and the flavor is milder.

Trees of 'Starking Hardy Giant' are vigorous, hardy, and very productive. The tree is upright in growth habit.

'SUE' is a light-fleshed introduction of the Summerland Research Station in British Columbia. It was selected from the cross 'Bing' x 'Schmidt' by A. J. Mann in 1946 and introduced in 1954 (12). It was released primarily because of its outstanding resistance to rain-cracking. Otherwise the cultivar is similar to 'Napoleon'. The cultivar is overproductive to the extent that fruit size often is very small. The relatively soft fruits ripen about a week earlier than those of 'Napoleon'.

'VISTA' is one of three new cultivars introduced by G. H. Dickson of the Horticultural Experiment Station at Vineland, Ontario, in 1959. It originated from the cross 'Hedelfingen' x 'Victor' and was selected in 1947 (33). It was released as a possible replacement for 'Black Tartarian' because of larger fruit, better firmness, and brighter, more attractive finish.

'VENUS' was also introduced by the Horticultural Experiment Station at Vineland, Ontario, in 1959. It is also from the cross 'Hedelfingen' x 'Victor' and was selected in 1950 (33). The fruit ripens about 5 days after that of 'Vista'. The fruit is less firm but more resistant to rain-cracking than that of 'Vista'. The tree shows a tendency to over-set in some years.

'VIC' is the third, and potentially the best, of the three Vineland station introductions

in 1959. It is from the cross 'Bing' x 'Schmidt' and was selected in 1937 (33). The fruit ripens at the same time as 'Windsor'. The cultivar was introduced as a possible replacement for 'Windsor' because of its larger fruit size and darker flesh color. 'VIC' is reported (33) to be superior to 'Windsor' in canning tests and satisfactory for freezing and brining. The tree is large, vigorous, and productive.

'VEGA', a seedling of 'Bing' x 'Victor', tested as Vineland 31034, was introduced by the Horticultural Experiment Station at Vineland, Ontario, in 1968. It is described as a large, attractive, 'Napoleon'-type cherry, adapted to processing and brining. It has firm fruit and small pits. The fruits ripen a day before 'Venus'. The fruits can be pitted without detaching the stem and thus are well adapted to use for cocktail cherries. Flavor is tart until the fruits are fully ripe (10).

'VALERA', a seedling of 'Hedelfingen' x 'Windsor' tested as Vineland 350427, was also introduced by the Horticultural Experiment Station at Vineland, Ontario, in 1968 (10). A sister seedling of 'Venus', it ripens about a day later and has darker fruit color, richer flavor, and more consistent productiveness than does 'Venus'. The tree is vigorous and early-bearing. It is suggested for fresh market use.

'CHINOOK' was jointly introduced by the U.S. Department of Agriculture and the Washington Agricultural Experiment Station in 1960. It was selected by Harold W. Fogle at the Irrigated Agriculture Research and Extension Center, Prosser, Wash., from the cross 'Bing' x 'Gil Peck' (131). 'Chinook' fruit ripens 4 to 8 days earlier than that of 'Bing', which it resembles in appearance. This earliness, offering the possibility of extending the harvest season earlier when cherries are most profitable, and the ability of 'Chinook' and 'Bing' to cross-pollinize each other, prompted the introduction of 'Chinook' as an early-shipment cultivar. The name was taken from one of the mountain passes in the Cascade mountain range in Washington.

'Chinook' fruit is large, heart-shaped to rounded, and with a relatively large stylar

scar. The skin color is mahogany, remaining glossy at maturity. The flesh is moderately firm, medium to dark red, and uniformly colored. The pit is medium sized and relatively free from the flesh. Soluble solids are higher than in 'Bing', and titratable acidity is lower.

Trees of 'Chinook' are very vigorous, upright-spreading, and productive. Blossoming is 1 or 2 days, and foliation 3 to 4 days, earlier than 'Bing' in the Yakima Valley of Washington. Petioles have a few fine hairs. Tree hardiness is slightly better than that of 'Bing' but poorer than that of 'Van'. 'Chinook' is adequately pollinized by 'Bing', 'Van', or 'Sam'. It processes satisfactorily. The fruit is more subject to rain-cracking than is 'Bing' fruit, is softer, and tends to abort heavily when planted with 'Bing'. Hence the cultivar has been rejected except in areas where its earliness can be exploited by shipping before 'Bing' shipments from the area are ready.

'RAINIER' was also jointly introduced by the U.S. Department of Agriculture and the Washington Agricultural Experiment Station in 1960. It was selected from progeny of 'Bing' x 'Van' at the Irrigated Agriculture Research and Extension Center, Prosser, Wash., in 1954 by Harold W. Fogle (131). 'Rainier' was introduced because it combines the superior bud and wood hardiness of 'Van' with large fruit size in a light-fleshed cherry. The name was derived from Mt. Rainier, a continuously snow-capped mountain in the Cascade Range in Washington, to connote the "white" flesh of this cultivar.

The fruit ripens 3 to 7 days before 'Napoleon', is Van-shaped, firm, of high quality, and attractive. The skin color is yellow with considerable pink blush. The flesh is clear and the juice colorless. The pit is relatively small and free from the flesh. Pits from some trees shatter, but the cause is not known. The condition has not occurred in experimental plantings in Washington State. Soluble solids are equal to those of 'Bing', and titratable acidity is lower.

Trees of 'Rainier' are vigorous, upright-spreading to spreading, very productive, and precocious. Blossoming and foliation coincide with those of 'Bing'. Winter hardiness appears

to be equivalent to that of 'Van'. Petioles are glabrous. 'Rainier' is pollinized satisfactorily by 'Bing', 'Van', or 'Sam'. 'Rainier' satisfactorily pollinizes 'Bing' and 'Chinook'. In experimental and commercial trials in Washington and New York, the cultivar appears well adapted to brining and to canning. The fruit has sufficient firmness for distant shipping.

'MOREAU' is the commercial synonym assigned in 1961 by the U.S. Plant Introduction Station, Chico, Calif., to a dark-fleshed cultivar, Bigarreau Moreau (Bigarreau de St. Charmez, Souvenir de Charmes, Bigarreau Sandrin), introduced from Germany in 1937 (64). The fruit ripens about a week before that of "Black Tartarian". It is round and blocky and is larger and firmer than other early sweet cherries. The flesh is semifreestone and more acid than that of 'Black Tartarian'. The tree is spreading in growth habit, becoming roundish when mature. Leaves are finely serrate. Pollination tests in France showed 'Moreau' compatible with 'Napoleon', and preliminary tests in California indicate it is compatible with 'Bing'. Doubling of fruit apparently is much less common than in 'Bing'. The fruit sometimes is irregular and soft-fleshed under California conditions.

'EARLY BURLAT' is the commercial synonym assigned in 1961 by the U.S. Plant Introduction Station, Chico, Calif., to a dark-fleshed cultivar from Europe, Bigarreau Hatif de Burlat (Precoce de Burlat). The fruit ripens 2 days after 'Moreau' or almost 5 days before 'Black Tartarian'. Fruit is larger, smoother, and firmer than that of the latter cultivar. Although 'Early Burlat' fruit is less firm than that of 'Bing', it is suitable for fairly distant shipping. The flesh is fine textured and less acid than that of most early cultivars. The tree is moderately vigorous and upright to upright-spreading. The leaves are coarsely serrate. Pollination tests in France showed 'Early Burlat' compatible with 'Napoleon'. Frequency of double fruit in 'Early Burlat' is lower than in 'Bing'. The fruit is susceptible to rain-cracking.

'CORUM' is a light-fleshed cherry of unknown origin, found in 1945 on the farm of Gordon Corum of Eugene, Oreg. It was tested

and introduced in 1961 by the Oregon Agricultural Experiment Station. 'Corum' resembles 'Napoleon' closely but ripens its fruit 5 to 7 days earlier and is slightly soft-fleshed. It is reported (154) to be well adapted to canning and brining and to be about equal to 'Napoleon' in hardiness and resistance to rain-cracking. 'Corum' satisfactorily pollinizes 'Napoleon', 'Bing', 'Lambert', 'Van', 'Sam', and 'Sue' in Oregon tests. The fruit skin is pale yellow with a pronounced red blush. The flesh is light yellow, and the juice is colorless. The pit is small and clings slightly to the flesh. The fruit stem is slender.

'MONA' was selected by Reid M. Brooks from seedlings of the cross 'LaCima' x 'Chapman' planted in 1940. It was introduced in 1964 by the California Agricultural Experiment Station as a possible replacement for 'Black Tartarian' (11). The fruit is larger and firmer, the tree is more spreading, and the bloom period coincides more closely with 'Bing' than does that of 'Black Tartarian'. The fruit ripens about a day later than 'Black Tartarian', and the flavor is less tart. Although primarily adapted to fresh-market handling, the fruit is considered adapted to canning and brining.

The tree is vigorous, productive, and upright to upright-spreading. Leaves are longer than average. Petioles have a few fine, scattered hairs. Glands are mostly large, oval to reniform, and located at the distal end of the petiole. The cultivar is considered a satisfactory pollinizer for 'Bing', 'Van', 'Starking Hardy Giant', 'Moreau', 'Black Tartarian', and 'Chapman'.

'LARIAN' was selected by Reid M. Brooks from the cross 'Lambert' x ('Bing' x 'Bush Tartarian') and was introduced in 1964 by the California Agricultural Experiment Station. The dark-fleshed fruit ripens about 1½ weeks before that of 'Bing' and is reported to be larger, firmer, and better flavored than that of 'Black Tartarian' (11). The cultivar is relatively free of fruit doubles and apparently more resistant to rain-cracking than 'Bing'.

The trees are moderately vigorous, upright to upright-spreading, and moderately productive. Leaves are large and lanceolate, with large dentations. Petioles are short and stocky

and have a few fine hairs. In California pollination tests, the cultivar blossoms with 'Bing' and is compatible with 'Bing', 'Jubilee', and 'Bada'.

'JUBILEE' was selected by Reid M. Brooks from the cross 'Lambert' x 'Napa Long Stem Bing' and introduced in 1964 by the California Agricultural Experiment Station (11). In California, fruit ripens about 6 days before 'Bing' and is larger than 'Bing'. The tree produces practically no doubles. Fruit, stem and suture characteristics are similar to those of 'Bing'. The stylar scar, however, occurs at the true apex, and the apex is pointed. The pedicel flange attachment to the cavity is relatively large. Flesh is red to dark red and is less tart and less firm than that of 'Bing'. It has good resistance to fruit doubling but is susceptible to rain-cracking. It may be harvested over a long period without excessive loss of quality.

Trees are productive, vigorous, and upright-spreading. Leaves are large and have long petioles with fine, scattered hairs. Glands are relatively small, oval or reniform, or sometimes lacking. Blossom season averages late but sufficiently overlaps 'Bing' and cultivars with similar blossom dates. In California tests, cross-pollination by 'Bing', 'Lambert', 'Napoleon', 'Starking Hardy Giant', 'Early Burlat', 'Moreau', 'Mona', and 'Larian' was adequate. Apparently the cultivar has a high chilling requirement.

'BERRYESSA' and 'BADA', two light-fleshed cultivars, were also selected by Reid M. Brooks and were introduced in 1964 by the California Agricultural Experiment Station (11). Both were introduced as possible replacement cultivars for 'Napoleon'. 'Berryessa', from the cross of a seedling of unknown parentage x 'Bush Tartarian', ripens about 6 days before 'Napoleon'. The fruit has medium to high blush, a glossy cream-colored skin, and is larger and firmer than that of 'Napoleon'. It is relatively free of doubles and rain-cracking. In Oregon, 'Berryessa' does not pollinize 'Napoleon' satisfactorily.

The tree is precocious, productive, and vigorous. Leaves are large, oblanceolate, and have long, mostly hairless, thick petioles. It blooms with 'Napoleon' and cross-pollinizes with 'Na-

poleon', 'Van', 'Moreau', 'Starking Hardy Giant', 'Mona', and other cultivars. It is suited for canning and brining.

'BADA', from the cross of a seedling of unknown parentage x 'Ord', ripens about 4 days before 'Napoleon' and pollinizes that cultivar. The fruit has medium to high blush, glossy cream-colored skin, and about the same size and firmness as that of 'Napoleon'. It is highly resistant to rain-cracking and free of doubles in California tests. The stem cavity is deep. The pedicel is longer and thicker than that of 'Napoleon'.

The tree is precocious, productive, moderately vigorous, and upright-spreading. Leaves are obovate and medium-sized. Petioles tend to be short, thin, and usually hairless. The cultivar blossoms between 'Lambert' and 'Jubilee' seasons but usually sufficiently overlaps blossom ranges of 'Napoleon', 'Bing', 'Berryessa', and 'Larian' and is pollinized adequately by these cultivars. It is also suited for canning and brining.

'ULSTER', which originated from the cross 'Schmidt' x 'Lambert' at New York State Agricultural Experiment Station, Geneva, N.Y.,

was selected in 1947 and introduced in 1964 as a possible replacement for 'Schmidt' (133). It has a more vigorous, more productive, and longer-lived tree than does the 'Schmidt' cultivar. The fruit ripens just after 'Schmidt' and is reported to be firm, large, very dark red, of high quality, and resistant to rain-cracking (133). Some resistance to cherry leaf spot and superior blossom hardiness has been noted in commercial test orchards. 'Ulster' cross-pollinates effectively with all important cultivars in New York.

'HUDSON', also originated by the Geneva, N.Y., station from the cross 'Oswego' x 'Giant', was selected in 1935 and introduced in 1964 as a cultivar to extend the harvest season 10 days later than 'Lambert' (133). Trees are very vigorous and rapid growing. The fruit is medium to large, firm to slightly tough when fully ripe, darker than 'Windsor', and sweet. It tends to hang well on the trees. The cultivar has some resistance to brown rot. It effectively cross-pollinizes with all important cultivars used in New York except 'Giant', 'Rainier', and 'Yellow Glass'.

## POLLINATION REQUIREMENTS

Provision for adequate pollination is a prime requisite in sweet-cherry production. All known cultivars except 'Stella' are almost completely self-incompatible, that is, the pollen, although normal in appearance and germinability, fails to extend a pollen tube sufficiently to fertilize ovaries of the same cultivar. Consequently, unless pollen is available from another cultivar capable of fertilizing the main one, practically no fruit sets.

In addition to being self-incompatible, some groups of cultivars are cross-incompatible. 'Bing', 'Lambert', 'Napoleon', 'Star', and 'Emperor Francis' constitute the best known group of cross-incompatible cultivars. Other cross-incompatible groups include: (1) 'Governor Wood', 'Saylor' (Stark Gold), and 'Elton'; (2) 'Schmidt' and 'Peggy Rivers'; and (3) 'Black Tartarian', 'Knight Early Black', 'Bedford Prolific', 'Black Eagle', and 'Early Rivers'. None of the cultivars function as pol-

linizers for other cultivars in the same grouping. A cultivar from another pollinizing group is needed to assure adequate fruit set. Incompatibility is reciprocally expressed; thus the pollinizing cultivar will be pollinized satisfactorily by the main cultivar.

Many European cultivars have been classified into pollination groups (26). Also these investigators have explained the nature of incompatibility in sweet cherries. As is true in tobacco, incompatibility in cherries apparently is controlled by an allelomorphic series of genes designated as  $S_1$ ,  $S_2$ ,  $S_3$ , and so on. Each plant carries two of the allelomorphs. Pollen germinates, but pollen-tube growth is inhibited in the style of a plant having the same incompatibility factors, either from self-pollination or from cross-pollination of two cultivars in the same group. Hence the male gamete is prevented from reaching the ovary in time to cause fertilization. If the pollen ( $S_1S_2$  for example) has one

factor in common with the style ( $S_1S_3$ ), the  $S_1$  pollen tube will be inhibited, but the  $S_2$  pollen tube will penetrate the style normally. Thus half of the possible combinations are fertile, and adequate fruit set can result. If four different allelomorphs are involved (for example,  $S_1S_2$  pollen and  $S_3S_4$  stylar constitution), all possible combinations are fertile.

The John Innes Institute in England has released 3 self-fertile selections, which are being used to breed self-fertile cultivars. 'Stella' is the first such cultivar released. The self-compatible selections are explained as trees carrying an allelomorph ( $S_41$ ), which nullifies the inhibition of pollen-tube growth by the  $S_4$  allele (66).

In the selection of a suitable cultivar for pollination, the blossom dates of the two cultivars in question should overlap enough to ensure an abundant supply of pollen at the time the blossoms are receptive. Canadian studies show that in the relatively unproductive 'Schmidt' variety, degeneration of egg cells occurs before blossoming to the extent that only a few embryo sacs are functional when blossoming occurs (35, 36). The same phenomenon, but to a lesser degree, exists in 'Bing', 'Windsor', and 'Hedelfingen', but most embryo sacs are still functional when the blossoms open.

Degeneration continues rapidly after the blossoms open. Hence, with these cultivars it is imperative that a source of pollen be available continuously as the blossoms open. The safest policy, therefore, is to use pollinizers which coincide in blossoming time with the main cultivar.

Apparently the reciprocal of any cross in which the two cultivars are compatible will also be compatible. Therefore, providing the blossoming of the two cultivars overlap, a known pollinizer can be planted with assurance it will be pollinized by the main cultivar.

In some cultivars, so-called "strains" are known to exist, and these vary somewhat in their ability to pollinize. In fact, strains of 'Black Tartarian' and other cultivars have been shown to be in different pollination groups (26). Care should be exercised, therefore, to assure that the main and pollinizing cultivars chosen for planting are from a true-to-variety source and are proved pollinizers for each other if either represents a variant strain.

Since the appearance of 'Van', 'Sam', 'Chinook', and other cultivars, it is now possible to fill the orchard pollinizer positions with profitable fruit-producing trees rather than merely with pollen-producing trees.

## PROPAGATION

Like most other fruits, sweet cherries do not produce uniform seedlings. Therefore, vegetative propagation is used to propagate trees of desired fruit and tree characteristics. Clones can be indefinitely maintained by budding and grafting, barring natural mutations or sports.

Nursery trees are produced by propagating the desired scion cultivar onto a desired rootstock. Usually this involves budding a single dormant bud onto a year-old seedling (liner) just above ground level in July to September. A bud formed in the axil of a leaf on current-year wood is used. The T-cut, shield-bud system (fig. 4) is usually used. Buds from previous season wood may be kept dormant by refrigeration and June-budded on liners. Thus nursery trees are 1-year-old scions on 3- or 2-year-old roots, respectively, depending on

whether they were summer-budded or June-budded. Bench-grafting dormant scions onto liners or root pieces is possible but is laborious and requires considerable proficiency.

A intermediate stem piece between the rootstock and scion sometimes is used to impart greater trunk hardiness, to induce early fruiting, or to cause dwarfing of the scion cultivar. This usually involves budding in 2 successive years, but bench-grafting sometimes is used to complete the propagation at one time.

In some instances, a shift in market demand for a cultivar, disease-susceptibility, or other economic factors may suggest changing cultivars. This can be done in young or bearing trees by budding or grafting the top to a new cultivar.

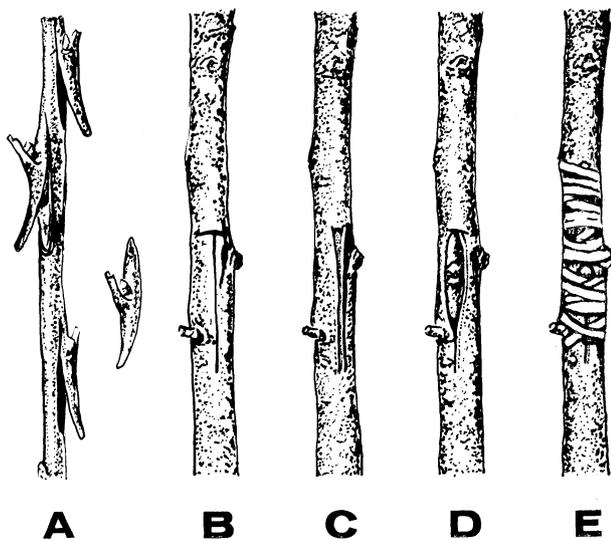


FIGURE 4.—Diagram of T-shield budding of sweet cherries. A, The bud stick with shield-shaped buds partly cut; B, T-shaped cut in the stock; C, bark raised along side of the T-cut; D, bud inserted; E, placement of rubber band to prevent drying.

## ROOTSTOCKS

Strong preferences have developed in different areas concerning the best rootstock for sweet cherries. As a result of a 13-year test, the St. Lucie cherry, *Prunus mahaleb* L., is recommended in Utah as the best stock for the arid climate and well-drained soils of that area (25). In most eastern States and California, wild sweet-cherry seedlings, commonly called mazzards, have been preferred by growers because mahaleb roots are reputed to dwarf tree size and reduce tree longevity (114). In areas where poor soil drainage is a problem, 'Stockton Morello' (*P. cerasus*) has adapted better than mazzard or mahaleb roots.

Although growers generally prefer mazzard rootstocks, nurserymen much prefer mahaleb because of better seed germination and easier budding over a longer period. As a result, nurserymen switched from almost exclusive use of mazzard as a cherry rootstock before 1850 to increasing use of mahaleb for the last half of the century and well into the present century. In certain areas, the advantages to the grower of the mazzard or 'Stockton Morello' rootstocks have outweighed the nursery ad-

vantages of mahaleb, and growers have demanded these rootstocks.

Gibberellins offer some hope for more dependable germination of mazzard seeds. Use of gibberellins with sweet-cherry hybrids substituted for at least 3 months of the usual 5-month after-ripening requirement and offered the possibility of growing liners suitable for budding a year earlier than possible without its use (42, 45). Maximum germination was combined with reduced rosetting, a condition associated with insufficient chilling, when gibberellin treatment followed 2 months of after-ripening of the seed. Foliar sprays of gibberellin were effective in forcing growth on plants that rosetted.

In areas such as the Yakima Valley of Washington, cultivars on mahaleb rootstocks free of disease produce trees of equivalent size and longevity to those on mazzard roots. Several factors could be involved. Day (29) noted that trees on mahaleb rootstocks gave earlier hardening and better tolerance to low temperatures in the early fall, more tolerance to zinc deficiency and an excess of lime, and better adaptability to sandy soils and dry conditions than did trees on mazzard rootstocks. Under less favorable conditions for mahaleb rootstocks, the rootstock has a tendency to be overgrown by the scion at the bud union, and to become dwarfed and short-lived. The shallower root system of mazzard rootstocks adapts better to higher soil-moisture conditions and heavier soils than do the deep roots of mahaleb rootstocks. Gophers often are more troublesome in orchards on mahaleb rootstocks.

'Stockton Morello' rootstocks adapt better to wet heavy soils than do mazzard or mahaleb rootstocks; also this stock may reduce tree size in lighter soils. It is not a satisfactory rootstock for 'Napoleon' in Oregon. 'Morello' and other sour cherries give seedlings of variable size, so elimination of less vigorous seedlings in the nursery row is desirable.

*Prunus fruticosa* Pall., the European dwarf ground cherry, has been used to a limited extent as a sweet-cherry stock. While the graft unions appear compatible, the roots give poor anchorage, and the understocks sucker profusely. True genetic dwarfs that occur from

sweet-cherry crosses have not yet been evaluated as rootstocks.

## INTERSTOCKS

Above-ground trunk sections or complete trunk and crotch portions of trees sometimes are substituted for that portion of the scion cultivar. These may be the same as the rootstock, or the stem piece may be different from both the scion and rootstock. Early fruiting, reduced tree size, and greater hardiness of the trunk usually are the objectives sought. The F12/1 mazzard rootstock from England, topworked out on the scaffolds, imparts bacterial canker resistance.

Budding sweet-cherry trees high on the trunk of *P. mahaleb* is effective in reducing bacterial canker (29). Also topworking above the crotches of mahaleb seedlings or substituting an interstock (trunk and crotches) of an upright mahaleb type (Russian or Turkish type) reduces infection by X-disease virus (buckskin), permits detection and removal of infected leaders and salvage of the tree, and allows replanting in areas where infected trees were removed (29).

Interstocks of *P. cerasus*, principally 'Montmorency' and 'Northstar', have been used to control tree size of sweet-cherry trees. These interstocks may be only a few inches of trunk or may extend from ground level to 18 inches out on main leaders. Because of the slower growth rate of the sour-cherry section, both the understock (usually mahaleb) and scion usually overgrow the interstock (fig. 5). Growth of nonbearing trees with 'Montmorency' or 'Stockton Morello' interstocks is not noticeably slower than that of standard trees, but bearing starts a year or two earlier. Hence the mature height of the trees is controlled more easily because of greater spreading by the weight of the first crop and reduction of vegetative growth.

The trunk is one of the last parts of the sweet-cherry tree to harden off in the fall. As a result, trees that are relatively hardy in other parts of the tree are vulnerable to injury from early fall freezes in the trunk and crotch areas. In areas where trees are subject to hard freezes



PN-3048

FIGURE 5.—Overgrowth of the interstock by the scion variety. Such overgrowth is found where sweet cherry is topworked high on mahaleb rootstocks or a sour-cherry interstock is used. Note overgrowth pointed out by the arrow.

before hardening is complete, substitution of a hardier trunk may be desirable. Also where "southwest injury" is common from sunlight reflected onto the trunk from snow, a hardier trunk section may be useful.

Trees using 'Northstar' (a dwarf *P. cerasus* cultivar) interstocks appear to be smaller than standard ones. Close plantings such as those used for apple trees on 'Malling VII' rootstock may be possible. Slightly closer planting of trees is possible with 'Montmorency' interstocks than with standard trees. Consideration should be given to the use of such trees as fillers, because they will fruit before standard trees. Particular care should be used in training to force wide-angled branches in trees with 'Montmorency' crotches. Interstems of 6 to 12 inches of 'Montmorency' trunk give the

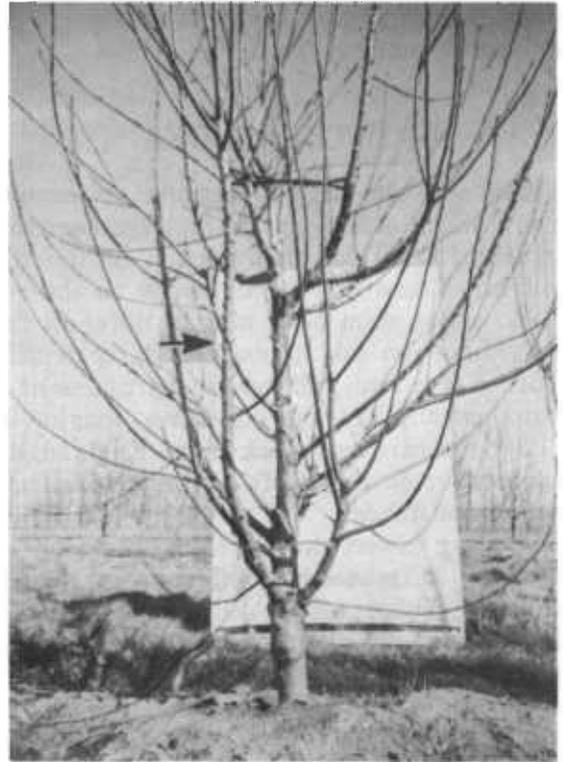
advantages of this stock but avoid the weak crotches.

## TOPWORKING

Topworking trees of bearing age to a more desirable cultivar allows the grower to change his production to the new cultivar with a minimum of delay. Sometimes a grower is not sure of the commercial potential of a new cultivar and may wish to be growing trees of standard cultivars, which he may later topwork to the new cultivar if it proves satisfactory. This removes some of the time loss from indecision on cultivars at planting time.

Trees that have been planted in the orchard only a year or two may be budded at ground level with a shield bud. However, even in young trees it is desirable to salvage the trunk and crotches unless the latter form narrow angles. Usually it is desirable to bud or graft at least 18 inches out on main leaders.

The topworked leaders may tend to develop as upright "poles" unless care is given to their training (fig. 6). It is advisable to leave considerable brush in the center of the tree to encourage spreading of the topworked leaders. Tying-down of the leaders in mid-May for about a six-week period spreads the tree and encourages earlier fruit set. Summer heading likewise encourages wide-angled crotches.



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FIGURE 6.—A vigorous sweet-cherry tree, topworked at 12 inches on mahaleb rootstock, showing good branching and early-fruiting tendencies. Note, however, a tendency for the branches to develop into upright "poles" (arrow) if not headed. Note also the intertwined sticks (upper portion) used to spread narrow-angled limbs.

## ORCHARD PLANTING

### SITE

Site is of greater importance for sweet cherries than for most other fruits. Soil and climatic requirements are more exacting than for most fruits. Since the trees usually blossom during potentially frosty periods, higher elevations with good air drainage should be selected. Soil should be reasonably well-drained and should be deep enough to hold 4 inches of available water or enough to supply a tree for 2 weeks during the high-water-use period. In general the soil should be relatively light and moderately productive. Excessive fertility may cause "leggy" growth, delayed fruiting, and greater susceptibility to winter injury or dis-

ease. The site should not be land recently used for potatoes, tomatoes, melons, or other hosts of *Verticillium*.

### SELECTION OF NURSERY STOCK

Usually 1-year-old nursery trees are preferred for orchard planting. These are obtained from single buds placed on rootstock liners in July or August almost 1½ years before orchard planting or in June of the year previous to planting. In the former case, the buds remain dormant the remainder of the first growing season and, in either case, the bud forms the nursery tree the summer previous to orchard planting. The liner top is removed just above

the scion bud after the scion forces, and all rootstock buds below the bud union are stripped.

No difficulty is encountered in detecting trees that failed to develop from scion buds where mahaleb or 'Stockton Morello' rootstocks are used. However, difficulty may be encountered in detecting bud failure when mazzard stocks are used. Careful nursery practices minimize this danger. It is well to become acquainted with nursery practices of the nurseryman from whom trees will be obtained. Nurserymen prefer to bud trees on a custom basis and usually offer discounts for custom orders. It helps them minimize the gamble of propagating cultivars for which there may be no demand two years hence.

The grower should analyze his prospective site in choosing the rootstock for his trees. If the soil is light-textured and tends to be droughty, he should consider the deeper root system of mahaleb. Mahaleb should be considered also when the soil is alkaline, where some replanting problems have been encountered, or where the soil is known to be deficient in zinc. In areas where early fall freezes are a known hazard, or where X-disease infected trees have been removed, mahaleb can be used for its earlier-hardening and disease-resisting tendencies.

On most eastern soils, except very light-textured and droughty ones, mazzard usually is preferred. On the irrigated western soils, where none of the problems in the preceding paragraph are serious, the grower has the option of fairly equivalent growth on either stock.

Where excessive moisture is a serious problem, 'Stockton Morello' understocks may be used.

Cultivars to plant should be selected on current and projected demand of the marketing outlets available to the area. If distant shipping is the chief outlet, and there are no immediate local market or processing outlets, only the firm-fleshed, large-fruited cultivars should be considered for planting. If processing is the main outlet, productive, relatively firm, freestone varieties are indicated. If brining is the sole outlet, productive, light-fleshed, and relatively firm cultivars are preferred. For

local markets, the softer-fleshed cultivars may be very acceptable.

Because of the rain-cracking susceptibility of the firm-fleshed cultivars, the other desirable characteristics of 'Bing' and similar cultivars may be overbalanced in areas of considerable rainfall during the late ripening and harvest seasons.

The availability of pickers and the feasibility of mechanical harvesting should be considered also in selecting probable outlets and cultivars.

Adequate pollinizers should be provided in the initial planting to suffice for the early harvest years. Usually the number of pollinizers needed is greater than in the mature orchards.

Pollinizers in every third permanent position in every third row are adequate for the mature orchard. It is often advisable to provide additional pollinizers in filler positions to ensure adequate pollination of the young trees. The ratio of eight trees of the main cultivar to one pollinizer makes a convenient planting.

Medium-sized trees, averaging 4 to 6 feet high and more than  $\frac{5}{8}$ -inch caliper, are preferred for planting and usually give highest survival. Smaller trees, except June-budded ones, are often not thrifty and grow poorly. Trees larger than  $\frac{7}{8}$ -inch caliper often give poor survival.

Upon delivery, the trees should be placed in underground storage with the roots covered by shingle tow or peat moss, or they should be heeled-in in a well-drained outside location, with the trees slanted to the southwest to avoid sunburning of the trunk and crotches. If the trees dry out in shipment, soak them for several hours before heeling them in.

## SOIL PREPARATION

The orchard site should be plowed or disked in the fall or early spring, if needed, and thoroughly prepared before planting. If there is a distinct plowpan, deep plowing may be advisable. A green-manure crop the year before planting is desirable to improve soil tilth. Other fertilization usually is not needed before planting.

If the orchard is to receive routine or sup-

plemental irrigation or underground heating lines, such systems should be fully installed before planting. These systems may dictate tree-spacing patterns.

On slopes subject to erosion, or where sod strips between rows are desired, row strips 5 to 6 feet wide may be plowed or rotovated, preferably on the contour. The young trees will not compete successfully with weeds and grass. Therefore, these strips or circles around each tree should be cultivated at least the first 3 years for optimum growth of the trees. Several kinds of rotary tree hoes are commercially available for this purpose.

## TIME OF PLANTING

Early spring, February to April, depending on latitude and suitable weather, is the traditional time to plant trees. It is important to be sure the nursery stock has been stored properly, protected from extreme cold, and kept dormant until planting time. If these conditions are met, and the soil is moist or water is added to the tree hole, excellent survival should be expected.

Fall planting has the advantages of better planting weather usually and of nursery trees that are freshly dug and that have not had a chance to dry out. The trees are dormant when planted, and roots have time to become established before leaf buds break. In areas usually subject to low winter temperatures, the grower should avoid fall planting. In temperate areas, as far north as New York, Michigan, and Washington, fall planting is increasing.

## TREE SPACING

A mature sweet-cherry tree with a favorable regime will occupy 30 feet of space between trees. However, 25 years may elapse before the space is fully utilized. It is usually desirable to plant filler trees. Despite the innate reluctance of most growers to remove trees when they are bearing well, these filler trees must be "fanned" (pruned more severely on one axis) and removed as the permanent trees gradually fill in the space. If fillers are removed

as required, there will be no serious drop in production. On the other hand, removal of fillers left several years too long may cut the crop in half for one or more years.

Where the square system is used, standard permanent trees usually are set 20 x 20, 25 x 25, or 30 x 30 feet. If filler trees are used, the initial spacing may be 10 x 10, 12½ x 12½, or 15 x 15 feet, or the rows may be left 20, 25, or 30 feet apart with closer spacing in the row. Assuming the former spacing system, two removals are necessary. First, alternate diagonal rows are pulled. This removes half of the initial number of trees and gives full-width row middles on the diagonal. The second removal is at right angles to the initial planting and leaves one-fourth of the original trees in a square arrangement (fig. 7, A). If wider initial spacing is provided between rows, only the final removal may be necessary. In this case, a tree remains in the center of each square.

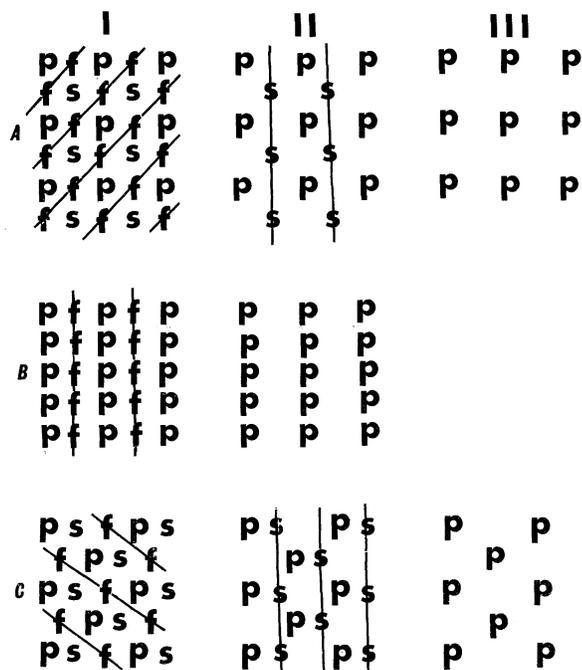


FIGURE 7.—Alternate planting systems: A, Square; B, rectangular; and C, hexagonal; designs formed by location of permanent (p) trees. I, Spacing of the initial planting; II, spacing after removal of filler (f) trees; III, spacing after removal of semipermanent (s) trees. Lines show direction trees are removed.

An alternative spacing that gives more permanent trees to the acre is the rectangular pattern (fig. 7, *B*). An initial spacing of 24 feet within rows and 18 feet between rows may be used. Pulling alternate rows removes half the trees and gives 36-foot middles while permitting complete use of the space within the rows. This system is generally used on hilly ground or in contoured plantings where cross-travel is impractical. Spacings of 30 x 22 or 15 x 22 feet are suggested in Oregon for orchards to be mechanically harvested.

In the hexagonal system, initial spacings are rectangles with a tree in the center (fig. 7, *C*). First removal (every third diagonal) eliminates one-third of the trees. Second removal of alternate rows removes one-half of the remaining trees. Either diagonal has wider middles than the rows, and the permanent planting becomes essentially squares or rectangles with a tree in the center. Performance of orchard operations in any direction is possible under this system.

## TRANSPLANTING

Losses during the first year after planting are greater in cherries than in any other tree fruit. Good care at the time the nursery trees are received will help minimize losses. Soaking trees that have become dry in shipment often will salvage trees that otherwise would not survive transplanting.

Holes should be dug wide and deep enough to accommodate the roots in their normal position. Tractor boom diggers with 18- to 24-inch augers are useful in digging holes. Unless water is added at planting time, however, the hole should be dug just before planting.

Any broken or injured roots should be trimmed off before planting, and thin roots may be shortened. Exposure of the roots to wind and sun should be kept to a minimum to avoid excessive drying out.

The trees should be set an inch or so below their level in the nursery row. This places the bud union at or just below ground level. If a dwarfing or other special rootstock is used, the union should be planted above ground. The topsoil removed should be placed around the

roots and settled by moving the tree up and down carefully as the first few shovels of soil are added. Then the soil should be stamped firmly. Where feasible, 2 or 3 gallons of water should be added to give good contact of roots and soil. The soil is firmed by stamping as the hole is filled completely. Slight rounding of the top will give a smooth surface for subsequent cultivation.

## TREE HEADING AND TRAINING

Unbranched average-sized nursery trees should be headed at about 30 inches height after planting (fig. 8). A second heading after 4 or 5 inches of growth occurs encourages wide-angled branching. If the trees are weak or winter-injured, heading lower than 30 inches may be desirable. Such trees should be avoided if possible. Heading at 12 inches usual-



PN-3050

FIGURE 8.—A well-branched tree in July of the first season after planting. The tree was headed at about 24 inches when planted.

ly forces a strong shoot with numerous wide-angled branches.

Heading should be done in the spring to avoid exposure of the cut surfaces to winter-damage. Whether the trees are planted in the fall or spring, they should be headed before the buds break dormancy.

Initial leaders may be selected on branched nursery trees if they are well spaced and are wide angled. The lowest leader should be about 18 inches above the ground and the others at least 4 inches apart and distributed around the tree. Usually three but not more than four leaders are left. Heading should be at the same height as for unbranched trees. If angles are

narrow and branches weak, all branches should be removed and the tree handled as for an unbranched tree.

## CARE OF YOUNG TREES

Newly planted trees should receive extra care until they are well established. Removal of weed competition for nutrients and water within the root area of the tree is essential. Irrigation should be supplied as needed while the tree is replacing roots lost in digging and planting it. Control of insects and diseases that may damage young trees during this critical period is important.

## ORCHARD MANAGEMENT

### CULTIVATION

The main objectives of cultivation are to remove competition between the weeds and trees for water and nutrients. Proper penetration of water and release of nutrients may be improved, particularly in older orchards where compaction of the soil by frequent use of heavy equipment has greatly reduced the water-penetration rate.

While the disk harrow is a time-honored implement in fruit orchards, its use sometimes causes more damage than benefit. Deep disking cuts the feeding roots near the surface, often defeating the purpose of cultivation. Where shallow disking will destroy the weeds or loosen the compacted zone, it is more advantageous to the trees than deep disking.

Where rainfall is sufficient to support a cover crop, or where irrigation is available, cultivation of only a 3-foot radius around each tree prevents direct competition of the cover crop with the trees and aids in preventing erosion. Several rotary tree hoes suitable to cultivation around individual trees or down both sides of tree rows are available.

### FERTILIZERS

Of the twelve essential nutrients, nitrogen is the one most often found to be deficient. In orchards with a good leguminous cover crop,

however, this element is almost always in adequate supply.

The other major fertilizer elements, phosphorus and potassium, are usually present in adequate quantities in most soils. Calcium and magnesium are not considered limiting to cherry-tree growth in most areas.

Small quantities of several microelements are also essential. Among these microelements, manganese, copper, iron, sulfur, and molybdenum are not usually limiting under normal conditions. Zinc and boron, however, may be deficient, particularly in the neutral or alkaline soils of the irrigated regions, and marked deficiency symptoms may appear.

As is true with other fruit trees, a balance between the fertilizer elements is desirable. Excessive applications of one element may induce deficiency symptoms of another element, for example, too much potash may induce magnesium deficiency.

Where leaf analyses are feasible, this additional index of fertility status may be useful. In general, soil analysis can be used only to determine the general fertility conditions in the orchard. Ultimately, adjusting fertilization of individual trees to maintain good, but not excessive, vigor is the most economical system.

Fertilization should be based on year-to-year observations of growth, production, maturity, quality, and deficiency symptoms of individual

trees. It is poor economy to add the major elements in quantities in excess of the needs of the trees and the cover. On the other hand, annual applications of zinc to prevent the occurrence of deficiency symptoms may be more economical than trying to correct symptoms after they appear.

## Nitrogen

Deficiency of nitrogen in cherry trees is expressed by short, slender terminals; by small, pale-green to yellow leaves; and by small, early-ripening fruit. These symptoms may also be induced by natural or mechanical injuries to roots or trunk, by girdling, by poor soil drainage, or by drought. Although adequate amounts of nitrogen may exist in the soil, the conducting system of the injured plant sometimes fails to deliver enough nitrogen to satisfy the needs of the tree.

Excessive nitrogen delays fruit maturity and retards fruit coloring. Applications of nitrogen should be reduced to trees pruned severely, to trees that lost fruit to low temperatures, or to those subject to ground water with high nitrate content.

The best source of nitrogen fertilizer is the one that costs the least per pound of actual nitrogen applied to the ground. Cherry trees appear to use nitrogen from various sources equally well. Thus 6 pounds of nitrate of soda, 3 pounds of ammonium nitrate, 2.2 pounds of urea, or 10 pounds of 10-10-10 fertilizer all give about 1 pound of actual nitrogen. Each of these nitrogen sources is very soluble and penetrates to the tree roots quickly.

The amount of nitrogen to apply should be based on the previous year's growth and production. A very general rule would be to apply 100 to 250 pounds of actual nitrogen per acre per year.

An index of the fertility status of trees is useful. Usually the amount of terminal growth the previous season, allowing for the crop borne, gives the grower an estimate of current nitrogen needs. If vegetative growth is excessive, for example, over 18 inches on average terminals, nitrogen application should be curtailed or even eliminated for a year. If terminal

growth is short, particularly when the crop is light, nitrogen application should be increased. Trees that are noticeably above or below average in vigor should receive less or more nitrogen than average trees.

The time of application may be late fall, early spring, or a split application in both seasons. Late spring or summer applications, particularly of less soluble nitrogen forms, may delay fruit maturity as well as possibly delaying tree hardening and increasing winter-damage susceptibility. Split applications may be desirable where frosts often cause less than full crops of fruit. The second application may be reduced or eliminated, thus saving fertilizer and preventing excessive growth, in light crop years.

The nitrogen fertilizer should be applied evenly in a circle slightly larger than the periphery or "drip line" of the tree. If a cover crop is growing in the orchard, a broadcast application to satisfy the needs of the cover should be superimposed on the tree applications. In heavy cover crops, a concentrated circle application may be necessary to get the nitrogen through the cover to the tree roots.

Use of barnyard manure as a nitrogen source may induce or aggravate zinc deficiency symptoms in western orchards.

Excessive alkalinity may result from continued use of sodium and calcium nitrate fertilizers on irrigated western soils. Alkali deposits tend to accumulate at the soil surface, sometimes encrusting it, as the water evaporates. As soil alkalinity increases, water penetration is greatly reduced, and plant growth is retarded. Eventually only alkali-tolerant plants will grow in the low areas where water accumulates.

Excessive irrigation may alleviate the problem by flushing part of the alkali below the root zone. Substitution of ammonium sulfate or nitrate helps reduce the soil pH and stops further alkali buildup.

On the other hand, continued use of ammonium sulfate or other acid-forming nitrogen fertilizers may reduce the pH to a growth-depressing level. This can be particularly serious in eastern growing areas.

Proprietary "leaf feeds" are available. These

may be used for rapid recovery from deficiency symptoms where a short-time residual effect of nitrogen is desired.

## Phosphorus and Potash

Most soils provide ample phosphorus and potash for sweet-cherry trees. The amounts applied should therefore be about equal to those removed annually by the trees.

In the irrigated Yakima Valley of Washington, ground application of phosphorus increased the P content of both leaves and fruits but did not affect maturity or keeping quality of fruits (117).

Potash response has been demonstrated in sweet-cherry trees only in one western Oregon orchard.

## Minor Elements

Zinc deficiency in sweet cherries often is called "rosette" or "little-leaf." Interveneal chlorosis and shortened internodes during the early flush of growth is an early symptom. In severe cases, buds fail to grow at several adjacent nodes, and the shoots that do grow have small leaves, giving a tufted or rosetted appearance.

Ground application of zinc fertilizers usually does not correct zinc-deficiency symptoms. Late fall and/or dormant sprays of zinc sulfate may correct incipient deficiencies. Severe deficiencies on alkaline soils usually require two applications of zinc oxide spray (2 lb. per 100 gal. water), as leaves are expanding, to correct zinc-deficiency symptoms.

Boron deficiency occasionally may cause leaf chlorosis between veins and necrosis of leaf serrations. Magnesium deficiency occasionally causes marginal reddening and necrosis of leaves. Chlorosis may occur from a low availability of iron in alkaline soils or may be induced by heavy applications of lime.

## IRRIGATION

Irrigation is a necessity in most western orchards. Commonly the systems are under-the-tree sprinklers, rills, or checks, often as dictated by the terrain. Supplemental irriga-

tion has proved beneficial also in area having enough total rainfall but subject to periodic droughts during the growing season.

Sweet-cherry trees are very susceptible to "wet feet." Hence irrigation should be on a demand basis rather than a calendar one. The general tendency where ample water is available is to overirrigate. The need for irrigation can be predicted reasonably well by following an evapotranspiration chart for the area in question (61). Likewise, moisture-tension blocks can be monitored to determine the approximate moisture at different soil depths in specific orchards. Periodic checking of soil samples in the upper 3 feet of soil will also indicate the necessity for irrigation. If a ball of soil taken from the 3-foot depth is moist enough to resist crumbling when squeezed and then jarred slightly, irrigation is not necessary.

On the other hand, cherry trees should not be permitted to suffer from moisture stress. Reduction in fruit size and tree growth may result from temporary stress.

Over-the-tree sprinklers are used in some western orchards. These systems are being used experimentally in efforts to reduce heat-induced disorders, such as fruit doubles. The rain-cracking and disease hazards might be increased by these systems, which irrigate when a predetermined temperature is reached. No conclusive evidence of benefit or damage is yet available.

## COVER CROPS AND INTERCROPS

Conservation of the soil is an overriding consideration in orchard management. Frost protection often dictates use of land subject to erosion. A permanent cover crop is the ideal solution for sites where soil erosion may occur. Competition for rainfall, however, may prevent use of permanent cover crops.

While a good cover crop has real advantages in a cherry orchard, provisions must be made for the fertilizer and irrigation needs of both the trees and the cover.

A clean-cultivated strip of about 3 feet on either side of the trees should be maintained at least 2 or 3 years after planting. Otherwise

tree growth is impeded by the competition for water and nutrients. The shallow roots of the cover may use most of the rainfall that would sustain the trees under clean cultivation. Until the trees have grown an extensive root system, they are also at a disadvantage in picking up nutrients.

Although intercropping of a young orchard often is practiced to offset some of the planting costs, it is not recommended. Interplanting with potatoes, tomatoes, melons, and other crops susceptible to *Verticillium* wilt, can introduce this disease to the orchard and result in death of many young trees. There is the additional danger of too much irrigating, fertilizing, and cultivating of the orchard trees in order to supply the demands of the intercrop. If an intercrop is used, it should be one that will adapt to normal cultural practices for the tree.

A good cover crop can be valuable in a mature cherry orchard for conserving the soil and for maintaining the organic-matter content and water-infiltration properties of the soil.

Legume covers supply at least part of the nitrogen requirements of trees. However, caution is necessary with alfalfa cover because it may cause delay in fruit ripening. Alfalfa also provides ideal conditions for gophers and field mice. Nevertheless, alfalfa is a good soil conditioner, and its deep root penetration tends to break up hardpans. It also tends to prevent or reduce zinc deficiencies. Shallow-rooted legumes, such as sub-clover (*Trifolium subterraneum* L.) are preferable.

Nonlegumes usually are preferred, because it is then easier to regulate the nitrogen regime for the trees. Root systems are shallower and offer less competition for nutrients. The fescues generally have proved best adapted to orchard cover. Of the fescues, creeping red (fig. 9) is very satisfactory. Orchardgrass and Kentucky bluegrass are also satisfactory. Merion bluegrass is satisfactory in most respects, but it is subject to severe rusting in the fall. Native or weed covers often are very satisfactory. Since the vegetation in such covers usually grows taller than creeping red fescue or similar grasses, it is necessary to mow the



PN-3051

FIGURE 9.—Creeping red fescue cover crop in a young sweet-cherry orchard.

cover to permit normal orchard operations and to prevent seeding of noxious weeds.

Rotary mowers are well adapted to most orchard covers. A pressure-sensitive attachment to the rotary mower can be used to trim closely around trees while the mower moves forward.

## WEED CONTROL <sup>11</sup>

Weeds compete with trees for moisture and nutrients. Elimination of this competition is essential during the first 3 or 4 years. Control of deep-rooted and noxious weeds is desirable in older orchards.

Weeds harbor insects, diseases, nematodes, and rodents. Therefore a systematic weed-control program should be incorporated into the general production program. In mature orchards this may consist merely of mowing or disking the ground cover at stages that will prevent seeding of noxious weeds. Usually, however, mechanical or chemical means of eliminating weeds must be employed.

Many annual broadleaved weeds and weed-grasses invade orchards. Smartweed (*Polygonum* spp.), pigweed (*Amaranthus* spp.), lambsquarters (*Chenopodium album* L.),

<sup>11</sup> This section was prepared principally by L. L. Danielson, chairman, Agricultural Environmental Quality Institute, Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Md.

goosegrass (*Eleusine indica* (L.) Gaertn.), and several others are particularly bothersome. In addition, many perennial species such as poison ivy (*Rhus radicans* L.), deciduous tree seedlings, wild blackberry (*Rubus* spp.), quackgrass (*Agropyron repens* (L.) Beauv.), Johnsongrass (*Sorghum halepense* (L.) Pers.), and Bermudagrass (*Cynodon dactylon* (L.) Pers.) are serious pests.

The methods and materials selected for use in a weed-control program depend on the cultural practices used in the specific production areas. In general, however, a combination of mechanical and chemical control practices is most successful. Some chemicals must be used differently under irrigated and nonirrigated conditions and under different cultivation methods. Follow local recommendations in combining methods.

## Mechanical Devices

Rotary tree hoes are available, which will cultivate a strip around the trees or down each side of the tree row if the orchard is ditched for irrigation. These hoes are side-mounted so the tractor operator can easily see the area he is cultivating and can minimize tree damage. One type has a revolving drum with spike teeth on the side-mounted shaft (fig. 10, A). Optional rotovator blades aid in cultivation as well as preventing accumulation of debris on the drum, and an optional wheel regulates depth of hoeing. For maneuvering the hoe in and out where cultivating in the row only is possible, a hydraulic-cylinder section may be added to the shaft. This type is best adapted to soils relatively free of rocks, but blade and spike edges may be hard-faced with suitable alloy weldings.

A second type of tree hoe has spikes in a floating head (fig. 10, B), which rotates right or left to cultivate towards, or away from, the tree. This type adapts particularly to uneven terrain and rocky ground.

No additional hand hoeing is necessary with either type of hoe if the operator is skilled. The row middles are maintained by periodic mowing, giving a firm turf for heavy sprayers



PN-3052 PN-3053

FIGURE 10.—Tractor-mounted rotary tree hoes: A, Drum-type with optional rotovator blades and depth-controlling wheel; B, floating-head type with the shaft lifted into road position.

and other equipment. Favorable nesting-places for mice are disrupted by tree hoeing.

## Chemical Methods

Cultivated weed-free areas under established trees can be easily maintained by applying simazine [2-chloro-4,6-bis(ethylamino)-s-triazine] or dichlobenil [2,6-dichlorobenzonitrile] herbicide as a soil treatment before weeds emerge. Simazine is applied in early spring, using a carefully directed coarse spray that does not touch the trunks, exposed roots, or foliage. Dichlobenil is applied in spray or granular form after harvest, allowing 12 months between treatment and the next harvest.

Contact herbicides such as dinoseb [2-sec-

butyl-4,4,6-dinitrophenol] and paraquat [1,1'-dimethyl-4'-bipyridinium salt], which destroy the foliage and stems of plants, are used to kill annual broadleaved weeds and weed-grasses in the early stages of growth. They are also effective in controlling topgrowth of perennial weeds, if additional applications are made when new growth appears. Dinoseb is usually fortified with fuel oil, diesel fuel, or Stoddard solvent, and treatments are made during crop dormancy. Thus, late winter or early spring applications destroy most established winter weeds and give some preemergence control of spring-germinating weeds. Dinoseb should not be used during the growing season. Paraquat is a relatively new, highly effective contact herbicide. Early spring treatments are made to destroy emerged annual

weeds and the tops of perennial weeds while trees are still dormant. Treatments are repeated as weeds continue to emerge during the growing season.

Each of these herbicides should be applied as localized, or shielded treatments, that prevent the herbicide from reaching the fruits, foliage, and trunks of the trees. Livestock should not be pastured in the treated areas.

Specific information on optimum herbicide rates and times of treatments should be obtained from local experiment station personnel because of the many factors such as climate, soil composition, moisture, and cultural practices that affect the safe and effective use of herbicides. The manufacturer's label on the herbicide package should be studied and all precautions carefully observed.

## PRUNING AND THINNING<sup>12</sup>

### PRUNING

Pruning of sweet-cherry trees, as is true of other fruit species, delays bearing. This delay is objectionable and to be avoided as much as possible. However, some pruning is necessary to maintain the selected leaders, to prevent crossing and rubbing of competing branches and to keep the tree within a reasonable height.

Of the numerous objectives of pruning cherry trees, keeping the tree low deserves special attention. If trees are allowed to go unpruned during the early years, very "leggy" framework branches result (fig. 6). In some trees, the first lateral on the bottom scaffold branch originates 6 or more feet above the base of the scaffold. This height adds very materially to the ultimate height of the tree.

Selecting leaders is the main thing to be accomplished in pruning the first 2 or 3 years (fig. 11, A). Narrow crotches are decidedly objectionable, particularly when sour-cherry interstocks are used. If necessary, it is advisable to take a second, and rarely a third, year to complete leader selection. Future crowding and pinching of limbs can be avoided by spac-

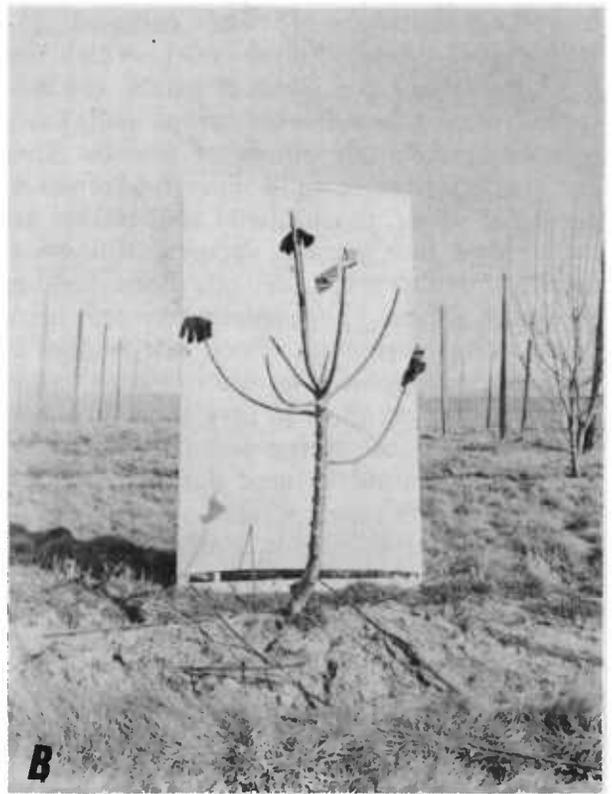
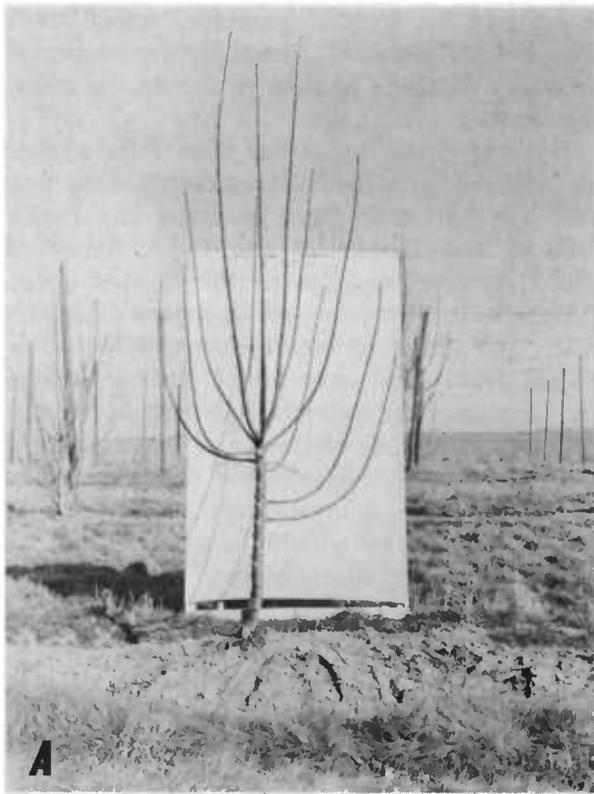
ing the leaders over a 2-foot trunk section (fig. 11, B). Selected leaders should be kept dominant over other branches. However, shortened interscaffold branches may help to keep the crotch angles wide and produce good early fruiting wood. Pinching young terminals during the growing season and heading during the dormant season (fig. 12) are both effective methods for producing low trees. The purpose of either method is to force lateral branches relatively low on the scaffold branches.

### Pinching

Branching about 14 to 18 inches from the base of the scaffold is desirable. After the shoots are about 18 to 20 inches long, 3 or 4 inches at the tip may be pinched out. Because all branches are not at the pinching stage at one time, it is usually necessary to go over the orchard two or three times the first growing season. Some orchardists pinch once the second season also (fig. 13).

Pinching is practiced more on trees that are headed conventionally than on those headed severely. Severely headed trees usually produce a flush of shoots. Because these shoots often produce 3 or more feet of terminal growth, pinching on them should induce good branching. Since pinching removes very little

<sup>12</sup> This section was prepared by J. C. Snyder, deceased, formerly Extension horticulture specialist, Washington State University, Pullman, Wash.



PN-3054 PN-3055

FIGURE 11.—*A*, A 2-year-old tree in which the strong shoot was headed severely the first winter. Note the numerous branches available for selection, and the wide-angled crotches. *B*, After pruning, four longer leaders are designated as main leaders, and several shorter branches are left for early fruitwood.

wood, it delays bearing only slightly. This slight retardation in early fruiting is a distinct advantage pinching has over dormant heading.

The effectiveness of pinching varies. It nearly always forces branching, but sometimes the resulting branches are sharp-angled. This condition seems to be more serious when only the tip, rather than several inches of the shoot, is pinched out. The main objective of pinching is a flush of branches below the point of pinching. These can be organized into a desirable framework later, provided, of course, that some attention is given to selecting permanent framework branches from the beginning.

## Heading

There is a tendency to be cautious about heading young cherry trees in northern re-

gions. Trees of the more popular cultivars are susceptible to winter-damage, particularly during the early years. Pruning almost inevitably intensified this susceptibility. There is a widespread feeling that cherry trees should not be pruned. Notwithstanding these reasons for caution, heading, during the training years at least, has some significant advantages. It is not imperative, however, because artificial spreading of the branches can produce an early bearing and low tree (fig. 14, *B*). Spreading of this kind requires considerable time for tying, but it gets the tree into bearing earlier.

The purpose of heading is to keep the framework branches from producing long sections without any side branches. The end result is a low, spreading tree. The severity of heading depends on the length of the terminal growth and how far beyond the last whorl of branches you want the next one. Ordinarily, laterals on a

main branch should not be closer than about 18 inches. This means that branches that have not grown more than 18 inches may not need heading. To be sure a branch produces laterals, it is well to clip the terminal. Some branches longer than 18 inches may not need heading. In general the upright main branches are the ones that need heading (fig. 15). If these are not headed, the tree will become too high. Most horizontal and nearly horizontal branches need not be headed.

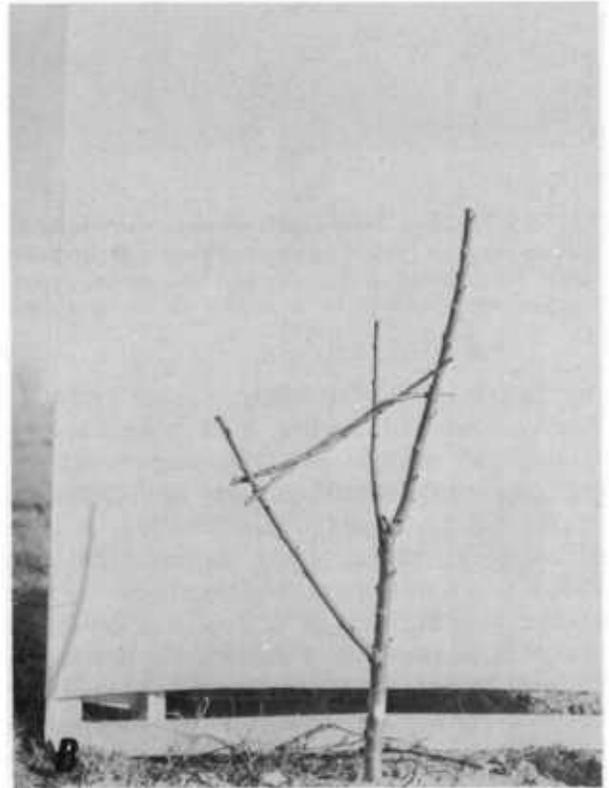
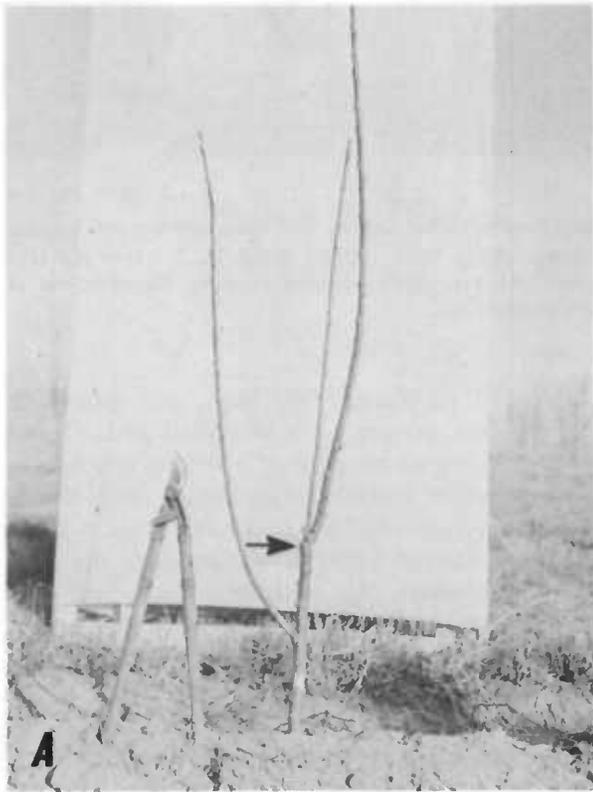
Heading should start with the first dormant pruning and continue for five or six years or until the framework is well established. As the tree gets older, the percentage of branches to be headed decreases. Also, as the tree gets older, some branches may be shortened to less than 18 inches. Eventually some thinning is necessary to allow the tree to develop the proper

shape. More thinning is necessary following intensive pinching or dormant heading.

### Artificial Spreading of Branches on Young Trees

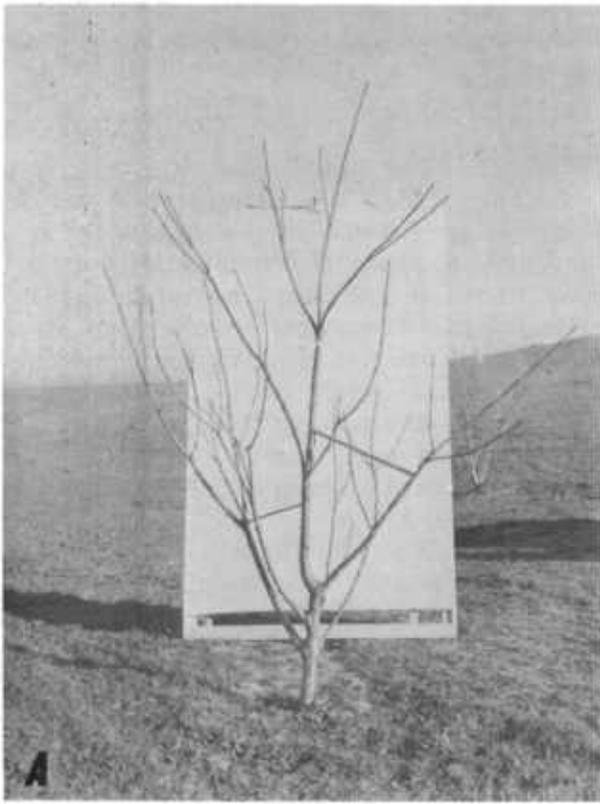
Pruning induces vegetative growth and delays bearing. Because of this fact, there is a tendency to prune the minimum necessary. For this reason mechanical spreading to make trees low has advantages over pruning. Even at greater cost and inconvenience, artificial spreading can be very profitable.

There are almost unlimited techniques and devices for spreading narrow-crochted and upright branches of a young tree. Notched boards and forked sticks are common. These, however, sometimes fall out, particularly in windy areas. A short piece of 1" by 1" board with a finish-



PN-3056 PN-3057

FIGURE 12.—*A*, A tree that received no pinching during the first growing season. Note the initial heading height (marked by the arrow) and the long terminal growth (about 5 feet) of the three branches. *B*, All branches were headed, but the uppermost one was left longer than the other two. The lowest limb was spread to prevent a narrow angle.



PN-3058 PN-3059

FIGURE 13.—A, A 2-year-old tree that was pinched twice the first growing season and once the second season. There was no further pruning. Framework branches have been spread with notched laths. B, A 5-year-old tree that was pinched during the first and second growing seasons with very little dormant pruning. Thinning out of excess branches will be necessary as the tree gets into full production.

ing nail in each end makes a good spreader. For very small branches, wire braces are effective and easy to use. For large branches, the wire must be stiff, but for most branches during the first season, telephone-type wire is satisfactory. When using braces, attention should be given to removing them near the end of the growing season or earlier. Tying the branches to stakes is a dependable but inconvenient technique (figs. 16 and 17). Tying branches down to an angle of 45 degrees is ideal. Stakes driven in early May can be removed by July.

### Girdling

Girdling or ringing of sweet-cherry tree trunks is *not* recommended because of the danger of breakage, the overgrowth (fig. 18) that

will result in the girdled area, and gumming which often occurs in a wounded area. However, girdling or ringing of a *temporary* leader is an effective method of inducing early fruiting. Removing a  $\frac{3}{16}$ " ring of bark from 3-year-old sweet-cherry hybrids in May near the base of a main leader ( $\frac{3}{4}$ " caliper or less) and covering the wound with grafting tape to prevent drying, induced large clusters of fruit in many instances the following year (40). Girdling of larger wood was less effective, presumably because the phloem tissues were replaced too quickly to increase fruit-bud initiation.

Concentric or spiral ringing with a knife is less drastic but can be effective. A continuous spiral ring twice or three times around a leader may induce fruit setting with less danger of breakage.

Timing of girdling or ringing is critical. In Washington State, girdling in early May (past full bloom but before much leaf growth) was most effective. Leaves on the girdled branches became yellowish-green, but they returned to normal green as the girdles healed. Accumulation of carbohydrates above the girdle overbalances the vegetative tendencies of the young tree, and some fruit buds, rather than all vegetative buds, are initiated.

### Chemical Control of Tree Size

Trees have been dwarfed experimentally with succinic acid, 2,2-dimethyl hydrazide (SADH)<sup>13,14</sup> (4). The material is now cleared for commercial use, but at rates and timings that do not retard growth. Under experimental conditions, the material will retard terminal growth, shorten internodes, and hasten coloring of fruit (4, 91). Further research may reveal chemical growth-retardant treatments that are compatible with regulations on residue and fruit quality. Possible benefits from use of this growth retardant are reduction of pruning and harvesting costs; control of tree size, thus avoiding crowding by filler trees and permitting mechanical harvesting; and spreading of fruit maturity. Labor could be used more efficiently by successive treatment of segments of orchards predominantly of one cultivar.

### Pruning the Bearing Tree

During the training period, a tree develops both tree structure and fruiting wood. By about the fifth year the tree should produce up to 50 pounds of cherries, and by the tenth year there should be an abundance of fruiting wood throughout the tree. Up to this point, no effort has been needed to maintain fruit size or to renew fruiting wood. The pruning has con-

sisted mainly of heading vigorous upright branches and, rarely, thinning out temporary branches that crowd permanent branches (fig. 19).

As the tree gets into heavy production, attention must be given to renewing fruiting wood. While the tree is young, slight heading, mainly to side branches, forces good fruiting wood. Most severe heading is necessary in older trees with spurs several inches long. In very old trees it may be necessary to prune out considerable 1- to 3-inch wood. As is true with other tree fruits, pendant and horizontal wood is least vigorous and should be the first wood pruned. In very heavy bearing trees, pruning may give all the fruit thinning necessary (fig. 20). Likewise this type of pruning helps to maintain a good supply of new fruiting wood distributed evenly over the entire tree. In general, removal of fairly large branches, but occasionally some detailed cutting, including some heading of heavily fruiting small branches, is required.

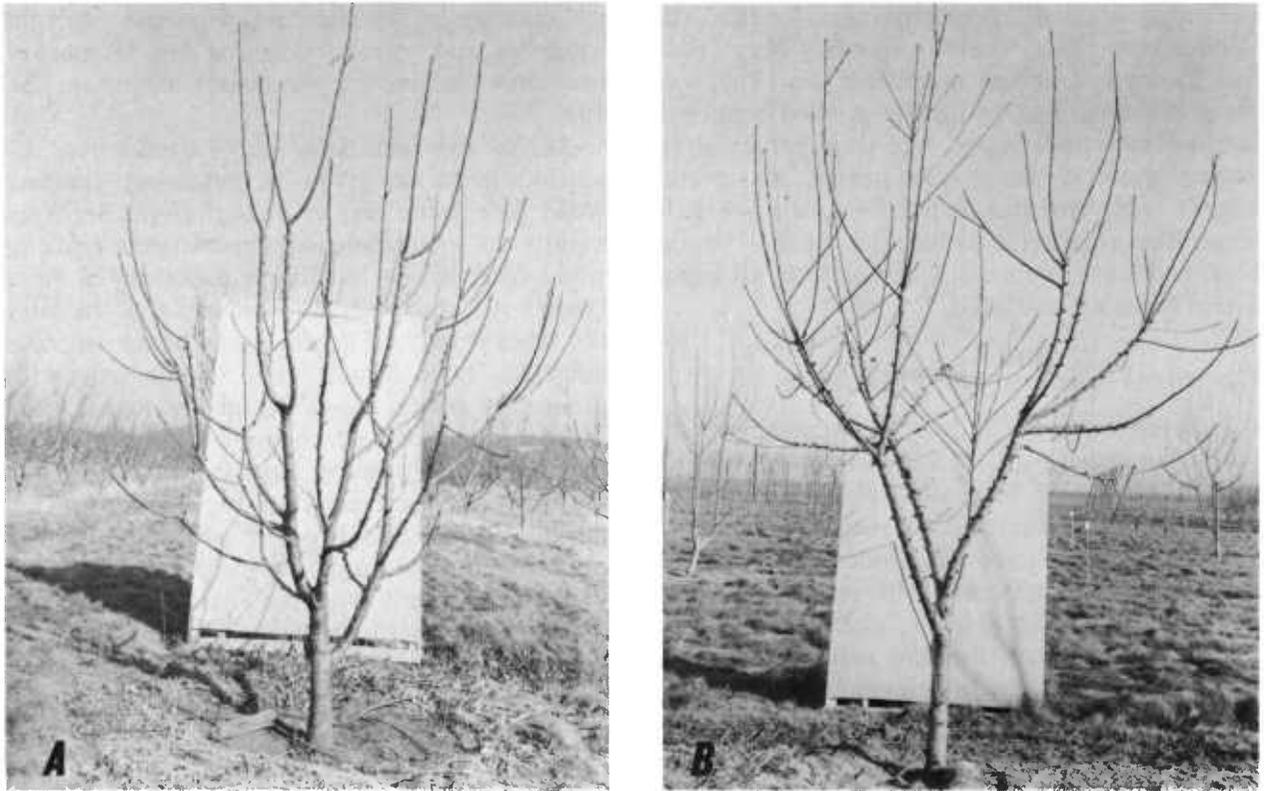
### THINNING FRUIT

Little information is available concerning methods of thinning cherry fruits. A higher percentage of the blossoms can be permitted to set fruit than in other *Prunus* species. However, some thinning to increase individual fruit size can give returns far outweighing the possible loss in total tonnage. Considerable care is necessary to prevent thinning beyond the point that will give appreciable fruit size increases (fig. 21).

Hand thinning methods, although effective, are usually too time-consuming to be economical. Some detailed pruning in mature trees will help reduce the number of fruit buds and thereby reduce the eventual fruit set. Restricting the number of pollinizer trees in orchards of productive cultivars will reduce set. Likewise restricting the time hives of honeybees are left in the orchard to a minimum of favorable pollinating weather will reduce set, providing native bees and other pollinating insects are not numerous. The latter practice would not be advisable on cultivars such as 'Schmidt', which has shy-bearing tendencies.

<sup>13</sup> Applied as Alar 85, manufactured by Uniroyal Chem., Fresno, Calif.

<sup>14</sup> Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.



PN-3060 PN-3061

FIGURE 14.—*A*, A 5-year-old tree headed and thinned each year from time of planting; *B*, one developed by spreading with very little pruning.

Sweet cherries have been thinned experimentally with chemical sprays. However, results have been variable, and no compound is registered for this use.

Selective pruning of the dormant tree accomplishes a large part of the thinning operation and at present is the only practical method.

## PROTECTION AGAINST BIRDS

Annual destruction of sweet-cherry fruit by birds is substantial. In large plantings, the damage may not be noticeable in individual trees. In small plantings or in backyard trees, a high percentage of the fruit may be destroyed or damaged by birds. Provisions for protection against bird damage should be considered, even though not adopted as a standard management practice.

In areas where large flocks of starlings occur, this bird may destroy large quantities of cherries. Blackbirds, while often numerous in cherry orchards, usually are not so destructive

of fruits as are robins, several of the finches, sparrows, crows, ravens, and magpies. Near large bodies of water, sea gulls may be very destructive.

Several methods have been devised for protection of ripening fruits from bird damage. Most of these have limited and temporary value or are almost prohibitive in cost. Control can be obtained by screening the trees with various types of netting, including used fish nets. Very recently, nylon and other plastic screens with  $\frac{1}{2}$ -inch and larger meshes have become available. An individual tree may be protected

by a cloth thrown over the tree or supported on a frame. Blocks of trees are protected in some foreign regions by nets supported on pole frames similar to those used to support hops.

Several less effective but less expensive devices may give temporary protection against bird damage or reduce the damage. Various carbide, acetylene, or liquid propane gas cannons, which can be regulated by the rate that water is dripped into the carbide or that gas is released into the chamber, are available. These give control for a few days, until birds become accustomed to the regularity of the explosions. Strings of firecrackers spaced on a continuous rope fuse to fire at irregular intervals can be exploded in the trees. Metallic or paper streamers, such as those used by service stations; strings of whirling devices; or strings of objects that will produce noises in the wind may give limited protection. Any noise-making or distracting device will give some temporary protection. Recordings of distress calls sometimes are effective in repelling starlings.

Repellent sprays have not appeared feasible because of undesirable residues and residue-tolerance restrictions.

Reduction of the population of noxious birds in the orchard by trapping has been appreciable in western orchards. Plans for a starling trap have been developed by Fish and Wildlife Service personnel for use near Pacific Northwest orchards and cattle feedlots (38).

Consult your agricultural extension agent for local recommendations.



PN-3062

FIGURE 15.—Wide-angled, well-spaced branches from heading leaders (at arrows).

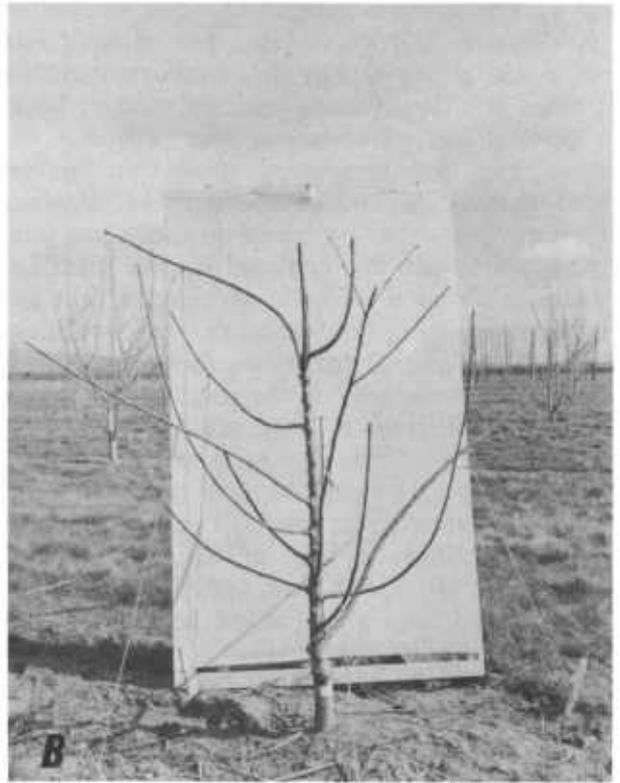
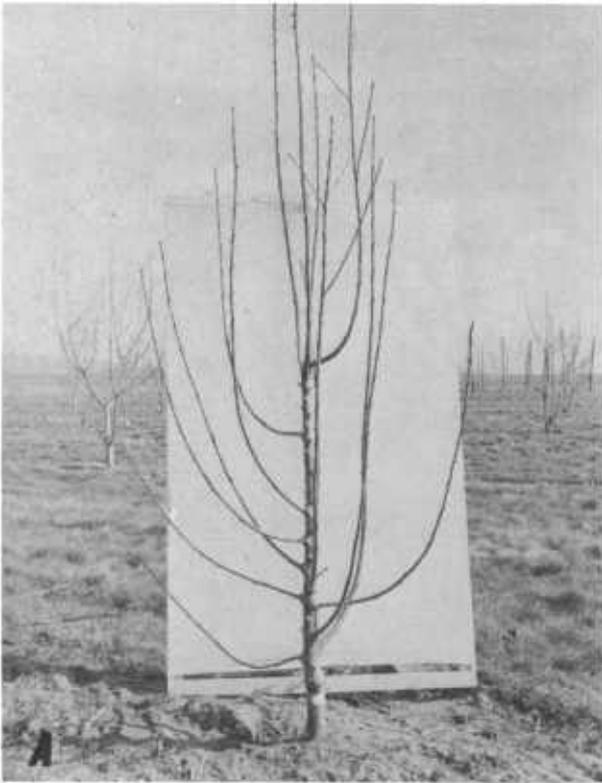
## INSECTS AND MITES<sup>15</sup>

Sweet cherries may be attacked by a variety of insects and mites, the most important of which are the cherry fruit flies, *Rhagoletis cingulata cingulata* (Loew), *R. cingulata indifferens* Curran, and *R. fausta* (Osten Sacken); the black cherry aphid, *Myzus cerasi* (Fabricius); the pear slug, *Caliroa cerasi* (L.); the San Jose scale, *Aspidiotus perniciosus* Comstock; the plum curculio, *Conotrachelus nenuphar* (Herbst); the European red mite, *Panonychus ulmi* (Koch); the mcdanieli

mite, *Tetranychus mcdanieli* McGregor; the two-spotted spider mite, *T. urticae* (Koch); the plum nursery mite, *Aculus fockeui* (Nalepa); certain lepidopterous larvae, as the pandemis moth, *Pandemis albaniana* Walker, fruit tree leaf roller, *Archips argyrospilus* (Walker), and mineola moth, *Mineola acitulella* Hulst; and the shot-hole borer, *Scolytus rugulosus* (Ratzeburg).

Insecticides are commonly depended on to prevent insect and mite damage to cherries. Recommendations for the control of these pests in the home orchard are given in Home and Garden Bulletin 190, entitled "Insects on Decid-

<sup>15</sup> This section was prepared by Howard Baker, formerly assistant chief, Entomology Research Division, Agricultural Research Service, Beltsville, Md. Retired.



PN-3063 PN-3064

FIGURE 16.—A combination of heading and tying down branches to maintain wide-angled branches in a vigorous 2-year-old tree: *A*, Before pruning; *B*, after pruning.

uous Fruits and Tree Nuts in the Home Orchard." Copies may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Similar information is published by the experiment stations or extension services of the various important cherry-producing States.

## CHERRY FRUIT FLIES

In the northern and northwestern States, sweet cherries are sometimes infested by the larvae or maggots of fruit flies. Two native species are involved; the cherry fruit fly, *R. cingulata* subspecies *cingulata* in the East and subspecies *indifferens* in the West (6, 47), and the black cherry fruit fly, *R. fausta*, which occurs in both areas. Adults of *cingulata* strains are about two-thirds the size of the house fly, and those of *fausta* are slightly larger. These

species have yellowish heads and legs but are distinguished by conspicuous bands across the wings (fig. 22) and differences in the coloration of their abdomens; the abdomen of *cingulata* is marked by a series of distinct white crossbands, and that of *fausta* is entirely black. These species commonly occur together, *fausta* appearing about a week in advance of *cingulata* strains and usually in smaller numbers. Otherwise, they have similar seasonal histories and habits.

Injury is caused by the larvae, which tunnel through the cherry to the pit and destroy the flesh. Infested fruit appears normal until the larvae are almost fully grown, when sunken spots appear on the cherries. Later, affected fruit may shrivel on one side, the flesh may decay, and small emergence holes may appear in the skin. Injury is generally greater in late- than early-season cultivars and still greater in



PN-3065

FIGURE 17.—A 5-year-old tree in which spreading by tying to ground stakes has been substituted for all but correctional pruning. Note the abundance of fruiting wood.

late-maturing fruits left on the trees after fruit-fly sprays are discontinued. Cherries grown for processing must be maintained free of fruit-fly infestation; any degree of infestation may result in condemnation of the entire crop by processors.

The cherry fruit flies overwinter as pupae at a depth of 1 to 3 inches in the soil. Adults begin to emerge late in May or early in June and continue to emerge for 3 to 5 or 6 weeks, depending on the area and season. After a pre-oviposition period of from 7 to 12 days, the flies deposit eggs singly in slits just through the skin of preferably ripening cherries. The eggs hatch in 5 to 8 days. In Washington State (47), an oviposition period of 36 days at 90° F. and longer periods at lower temperatures was reported. During that time females deposited on the average of 386 eggs each at 90°, 99 at 65°, and 17 at 60°. Frick also found the flies to be very sensitive to extremes of

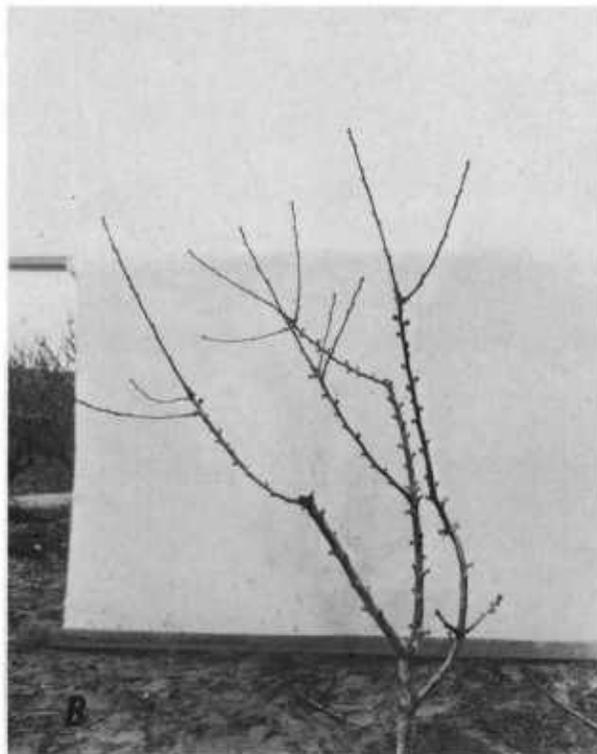
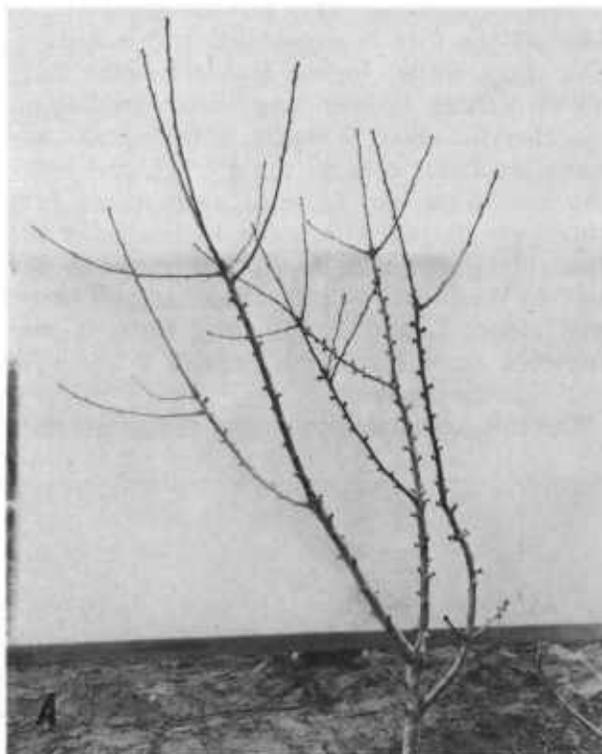
temperature; at 55° they laid no eggs, and at 100° all the flies in cages died within 5 days. The dirty white, legless larvae become fully grown (about ¼-inch long) after feeding in the cherries about 2 weeks, after which they leave the fruit, drop to the ground, and enter the soil to pupate. In most areas there is a single generation, with about 10 months of the year being spent in the pupal stage in the soil. In Washington (47), a small second brood was reported, and in Montana (37), it was reported some specimens require 2 years to complete the life cycle.

Control consists of poisoning the adults dur-



PN-3066

FIGURE 18.—Typical girdled leader (left) and ungirdled one (right) of a sweet-cherry seedling. Numerous fruits were induced on the girdled leader of this 4-year-old seedling girdled the previous May. A few fruits also were produced on the ungirdled limb (right). Ungirdled seedlings of this age rarely produce fruit.



PN-3067 PN-3068

FIGURE 19.—A semihorizontal young bearing cherry branch: *A*, Before pruning and *B*, after pruning. Note the vigorous terminal growth (about 10 inches) and the 2-year-old wood, which has numerous fruit spurs. Some of the heavy 2-year-old wood is removed to encourage development of new wood and to thin fruit buds.

ing the 7- to 12-day interval between emergence and egg-laying, with two to four spray applications at intervals from the time the first adults are reported to the beginning of harvest.

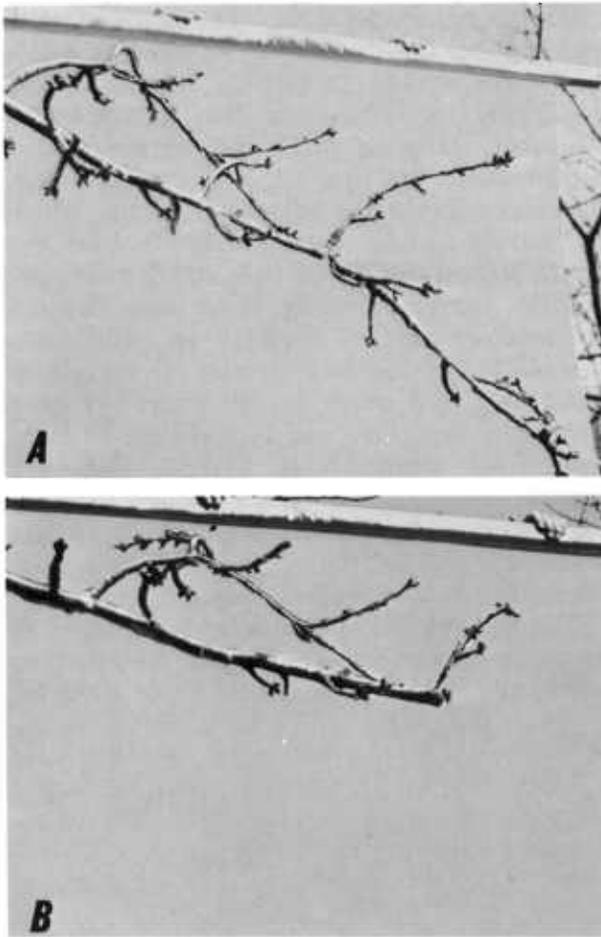
Information on adult emergence can usually be obtained from County extension agents; if not, it can be obtained by seeding the ground with wormy cherries in the summer and placing a cage over the seeded area the following spring or by suspending one or two simple traps on cherry-tree limbs 6 to 8 feet above ground just before the time early cultivars of cherries begin to show color. A simple, effective trap consists of a  $\frac{1}{8}$ -inch tempered composition or plywood board, 6 x 8 inches, painted with yellow enamel, coated with a sticky adhesive that retains its tackiness, and suspended over a small jar about half filled with lumps of ammonium carbonate. Examine the traps at 3-day intervals, and replenish the bait as needed.

The presence of cherry fruit flies can be determined by comparing the wing markings of flies emerging in the cages or captured on the sticky boards (fig. 23) with those in fig. 22.

### BLACK CHERRY APHID

The black cherry aphid is the fairly large black, shiny aphid that curls the tender foliage of sweet-cherry trees (fig. 24) in the spring and early summer throughout the cherry-growing areas of the United States, often severely checking the growth. Infested trees and fruit are often covered with a sticky honeydew in which a sooty mold may develop.

This aphid passes the winter in the egg stage, the eggs being placed among or near buds and in crevices, leaf scars, and other places offering protection on twigs and small branches. Hatching of eggs usually begins about the time



PN-3069 PN-3070

FIGURE 20.—A mature bearing limb: *A*, Before pruning and *B*, after pruning. Terminal growth ranges from none to several inches. Pruning consisted of heading fairly large wood and thinning out some spurs.

sprays fail to give adequate control, the trees should be sprayed again in the spring and summer when the aphids appear. For best results, applications should be made before many leaves are curled.

## MITES

Mites are tiny, eight-legged sucking pests, closely related to insects (fig. 25). They cause major damage to the foliage of sweet-cherry and other orchard trees throughout the United States. Four species occur most commonly on

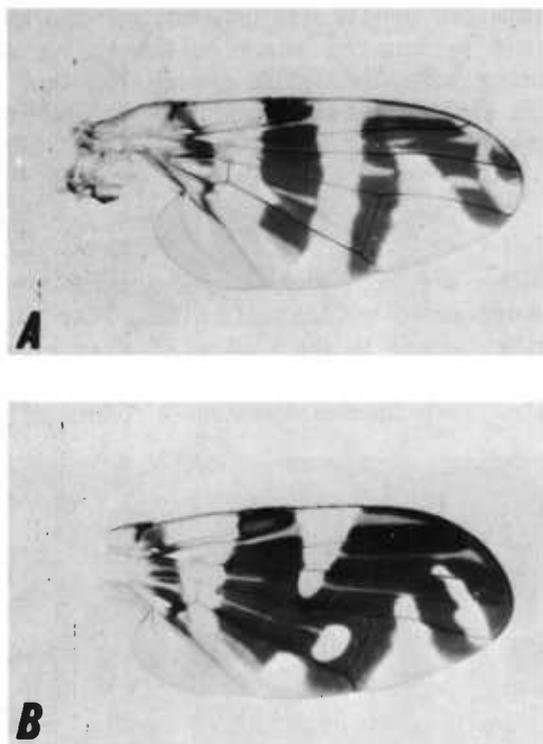


PN-3071 PN-3072

FIGURE 21.—*A*, A branch with excessive fruit set in some places. Such heavily loaded branches are difficult to pick and may reduce fruit set the following year. *B*, A branch on which the load is well distributed. The stems are exposed for easy picking, but the fruit load is adequate.

cherry buds swell and is generally complete by the time the buds open. The young aphids promptly migrate to the buds to feed, where they become adult females in about a month and then produce living young. Several generations follow until, in midsummer, winged forms are produced that leave the cherry trees for alternate hosts not completely known. A later generation returns to the cherry trees in the fall and produces a wingless generation that lays the overwintering eggs.

Control is most effective when the trees are sprayed while they are completely dormant to destroy the overwintering eggs. If the early



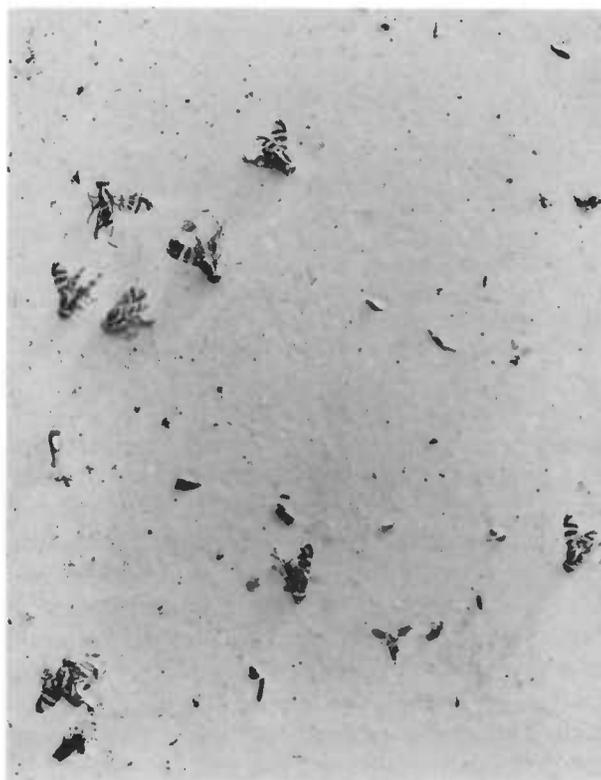
PN-3073 PN-3074

FIGURE 22.—Wing patterns of cherry fruit flies. *A*, Cherry fruit fly; *B*, black cherry fruit fly.

sweet cherries—the European red mite and two-spotted spider mite throughout the sweet-cherry growing areas of the United States, the plum nursery mite (92) throughout northern cherry-growing areas, and the mcdaniel mite (78, 80) in the Pacific Northwest. The nymphs and adults suck out the contents of the leaf cells, including the chlorophyll, causing the leaves to become bronzed or brown and dry. The plum nursery mite cuts up the leaves and causes them to have a dry or russeted appearance. When injury is extensive, many of the leaves drop prematurely, and the size and quality of the fruit may be reduced. On sweet-cherries, except with the plum nursery mite, serious injury does not usually occur until after harvest and occurs less commonly than on most other deciduous tree fruits. With the plum nursery mite, injury most commonly occurs just before or during harvest, depending on the weather.

The European red mite overwinters as small red eggs on the twigs and branches of deciduous tree fruits, principally around rough areas on the twigs on the underside of branches. Hatching of the overwintering eggs begins about the time apple buds show pink. The tiny nymphs and subsequent adults, which are barely visible without magnification, are characterized by their red color and stiff, whitish, curved spines on their backs. During the summer most of the eggs are laid on the leaves. This mite may develop from egg to adult in 2 to 3 weeks or less under the most favorable conditions and in a month or more when cool temperatures prevail. Hot, dry weather accelerates development and favors a rapid increase to outbreak numbers. There may be from 4 or 5 to 10 or 12 generations a year, depending on the area and season.

The two-spotted spider mite overwinters as an adult orange-colored female, protected by leaves and trash on the ground or, to a limited



PN-3075

FIGURE 23.—Cherry fruit flies on sticky board trap.

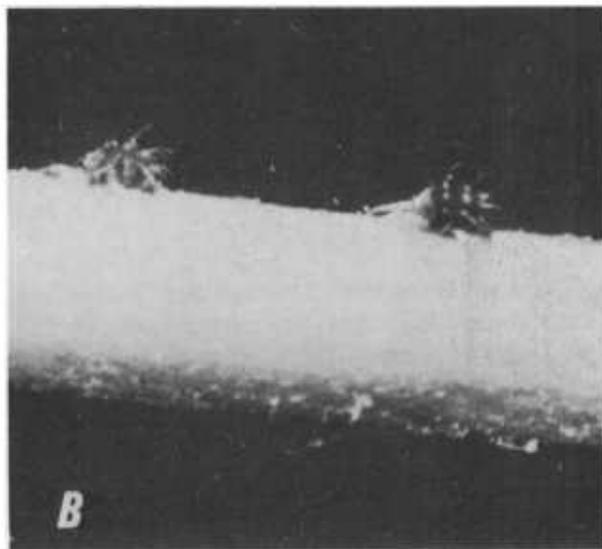
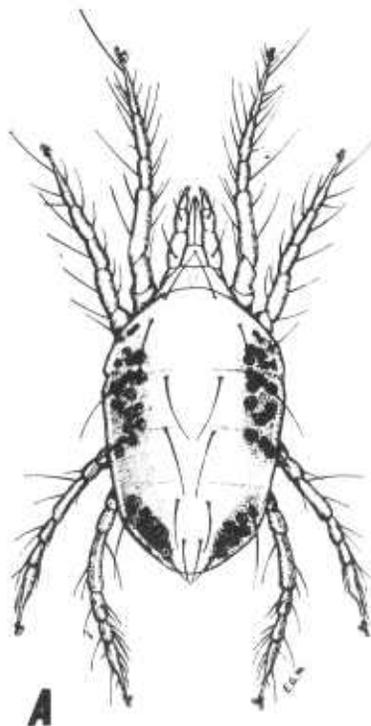


PN-3076 PN-3097

FIGURE 24.—Cherry foliage injured by the black cherry aphid: *A*, Before leaves are curled; *B*, after leaves are curled.

extent, under bark scales on the trees. The overwintering females become active with the advent of warm weather in the spring and begin feeding on the foliage in the lower, interior portion of the trees and on weeds and grasses in the orchard. When the orchard ground cover becomes unsuitable as food, the mites migrate to the trees. As the season advances or infestation increases, the mites spread upward and outward over the entire tree if permitted to develop unhindered. The mites are usually greenish or yellowish when feeding, often with two dark spots showing through the body. The eggs, which are nearly colorless, are laid on the underside of the leaves, especially along the veins and midrib. The mites develop from egg to adult in a week to

ten days under the most favorable conditions, but may require as long as a month or more, depending on the season. There are several generations each year. Toward the end of summer, when the mites become crowded or cool temperatures occur, many of the adults cease



PN-3078 PN-3079

FIGURE 25.—*A*, Two-spotted spider mite; *B*, European red mite.

feeding, and the females become reddish to orange and migrate to their hibernation quarters.

The mcdaniel mite is similar to the two-spotted spider mite in general appearance, habits, and seasonal history.

The plum nursery mite overwinters in clusters as an adult female, chiefly in cavities of dead or shrunken buds and to some extent in crevices in twigs and bark. This mite emerges from its overwintering quarters when buds are expanding and soon scatters over the new foliage, primarily to the underside of the leaves. Injury is characterized by curling and dwarfing of foliage and by a brown or bronze, scurfy condition of the lower epidermis. The adult mites are minute vermiform creatures, which are pale to brownish yellow. They are invisible on the foliage, the larvae being whitish and somewhat translucent. A generation may be completed in 6 days in warm weather, and there may be as many as 15 generations each season. In most seasons the population reaches its maximum during July, but activity may continue until low temperatures prevail, as long as succulent foliage remains (92).

Since mites are less likely to reach outbreak proportions on cherries than on most other deciduous tree fruits, a suppressive-type spray program after harvest is usually adequate, but it is sometimes necessary to apply control measures before harvest. When mites appear on the leaves, two applications, 7 to 10 days apart, of an effective miticide are usually adequate for control.

## PEAR SLUG

The appearance of skeletonized leaves on cherry trees indicates the occurrence of the pear slug (80), often referred to as the cherry slug when it occurs on cherries. Damage is due to the feeding of the slimy appearing, sluglike, olive-green to almost black larvae that skeletonize the leaves by eating the upper surface (fig. 26). The full-grown larvae are about one-half inch long. When abundant they may cause sufficient injury to, and loss of, foliage to interfere with the growth of the fruit and development of fruit buds. This insect,

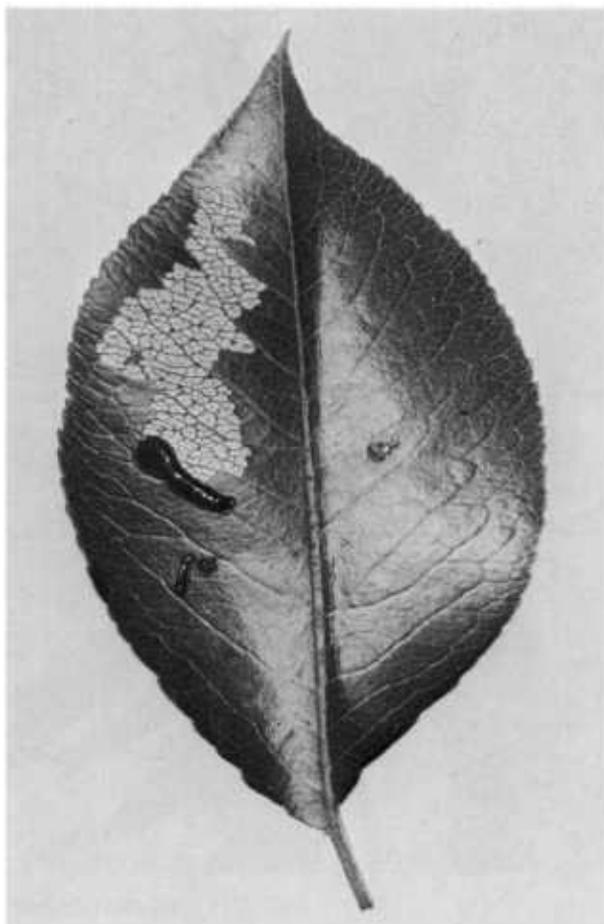


FIGURE 26.—Pear slug and its injury.

PN-3080

originally from Europe, occurs throughout the cherry-growing areas of the United States.

This insect overwinters in the pupal stage at a depth of 2 or 3 inches in the soil. Adults appear late in the spring, in May or in June, according to locality and seasonal conditions. They are 4-winged black and yellow sawflies, a little larger than the house fly. The female sawflies cut slits in the upper surface of the leaves, in which the eggs are laid. The eggs hatch in one or two weeks, after which the young slugs feed almost exclusively on the upper surface of the leaves. Two to three weeks are required for them to become full-grown, after which they drop to the ground and form cells in the soil. Within these they pupate and transform to adults in about two weeks. A second brood of slugs appears in

the trees in August. These slugs, when fully grown, drop to the ground and enter the soil to form a cocoon in which they pupate and pass the winter.

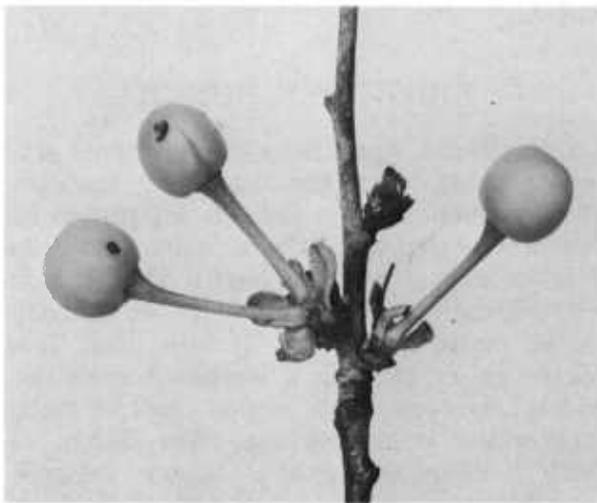
The pear slug is easily controlled by spraying the trees when the young slugs are first observed on the foliage.

## PLUM CURCULIO

The appearance of crescent-shaped scars (fig. 27) on the fruit soon after it sets and for 2 to 3 weeks thereafter indicates attack by the plum curculio. Damage is due to the feeding and egg-laying punctures of the adult curculios in the cherries and to the destruction of the flesh of the cherries by the feeding of the developing larvae. Damaged fruit is scarred, misshapen, and worthless. This native insect attacks cherries in all areas in which they are grown east of the Rocky Mountains. It is also an important pest of apples, peaches, and cultivated and wild plums. Unlike most other host fruits, the injured cherry does not drop, but may hang and mature. Thus, larvae may be present in harvested fruit, constituting a serious problem for the fresh-fruit and processing market.

This curculio overwinters as an adult in protected places, such as afforded by leaves

and trash in and around the orchards. The adults are about  $\frac{1}{4}$  inch long, hump-backed, brownish snout beetles mottled with gray (fig. 28). They become active in the spring shortly after peach trees begin to bloom or a little later. They feed on the leaves and blooms until fruit is present. Feeding and egg-laying in the fruit begins soon after the fruit sets and starts to grow. The eggs are laid in crescent-shaped cuts. Under laboratory conditions each female may lay an average of several hundred eggs, but under natural conditions the number is much less, at times less than 100. Eggs hatch in about a week, and the yellowish-white, legless grubs feed in the flesh of the fruit for about 2 weeks or slightly longer. The full-grown grubs (fig. 29), which range from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch in length, leave the fruit and enter the soil to a depth of 1 to 3 inches. There, they pupate and develop into adult beetles in 3 to 4 weeks. In a few days the adults leave the soil and may feed on available hosts until they hibernate in the fall. There is but one generation a year in the important sweet-cherry growing areas, but



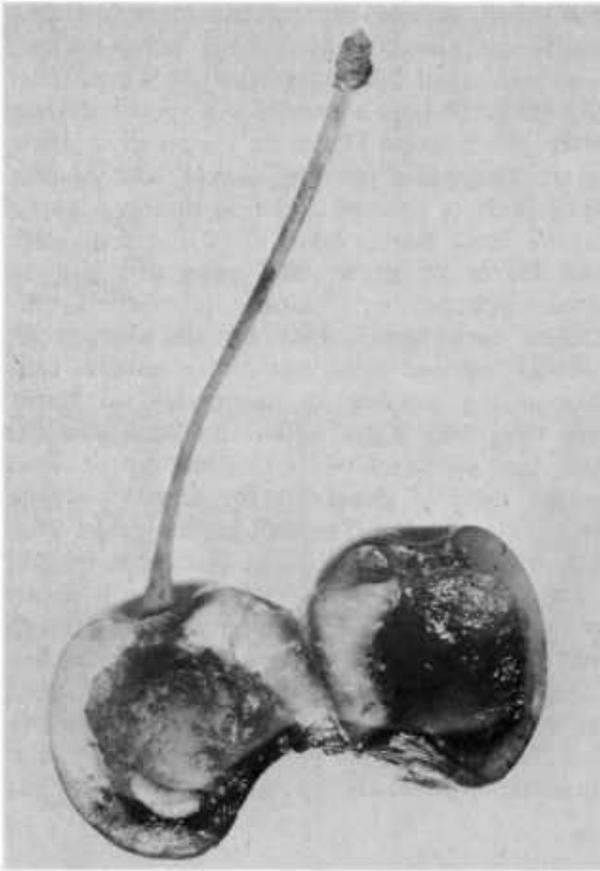
PN-3081

FIGURE 27.—Curculio egg and feeding punctures in the cherry.



PN-3082

FIGURE 28.—Plum curculio adult on peach.



PN-3083

FIGURE 29.—Plum curculio larva in cherry.

in a zone in the latitude of Delaware to Virginia there may be a partial second generation, and farther south there may be two generations.

Control can be obtained by spraying the trees two or three times at 8- to 10-day intervals, beginning at petal fall or shuck split, with an effective insecticide.

### SAN JOSE SCALE

The occurrence of roughened bark with a grayish appearance and weakened and dead twigs and limbs and small reddish spots often occurring at points of attack indicate the presence of the San Jose scale (fig. 30). This introduced insect now occurs throughout the United States. Injury is due to the sucking

of the juices from the twigs and branches, which gradually weakens the affected parts. If left undisturbed, this insect may cause the death of the infested trees with its feeding.

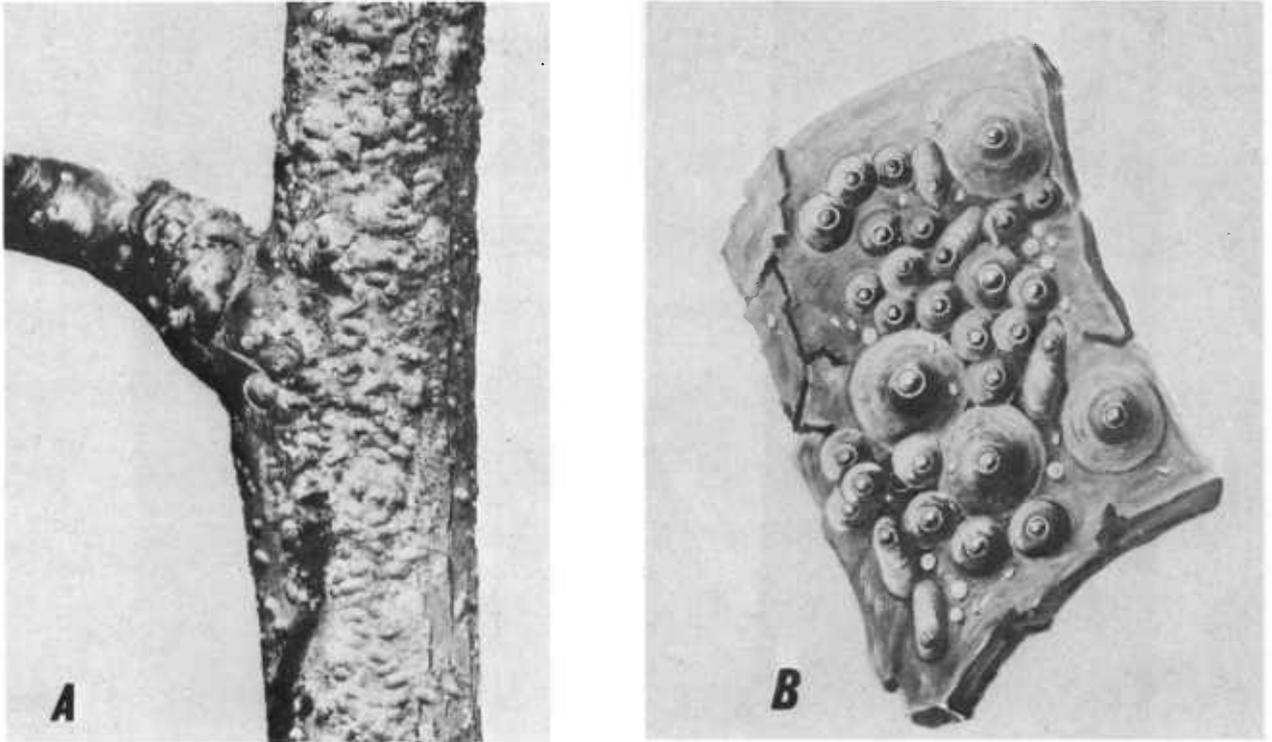
The insect overwinters most successfully as a half-grown nymph beneath a protective scale covering, although all stages are present in the fall. Growth is resumed shortly before bloom. In sweet-cherry growing areas, the scale becomes full-grown and starts giving birth to living young in June. The covering of the full-grown female is nearly circular, about the size of a pinhead and grayish, with a darker central nipple-like projection; that of the male is somewhat smaller and elongated, with the nipple at one end.

Underneath, the scales covering the mature females are yellow. Each female produces 200 to 300 young or crawlers, which move about for a short time. Then they settle on the bark, leaves, or fruit and secrete a covering, beneath which the insect remains the rest of its life. The covering is enlarged as the insect develops. There are commonly two to six annual generations, depending on the length of the growing season.

Scale insects usually are best controlled by spraying infested trees during the dormant or delayed dormant periods. If necessary, they can also be controlled by sprays applied later in the growing season when the crawlers are active.

### SHOT-HOLE BORER

Conspicuous, small holes in a scattered pattern (fig. 31) over the trunk and branches of a sweet-cherry tree indicate infestation by one of the shot-hole borers, most commonly *Scolytus rugulosus* (Ratzeburg). The adult is a small, dark-brown or black beetle, cylindrical in shape, and about  $\frac{1}{10}$  inch long. This borer prefers trees in a weakened condition, which may occur from neglect, lack of moisture, winter injury, disease, other insects, or from mechanical damage. Injury to such trees is caused by the larvae and adults feeding in the sapwood, forming centipedelike figures in the wood. When the insect is abundant, it may attack healthy trees, boring into the



PN-3084 PN-3085

FIGURE 30.—San Jose scale: *A*, Bark encrusted with scale; *B*, scales magnified.

twigs just beneath or into the base of a bud or fruit spur that is weakened or killed.

The beetles first appear from April to June, according to the latitude. The female gnaws a hole about  $\frac{1}{20}$  inch in diameter through the bark and a slightly larger burrow in the sapwood about parallel with the grain of the wood, mining out small niches into which the eggs are deposited. The eggs hatch within a few days into small footless larvae that burrow and feed in the sapwood for 30 to 36 days. Soon thereafter, they become adult beetles and gnaw their way out through the bark. A few days after the adult females emerge, they begin depositing eggs for a second brood of larvae, which will feed in the trees during the latter part of the season. In the more northern area of infestation, the second-brood larvae spend the winter in the trees, becoming adult early the following spring. Farther south, the larvae become

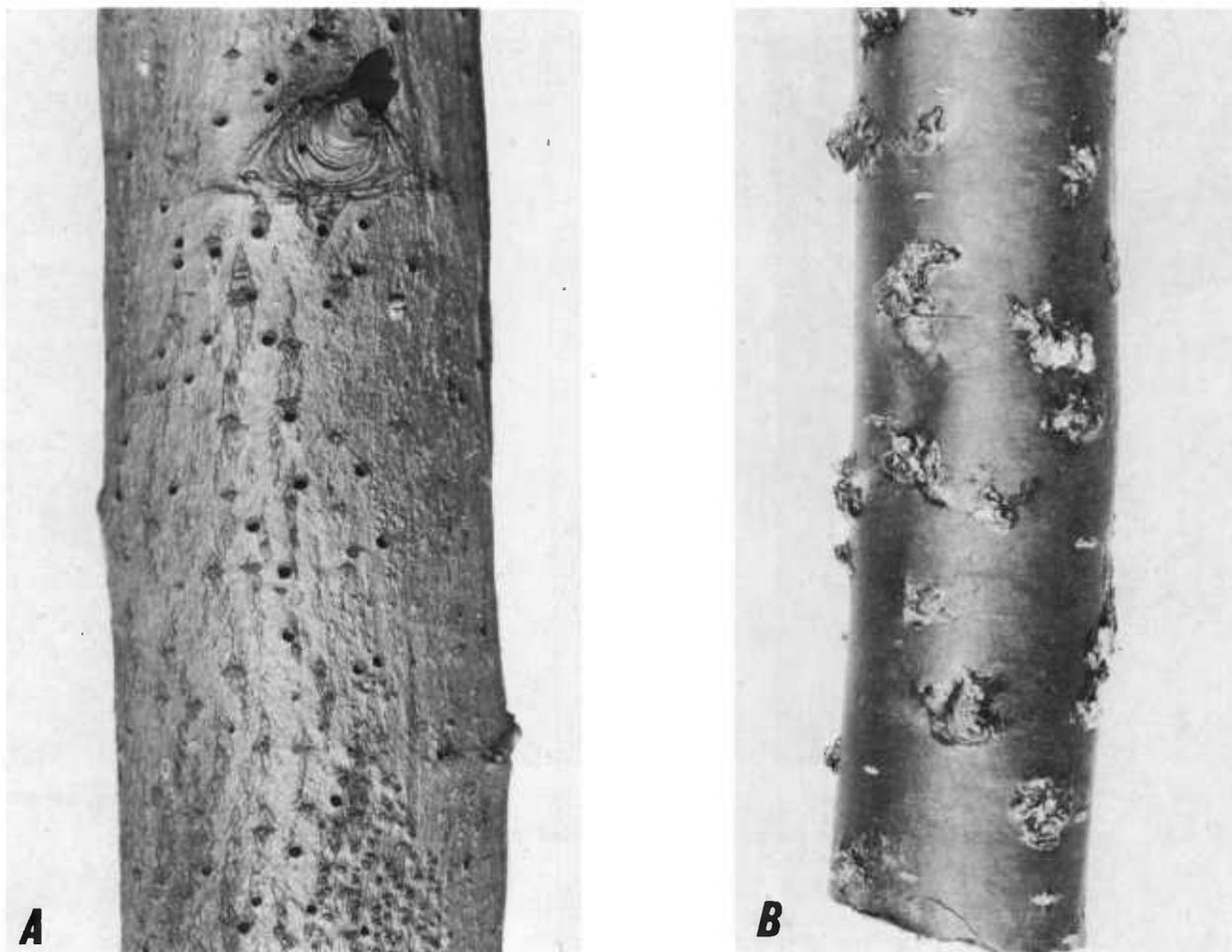
adults before winter and deposit eggs, which hatch to provide a third brood of larvae.

To discourage attacks of this insect, maintain trees in a healthy vigorous condition and destroy weak and dying trees. Remove infested branches and broken or weak ones that might become infested, and destroy them promptly. An insecticide spray applied when adults are active sometimes will prevent damage. Whitewash trunks to prevent sunburn, especially high-headed trees.

## LEPIDOPTEROUS LARVAE

Damage to the buds and foliage of cherries early in the growing season, particularly in the Pacific Northwest, is generally caused by one or more species of lepidopterous larvae, such as the fruit tree leaf roller, pandemis moth, and *Mineola* moth (80).

The fruit tree roller overwinters in the egg



PN-3086 PN-3087

FIGURE 31.—Shot-hole borer: *A*, Exit holes in apple branch; *B*, gum exuding from points of injury on cherry.

stage (fig. 32) in masses of 100 or more eggs on the limbs, twigs, and trunks of trees of most deciduous tree fruits, including cherry. The eggs hatch about the time the buds begin to open. The small green caterpillars with black heads feed on the unfolding leaves, webbing them together. They eat large irregular holes in both fruit (fig. 33) and foliage until they become full grown in June. They then pupate in the rolled-up leaves and emerge as moths 10 to 12 days later (fig. 34). These moths lay the overwintering eggs in June and July.

The pandemis moth overwinters as a small light yellow-green larva in trash or in a web

constructed on a tree trunk at the surface of the ground. These larvae crawl up the trees in the spring as soon as leaves are out, and feed on the foliage. They become full grown in May and spin loose cocoons in the leaves. Moths appear late in May or in June and deposit eggs in clusters of 90 to 150 on the upper surface of the leaves (fig. 35). These hatch in about 2 weeks. The small larvae feed on the tender foliage at the tips of branches or along the midrib of leaves. Later they feed on fruit, on cherries most commonly about the stem end. The second brood matures in July or August, and the moths are active in August and September. The young larvae from

their eggs feed on the foliage until cold weather forces them into hibernation.

The Mineola moth overwinters as partly-grown brown larvae in hibernacula placed in the smaller crotches or in crevices in the bark on the trees. They leave the hibernacula in the spring and bore into the buds, destroying many blossoms. They become full grown in 2 to 4 weeks, then they drop to the ground and form cocoons, within which they pupate. The moths emerge from these cocoons in July and lay eggs singly on the lower surface of the leaves. The pinkish larvae hatching from these eggs burrow into the fruit and, if abundant, may cause considerable damage. This brood of worms becomes full grown late in July or early in August and produces a second brood of moths. Larvae hatching from eggs laid by these moths feed on maturing fruit or foliage, then spin silken cocoons in which they hibernate.

These species and the eye-spotted bud moth (*Spilonota ocellana* (Denis and Schiffermuller)), which also attacks the opening buds, can be controlled by spraying or dusting with

an insecticide just before the buds open. If the pandemis moth is present, a second application should be made at petal fall.



PN-3088

FIGURE 32.—Egg mass of fruit tree leaf roller.

## FUNGAL AND BACTERIAL DISEASES<sup>16</sup>

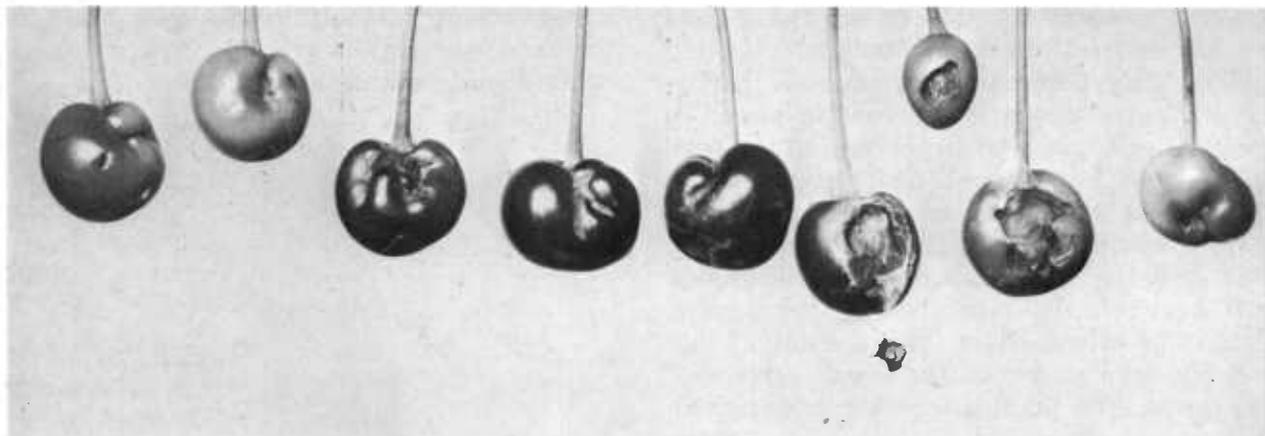
Fungus-, bacterium-, and virus-incited diseases cause the loss of approximately one-quarter of the potential cherry crop; estimates on the sweet-cherry portion are not available. Bacterial diseases and fungus-caused root and trunk rots may kill trees and thereby remove part of the orchard from production until new trees are bearing. Some organisms kill buds and blossoms before fruits are initiated, and others attack the developing fruits or indirectly reduce the yield by impairing the leaf surface that supplies nutrients to the fruit (2). Even after the crop is mature and harvested, diseases originating in the orchard continues to take their toll of the harvested fruit.<sup>16a</sup> The costs, in time, effort, and money,

<sup>16</sup> This section was prepared by H. R. Cameron, Oregon State University, Corvallis, Oreg. Assistance on the brown rot disease by J. Ogawa, University of California, Davis, is gratefully acknowledged.

of controlling or living with diseases must be considered in determining the feasibility of establishing new orchards.

Sweet cherries are damaged by several fungus diseases, most important of which are: Brown rot, *Monilinia laxa* (Aderh. and Ruhl) Honey or *M. fructicola* (Wint.) Honey; armillaria root rot, *Armillaria mellea* (Vahl ex Fr.) Kummer; verticillium wilt, *Verticillium albo-atrum* Reinke and Berth.; collar rot, *Phytophthora cactorum* (Lebert and Cohn) Schroet., or *P. syringae* (Kleb.) Kleb. and *Poria ambigua* Bres.; cherry leaf spot, *Coccomyces hiemalis* Higgins; coryneum blight,

<sup>16a</sup> These diseases are described and some are illustrated in color in U.S. Dept. Agr. Handb. No. 414, "Market Diseases of Stone Fruits: Cherries . . ." issued December 1972. Copies available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 65 cents.



PN-3089

FIGURE 33.—Cherries injured by feeding of fruit tree leaf roller.

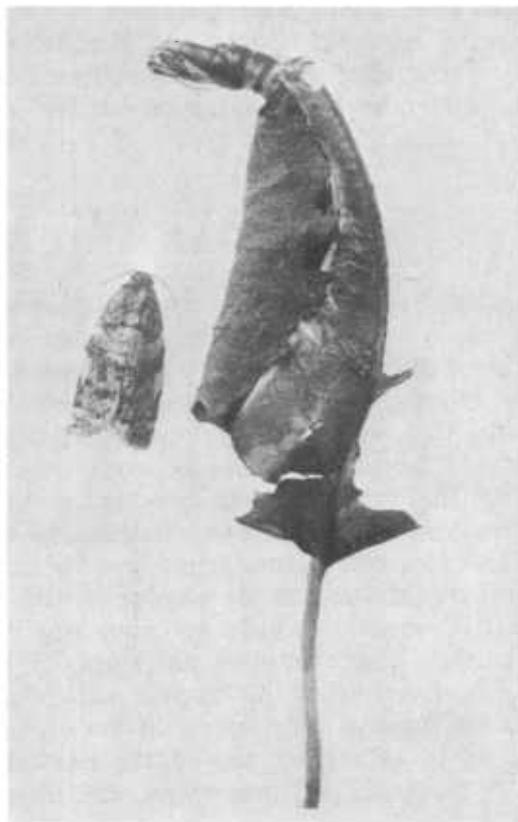
*Coryneum beyerinckii* Oud.; black knot, *Diobotryon morbosum* (Schw.) Theiss. and Snyder; witch's broom (cherry leaf curl) *Taphrina cerasi* (Fckl.) Sadeb.; powdery mildew, *Podosphaera oxycanthae* [DC.] deBary; perennial canker, usually caused by *Valsa leucostoma* [Pers.] Fr.

## BROWN ROT

Brown rot is the major fungus disease, because it can severely damage blossoms, shoots, leaves, and fruit (145). In areas where spring rainfall is high, blossom infection is the most serious. It occurs early in the season, and subsequent infection of other parts of the tree result from conidia (asexual spores) that develop on, and are disseminated from, infected blossoms. In areas that receive summer rains or use sprinkler irrigation, fruit infection may be more serious than blossom infection (85).

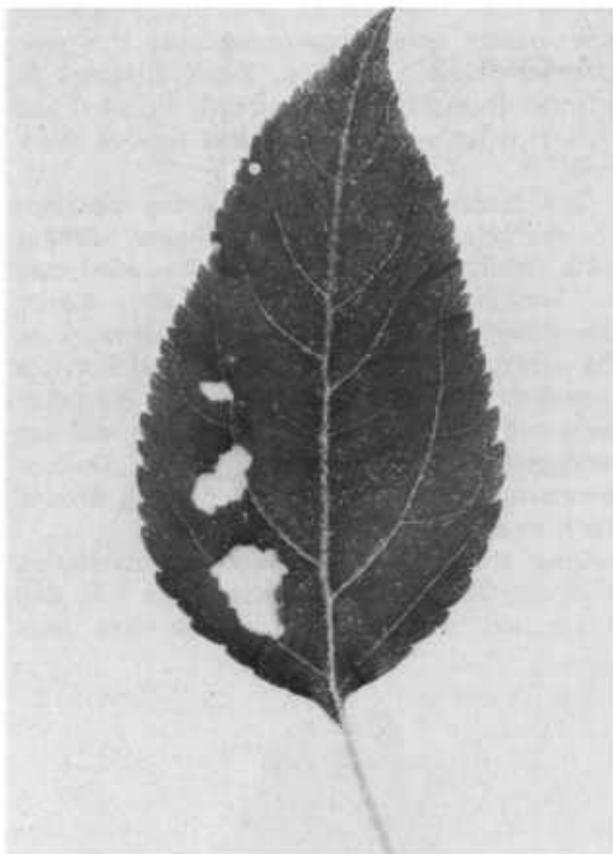
Cherry blossoms may be infected at any time from bud swelling to petal fall, but are most susceptible after full bloom. The amount of infection depends on the temperature, moisture, and amount of inoculum present. About 6 days after infection, single-celled spores (conidia) develop on the affected blossoms and are released in large numbers. These infect other blossoms, and in wet climates, young leaves and green fruit. Since spores are continually released from infected

parts of the tree throughout the growing season, new infections may be initiated whenever conditions for infection are favorable.



PN-3090

FIGURE 34.—Adult of fruit tree leaf roller, and pupal skin protruding from leaf cocoon.



PN-3091

FIGURE 35.—Egg mass of pandemis moth.

The brown-rot fungus can penetrate fruit directly, but more frequently it enters through wounds or cracks. Mature fruit of most sweet-cherry cultivars cracks when wet, providing an ideal infection point for the spore from infected blossoms and twigs. Once infection is established and the amount of inoculum builds up rapidly, control may become very difficult.

Infected fruits that remain on the tree shrink and dry into structures known as "mummies." In the spring mummies on the ground may produce apothecia (cup-shaped fruiting bodies) in which sexual spores are formed and shot into the air. Apothecia are rarely seen in the orchard and are not an important source of spores that infect blossoms. The mummies that remain on the tree, and the cankers that develop on infected

shoots produce abundant conidia, which infect the blossoms during the following spring.

Blossom symptoms start as water-soaked areas on the white petals (fig. 36). These areas turn light brown and are sometimes mistaken for normal senescence, or freeze damage. In moist weather the infected areas soon become covered with gray or tan pustules of spores, which infect other blossoms. The fungus may grow from infected blossoms into the attached shoot or leaves. Infections on shoots eventually form cankers, which may girdle and kill the entire shoot. Infections on leaves most frequently are associated with damage from hail or wind, or with direct contact with other diseased tissue. Symptoms consist of an expanding dark-brown water-soaked area.

Fruits become more susceptible as they ripen, and symptoms develop rapidly. Infected areas are dark brown and soft, and they may extend to the pit. Production of gray or tan spores usually follows a few days after infection. Because of the extreme susceptibility of the ripe fruit and the rapid growth of the fungus, brown rot may be a serious problem during harvesting, processing, and shipping.

Control measures are necessary at all of the various stages of the disease. For many years control measures were limited to pro-



PN-3092

FIGURE 36.—Brown-rot blossom blight of sweet cherry.

tection of the ripening fruit. Numerous sprays or dusts were applied just before and during harvest. These methods have been fairly satisfactory, but they leave chemical residues on the fruit. With the use of the newer organic chemicals, the residue problem has increased, and efforts are now being made to control the disease at an earlier stage. In most areas, protectant sprays are recommended against blossom infection. Preventing infection early in the season increases fruit set and greatly reduces the amount of inoculum available to infect the mature fruit.

Although brown rot can greatly reduce the marketable crop, satisfactory control can be obtained by carefully following recommended control measures (78). Current recommendations on the control of brown rot should be obtained from the Extension Service of your State agricultural university.

## ARMILLARIA ROOT ROT

Armillaria root rot is a very serious disease of fruit trees in localized areas. The causal fungus, once established, lives as a saprophyte on organic matter in the soil but can infect and invade roots of living plants with which it comes in contact. Infected trees usually are killed, and replants are subject to the same hazard. The areas of infection can usually be associated with previous orchards or with cleared deciduous-forest sites. *Armillaria* isolates from evergreen forests do not seem to be pathogenic on fruit trees.

The fungus attacks and follows roots, spreading from tree to tree at the point where roots from adjacent trees intermingle. Infected roots have been known to maintain the fungus in the soil for more than 15 years. Roots of new trees planted where old trees were removed eventually come into contact with old infected roots, and the disease reappears.

Tree symptoms are typical of diseases caused by root pathogens that girdle the trunk and main root system. Leaves are smaller than usual, pale green in color, and curled. Eventually they wilt. Affected trees usually die the first year after symptoms appear but may

linger into the second season. Frequently, surrounding trees show symptoms the year after the first tree dies. Trees adjacent to infected trees usually are already infected and should be included in attempted control measures.

The disease is identified by the presence of characteristic white fan-shaped fungus mats, which develop between the wood and the bark in rotting roots (fig. 37). Brown shoestringlike rhizomorphs often develop on the surface of roots and may extend into the surrounding soil. These can be mistaken for small roots, but they are darker and are composed of many strands of fungus. Golden-brown mushrooms sometimes develop around the base of the dead or dying tree.

Once the fungus has become established, it is very difficult to eliminate from soil. Soil fumigation with carbon disulfide has been



PN-3093

FIGURE 37.—Armillaria root rot at base of sweet-cherry trunk.

satisfactory on light sandy soils in California, but on heavier soils it has not been possible to get the fumigant deep enough into the soil to penetrate infected pieces of root. Fumigation treatments with more effective chemicals are expensive and have not been completely satisfactory.

## VERTICILLIUM WILT

Verticillium wilt has caused serious damage in sweet-cherry orchards planted on infested sites. The fungus enters through wounds in roots or rootlets; then it grows through the woody cylinder up into the trunk and scaffold limbs. Initial external tree symptoms are small leaves and poor terminal growth. During hot weather, when transpiration is high, leaves on the infected parts of the tree may wilt and die. Usually only one or two major limbs are affected at a time. In subsequent seasons the disease may show up in other parts of the tree or may not appear again (115). Internal symptoms consist of dark-brown discolored areas in the wood of the trunk and scaffold limbs and irregularly scattered brown flecks in the smaller wood. Isolation of the fungus from the wood frequently is difficult during the summer months. Topworking of infected trees frequently results in a lower percentage of successful unions than normal. No satisfactory measures are available for treating infected trees; sites that have a past history of verticillium wilt should be avoided. A few clones of mahaleb cherry are somewhat tolerant and may come into use as resistant rootstocks.

## COLLAR ROT OR CROWN ROT

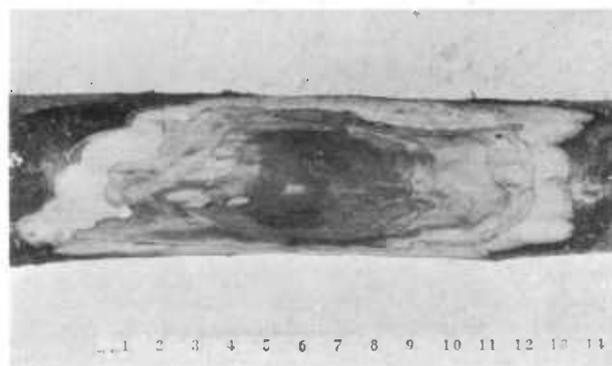
Collar rot is caused by one of several species of *Phytophthora* and by *Poria* (31). In most areas tree losses due to this disease are small. Poor drainage, overirrigation, or heavy rains, which cause waterlogging of the soil, favor the *Phytophthora* organism. Losses due to *Poria* may be associated with well-drained soils. The causal fungi infect roots and may kill a band of bark on the lower trunk below the ground level, resulting in girdling of the

tree. *Phytophthora* species are classed as water molds. They produce zoospores (swimming spores), which are easily moved from tree to tree by flowing water. Infected areas in the orchard tend to be more irregular than those of *Armillaria*. Single infected trees may occur randomly through the orchard.

The first symptoms are failure of foliage to develop normally in the spring, wilting, and finally collapse of the tree. The bark and wood tissues in the upper part of the tree appear healthy, but infected tissue can be found near the ground line. In trees infected by *Phytophthora*, the advancing margin of the infection appears irregular and consists of thin bands of brown, reddish brown, and/or greenish brown tissue (fig. 38). The infection may move as high as 3 feet above soil level, but is generally only in tissues below the ground level. *Poria* infection is associated with a white fungus that produces pale yellow fruiting structures. Top symptoms are seldom noticed until the fungus has girdled the tree and it is too late for control measures. Chemical control measures have not been very satisfactory. The best control for *Phytophthora* is to reduce the amount of time that the soil near the trunk is saturated with water. This may mean improving the drainage or changing methods of irrigation.

## CHERRY LEAF SPOT

For many years cherry leaf spot has been a serious disease of sour cherry, but has not



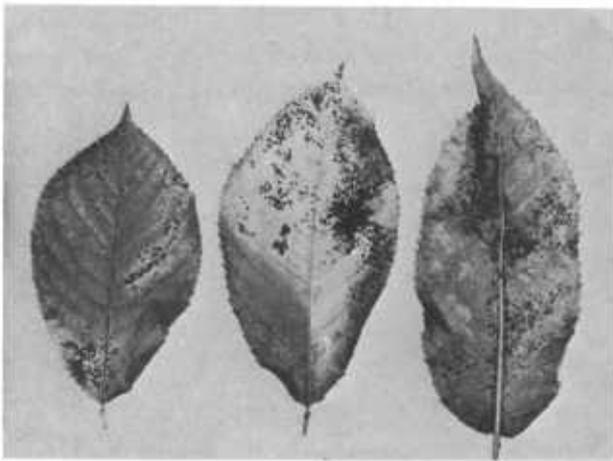
PN-3094

FIGURE 38.—*Phytophthora* canker from inoculation of scaffold limb.

been of commercial importance on sweet cherry except on nursery trees. During the past 5 years the incidence of leaf spot in sweet-cherry orchards has increased rapidly. The cultivar 'Republican', commonly used as a pollinizer, has been particularly susceptible. Serious infections have also been observed on other commercial cultivars.

The causal fungus enters the leaf through the stomates when moisture is available for spores to germinate. The first infection of new leaves is from spores released from the dead leaves on the ground. These spores are carried to the lower branches of the tree by air currents and windblown rain. The spread up through the tree may be quite rapid, depending on the temperature and the frequency of summer rains. Foliage loss may eventually be from 5 to 90 percent. In severe cases the tree may leaf out again and the new foliage also become infected. In addition to crop reduction, severely infected trees frequently go into dormancy with insufficient food reserves and are therefore much more susceptible to winter injury.

Leaf spot infections are first noticed as small purple areas on the upper surface of green leaves (fig. 39). On the lower surface directly below the purple area there is a small white spot. The white area has a sharp margin in contrast to the rather diffuse margins



PN-3095

FIGURE 39.—Cherry leaf spot on sweet-cherry leaves. The leaf on the right shows the white spore masses on the lower surface.

of the purple area. Numerous infections may occur on one leaf, which causes it to turn yellow and drop off. Infection also may occur on the fruit pedicel causing a girdling of the pedicel and a subsequent fruit drop. Fruit infection may occur but is seldom serious.

Spray injury or viruses may also cause leaf fall, but these can be distinguished from leaf spot by the absence of white spore masses in the spots.

Chemical control measures in sweet-cherry orchards for this disease usually have not been recommended. In some areas, such as Western Oregon, summer sprays are suggested to reduce defoliation in severely infected orchards. The number of sprays necessary for control depends on the amount of infection and the frequency of summer rains.

## CORYNEUM BLIGHT

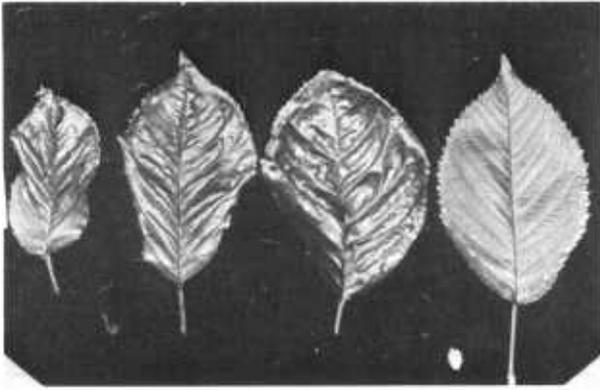
Coryneum blight is seldom of commercial importance in sweet-cherry orchards. Symptoms on the fruit consist of small pale spots with a red margin. The spots may coalesce to form irregular shapes. Early infection results in failure of the fruit to size evenly. In western United States the disease is seldom sufficiently serious on sweet cherries to warrant application of chemical sprays.

## WITCH'S BROOM

Witch's broom, or leaf curl, of sweet cherry is sporadic in occurrence and not usually of commercial importance. In early spring the infected leaves are red to rose-colored, somewhat thick and curled (fig. 40). Shoots growing from infected buds are thick, twisted and bushy, giving a broomlike appearance. The disease is easily controlled by removing and destroying the infected witch's brooms.

## BLACK KNOT

Black knot is seldom observed on sweet cherry and is normally controlled by removing the infected limb. The disease may be recognized by the irregular black swellings on the infected limbs.



PN-3096

FIGURE 40.—Leaves from a limb infected with witch's broom. The leaf on the right is healthy.

### POWDERY MILDEW

Powdery mildew is very common on the leaves of sweet-cherry trees, but it seldom causes serious damage except on young nursery trees. It develops as white patches of fungus scattered over the leaf surface (fig. 41). In severe cases it may cause defoliation or stunting of the infected shoots. Mildew may also infect the fruit, causing a brown leathery area on the skin, and may under favorable conditions cause serious losses. Control measures are usually not necessary, but sprays or dusts may be applied if the local situation warrants.

### PERENNIAL CANKER

Perennial canker, often referred to as Valsa or Cytospora canker, has not been a serious disease of sweet cherry where good pruning practices have been used. Where infection has occurred, it has been through wounds caused by breakage or improper cultural practices (32). With the proposed use of shakers to harvest the fruit mechanically, the number of wounds may increase. The bark at the point where the shaker grasps the limb can be broken by the jarring action of the shaker. These wounds serve as points of entry for both saprophytic and parasitic organisms.

### BACTERIAL CANKER

Bacterial canker and crown gall are the only two significant bacterium-incited diseases of

sweet cherry. These diseases are caused by *Pseudomonas syringae* van Hall and *Agrobacterium tumefaciens* (Smith and Townsend) Conn, respectively. However, both may cause serious damage to trees and eventually loss in production.

Bacterial canker is characterized by various-sized, usually sunken lesions on the trunk and smaller limbs of the trees, some of which exude copious amounts of gum (143). The canker characterized by gum exudation is the best known and most easily recognized. These usually develop at the base of an infected spur and then enlarge up and down the trunk. Extension of the canker is usually much more rapid above the point of infection than below, and spread to either side is relatively slow, resulting in a long, narrow canker.

Cankers usually develop during fall and winter but are first noticed in late winter and early spring. Infected areas are slightly sunken and may have a slightly darker brown color than the rest of the bark. When the cankered area is cut, the bark may be any shade from bright orange to brown. The cambium may or may not be affected. At both the lower and upper margins of the canker, narrow brown streaks extend into the normal tissue. As the trees break dormancy in the spring, gum will be formed by the surrounding tissue and may exert enough pressure to break through the bark and run down the outside of the limb.

Cankers that do not produce gum are similar



PN-3097

FIGURE 41.—Powdery mildew on young sweet-cherry leaves.

in appearance but are usually more moist and sunken, and may have a sour odor. Cherry trees may exude gum from wounds other than those caused by bacterial canker. Wounds resulting from winter injury and mechanical damage may be confused with bacterial canker symptoms.

The first symptoms of bacterial canker infection on cherry leaves are dark-green, angular or circular, water-soaked spots about 1 to 2 mm. in diameter (27). The spots frequently are surrounded by a yellow halo. As the leaves mature, the water-soaked area becomes brown and eventually the infected area becomes dry and brittle. If these areas fall out, the leaves take on a shot-holed or tattered appearance. In severe cases the entire leaf tip and margin may drop off.

Infected areas on fruit are flat, irregular in shape, dark brown to black, and range from 2 to 3 mm. in diameter. Some spots are depressed and have underlying gum pockets.

When the trunk or limb of a tree is girdled by a canker, the area above the girdle eventually dies. A slight inward curling and drooping of the leaves is the first indication that the limb has been girdled. The foliage turns progressively light green to yellow. At this stage, the leaves hang straight down and are strongly rolled. If the canker is on the main trunk below the scaffold limbs, the entire top of the tree dies (fig. 42). When the top is killed, several suckers may initiate near the ground line, above and below the graft union.

Blossom infection usually is not important in sweet cherry, but it can be very severe under climatic conditions favorable to the disease. Blossom infections may progress into the twigs and cause shoot wilt; they commonly infect spurs and progress into the main limbs of the tree, where they cause characteristic cankers. Infected blossoms appear water-soaked, turn brown prematurely, and hang, producing the symptoms that prompted the common name "blast."

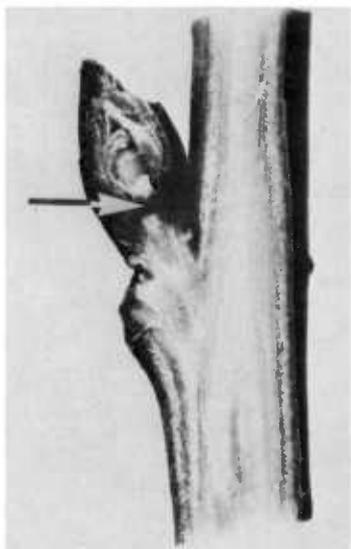
In some areas, where environment favors bacterial canker, a great number of dormant cherry buds are killed. This type of infection usually is limited to the buds in severely af-

ected orchards in western Oregon; up to 80 percent of the buds may be killed (16).

The first evidence of infection in the buds shows as a brown necrotic area at the base of the bud scales in February and early March (fig. 43). Infection of buds takes place during fall or early spring; the bacteria enter the bud between the lower scales (15). Such affected



FIGURE 42.—Three-year-old cherry tree with upper portion injured by bacterial canker.



PN-3099

FIGURE 43.—Cross section of a bud damaged by a strain of *Pseudomonas syringae*.

buds fail to open, then dry up. When observed at full bloom the black skeletons of diseased trees are a striking contrast to healthy trees (fig. 44). Once an infection is established, the bacteria may move in the conductive elements to other parts of the tree (17). Under these conditions infection may be latent, and the tree may appear healthy until climatic conditions are favorable; then severe symptoms of bacterial canker develop rapidly.

Where the leaf-infection phase is severe, application of spring and summer sprays are effective. Dormant-bud infection can be prevented by applying fall and early spring dormant sprays of bordeaux mixture.

Control measures applied after the canker phase of the disease is established are seldom satisfactory. Heavy dormant bordeaux sprays, such as 16-16-100, have reduced the severity

of symptoms in some cases. Some sweet-cherry cultivars are most resistant than others, but none are immune. In some areas relatively resistant mazzard rootstocks are used for the trunk and scaffold arms, and the desired commercial cultivars are topworked onto them 12 to 18 inches from the trunk (18). On such trees, infection stops at the graft union, and only portions of the tree are lost.

## CROWN GALL

This disease occurs widely in cherry-growing areas, but the amount of damage attributed to it ranges from severe to slight. It is characterized by galls, which generally occur at or near the crown. They are irregular in shape, varying in size from  $\frac{1}{8}$  to 5 inches on young trees to much larger on mature trees. The galls are commonly located at the pruned end of tap roots and along the crown where injuries have occurred, but may also occur along the lateral roots. Most nursery trees with galls are culled out by the nursery; the grower should not plant trees that are visibly infected. Growers should always purchase top-quality trees and not buy lower grades or culls in an attempt to save money. Some nurseries treat lining out stock by dipping it in a chemical disinfectant before planting. Dipping of all nursery trees before orchard planting may be advisable in areas where the disease has given trouble.

Specific control measures have generally not been listed for fungus and bacterial diseases because of differences in climate, time of application, and the advisability of coordinating application with those of recommended insecticides. Many new chemicals are available, and these should be tested locally before being applied.

## VIRUS AND VIRUSLIKE DISEASES<sup>17</sup>

Virus diseases present serious production limitations, but the losses they cause may not be readily apparent (2, 105). Most do not cause immediate tree collapse or even eventual tree

loss. However, affected trees often are debilitated to the extent that yield is reduced by one-half or more, quality of fruit is lowered, fruit size is reduced, or the percentage of cull fruits is increased. Each of these effects reduces economic returns. Virus diseases are conta-

<sup>17</sup> This section was prepared by L. C. Cochran, Oregon State University, Corvallis, Oreg.



PN-3100 PN-3101

FIGURE 44.—Sweet-cherry trees in full bloom: *A*, Buds severely infected by bacterial canker (note lack of blossoms on lower two-thirds of the tree); *B*, a healthy tree.

gious, and when affected trees are detected they have already exposed other trees. In most cases there is no known method of curing affected orchard trees. The only control is avoidance of infection through use of virus-free nursery stock and prompt removal of affected trees and natural host species. In older orchards, growers may obtain profitable crops from trees affected by some of the less debilitating diseases. However, in young orchards, it is always wise to replace trees debilitated by viruses.

Viruses are infectious particles too small to be seen except with the aid of an electron microscope. Viruses are transmitted readily by normal vegetative propagation methods. Graft transmission of *Prunus* ringspot and rusty mottle occurs after 74 hours of contact with a live inoculum bud, and little cherry virus after 152 hours (50). Aphids, leafhoppers, eriophyid mites, and nematodes are known to be vectors

of specific viruses. Natural root grafts also may permit spread of virus from one tree to another.

Some diseases formerly ascribed to viruses are now known to be caused by mycoplasma. Mycoplasma are small organisms, generally intermediate in size between viruses and bacteria, which are transmitted by insects and mites and which induce diseases similar to those caused by viruses.

Nursery trees grown from regularly-indexed budwood and rootstock seed sources are good insurance for the grower (76). Several State nursery improvement programs and an Inter-regional Repository of indexed material at Prosser, Wash. (49), have been of great service in making better nursery stock available.

## X-DISEASE

The designation x, connoting a mathematical unknown, was given to this disease because

of its unusual symptoms by Stoddard (120). It occurs in almost all the sweet-cherry growing districts of the United States. It has been described on cherries under several names including western x-disease, western x-little cherry, small bitter cherry, western x-wilt and decline, buckskin, and yellow-red viruses (94, 96, 104, 106, 151). In most areas x-disease also occurs on peach, where it induces more easily recognized symptoms (59, 151). X-disease has caused serious losses to sweet cherries in local areas, particularly in Utah, southern Idaho, the Dalles area of Oregon, and the Green and Napa Valleys of California.

In warmer areas, x-disease kills sweet-cherry trees growing on mahaleb cherry rootstock in one to two years (95, 96, 101). Trees that become diseased in midsummer usually wilt and suddenly collapse, retaining their dried leaves into the fall. At other seasons, death is preceded by varying rates of decline, including cessation of current growth, yellowing and loss of leaves, and failure of fruit to mature (129). Roots on affected trees are discolored and die progressively from the feeder roots to the larger ones. When symptoms appear in the tops, necrosis can usually be found in the cortical tissues of the mahaleb rootstock immediately below the graft union. In cooler areas, symptoms on affected trees on mahaleb rootstocks consist of rosetting, dwarfing, and failure of fruit to mature.

In trees on mazzard rootstock, the disease is less spectacular. The most striking feature is failure of the fruits to size and mature at the normal season. Affected and normal spurs are commonly interspersed, and sometimes normal and diseased fruits occur on the same spur. In advanced cases, whole leaders are affected, but involvement of whole trees occurs rarely and only in the last stages.

In California, affected fruits of light-colored cultivars, particularly 'Napoleon', remain dull white resembling kid leather, hence the name "buckskin" (95). On normally dark-colored fruit cultivars, affected fruits remain dull light red and fail to size. Affected fruits fail to develop their normal sweetness and flavor. Leaf symptoms include various abnormal color changes ranging from dull green to yellows

and bronze. In Utah, leaves on affected trees are smaller than normal and commonly develop enlarged, proliferated stipules (129).

The causal agent is transmitted by a number of leafhoppers (62, 63, 81). These leafhoppers feed on diseased plants and then carry the virus to normal trees in the course of their normal feeding habits.

Control of x-disease is difficult in some areas, especially where orchards are near stands of infected native chokecherries. New orchards should not be planted adjacent to old infected plantings, especially those on mazzard rootstocks or near stands of native chokecherries. Removal of virus host reservoirs near new orchard sites with herbicides before planting will materially reduce the incidence of x-disease. Experimental injection of trees with antibiotics has shown some promise for reduction of x-disease symptoms.

In areas like Utah, which are favorable to vectors that breed on cherries, spread has been particularly rapid. In these areas, infection may become extensive in orchards on mazzard rootstocks, which in turn serve as reservoirs for further spread. In such areas, the use of mahaleb rootstock with 9 to 12 scaffold leaders separately topworked has shown promise. The infectious agent does not move from one sweet-cherry leader to the other through the mahaleb portion of the tree. Diseased leaders can be pruned back to the mahaleb portion and topworked with a healthy scion, or the other scions can be allowed to fill in. Use of resistant cultivars such as 'Long Stem Bing', 'Dicke Braun', and seedlings of these has also been effective.

In eastern United States, removal of diseased chokecherries from the vicinity of the orchard provides good control. The natural vectors apparently do not breed on cherries, hence do not spread the disease within the orchard.

## LITTLE CHERRY

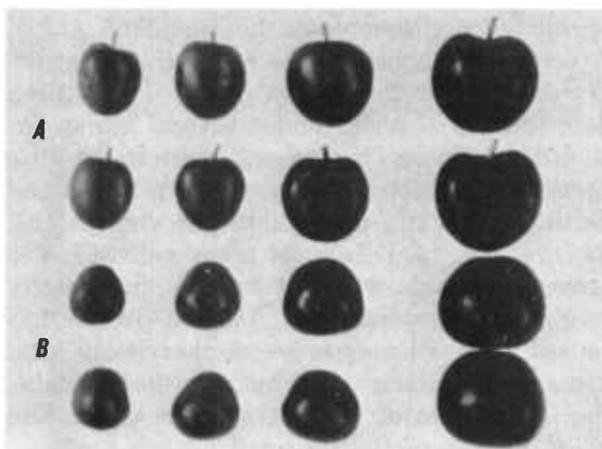
The little-cherry disease, as the name implies, is characterized by failure of the fruit to size and mature normally (46). On most cultivars, symptoms are confined to fruits. Some cultivars, such as 'Van' and 'Sam', when

infected, produce reduced growth, and some leaves develop a yellow-bronze color (101). Many cultivars show no foliage symptoms. Most of the oriental flowering cherries in the United States are infected symptomless carriers of the virus. It seems likely that the little-cherry virus was introduced into the United States in infected symptomless oriental cherry trees (100, 102, 104).

Little cherry was first observed in North America on commercial sweet cherries near Nelson, British Columbia, in 1933 (46). It spread rapidly in orchards along Kootenay Lake in the 1940's and is now generally present in most trees in that area (34). Although the virus is generally present in flowering cherries, often growing in yards near commercial orchards, very little spread has been observed in most commercial sweet-cherry areas of the United States. Little-cherry disease, however, is a serious threat to the cherry industry, and its spread in isolated local areas indicates its potential, should conditions become favorable to the leafhopper vectors. The disease was recognized in commercial sweet cherries in England in 1955 (89). Subsequently it was found widespread in commercial orchards in England and in various other parts of Europe (88).

Symptoms of little cherry vary with cultivars and climate areas. 'Lambert' (fig. 45), 'Republican', and 'Hedelfingen' are severely affected. 'Bing', 'Napoleon', 'Black Tartarian', and 'Deacon' are moderately affected. Some cultivars are severely affected during the first year of infection, but fruit size improves in later years. In areas like the Kootenays, where climate is conducive to large fruit size, fruit production has proceeded, with most of the crop going to the brining industry.

The little-cherry virus appears to be restricted to cherry species. All attempts to infect peaches and plums experimentally have been unsuccessful (141). Wilde (138) was able to transmit the little-cherry virus in British Columbia with two species of leafhoppers. Neither of these species are present in England, yet natural spread occurs there. Natural spread from oriental cherries to sweet cherries



PN-3102

FIGURE 45.—'Lambert' cherry fruits affected with little cherry, showing a gradient in size as contrasted with normal fruits at right; A, Side view; B, stylar-end view.

does not appear to occur in the United States, but spread from sweet cherry to sweet cherry does occur.

There are a number of viruses that cause reduced fruit size and abnormal maturity. Albino cherry, described from southern Oregon, induces fruit symptoms with some similarities to those of little cherry, but this disease usually kills most cultivars, particularly 'Bing' growing on either mazzard or mahaleb rootstocks. Small fruits that fail to mature are characteristic of x-disease, especially on trees growing on mazzard rootstock. This disease, however, kills trees growing on mahaleb rootstock, and the virus will infect peach and other *Prunus* hosts. Diagnosis in the field may be difficult and may require tissue transmission to indicator plants, such as 'Van' (139).

No satisfactory control is known for the little-cherry disease. Growers generally agree that oriental flowering cherries near commercial orchards are a hazard and should be removed. Wild mazzards and other cherry species should be removed from orchard perimeters. Growers should observe their trees carefully at harvesttime, and any suspicious trees should be removed promptly.

## ALBINO

The name albino was given to this disease because fruits on affected trees of most cultivars remain small, immature, and white at normal maturity time (152). Unlike some of the other diseases characterized by small fruit, albino is a tree killer. Trees often die during the first year of infection and usually in the second and third year. Fortunately, this disease has not been found outside of the Rogue River Valley of southwestern Oregon.

The symptom of albino have characters in common with those of some strains of x-disease. In early spring, branches on affected trees start to die back, and by summer the leaves

become uniformly golden bronze to olive brown, and the margins roll upward. New growth induced from terminal buds late in the summer is small and rosetted. Fruits remain small and immature, even those on dark-red-fruited varieties turn white (fig. 46). Most of the fruits on affected trees drop before harvesttime, but some of the small white ones remain. As in x-disease, trees on mahaleb rootstock die more rapidly than those on mazzard. Spread may be very rapid; all trees in some orchards become diseased in 2 or 3 years (125).

Albino is distinguished from x-disease by the more drastic symptoms produced on sweet cherries and by the failure of the causal virus to infect peaches.

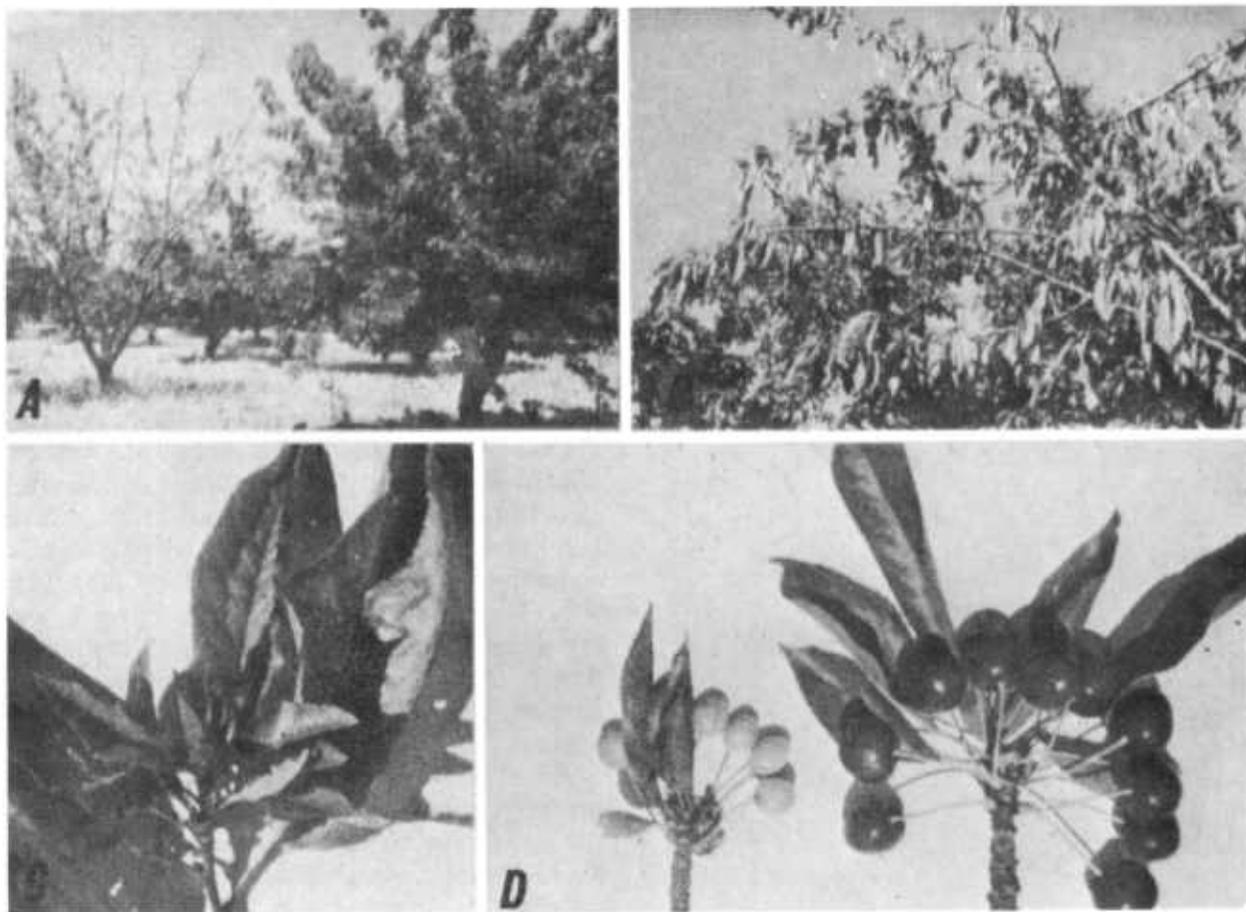
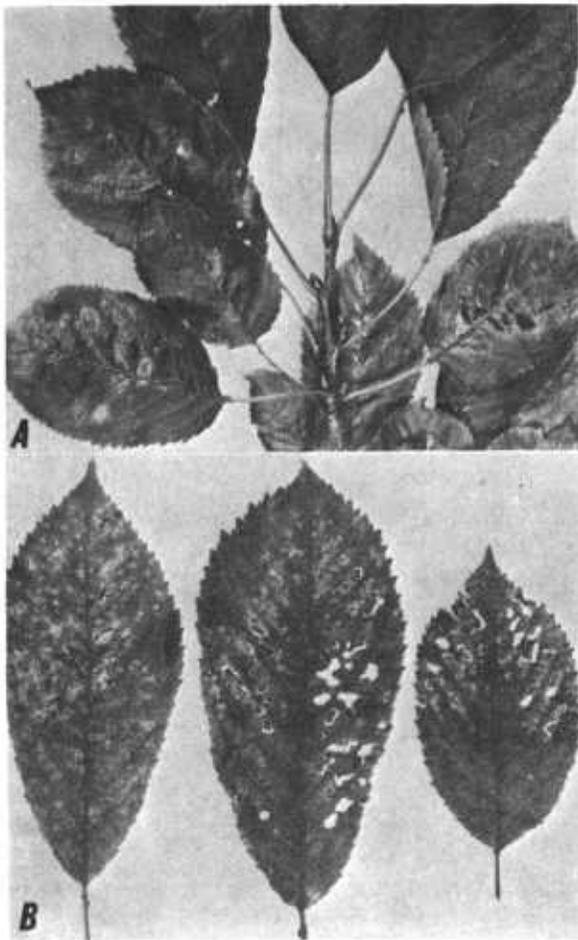


FIGURE 46.—A, Dying albino-affected sweet-cherry tree (left) and nearby healthy tree; B, branch of albino-affected tree showing late-season symptoms; C, terminal from a similar tree, showing small green and older greenish-bronze leaves; and D, 'Lambert' fruits affected by albino (left) and normal fruits.

Albino still poses a threat to sweet cherries in other areas. Care should be taken to prevent movement of the causal agent out of the area. A number of partially tolerant cultivars have been developed in the area and are available for local planting.

## PRUNUS RINGSPOT

Many trees in sweet-cherry orchards of the United States are infected with one or more strains of the ringspot virus (74, 77). Symptoms range from obscure chlorotic rings and lines to brilliant chlorotic and necrotic patterns, often with concentric rings (fig. 47).



PN-3104

FIGURE 47.—A, Twig of 'Yellow Spanish' cherry affected with tatter leaf; B, affected leaves of the same cultivar.

Where necrosis is involved, leaves may become shot-holed, shredded, and tattered. Symptoms are most striking in new growth and tend to fade later in the season. They are also more pronounced the first year of infection and, in some trees, the disease becomes entirely latent after the initial stages. Growth of affected trees is reduced, but this is not evident unless healthy trees are available for comparison.

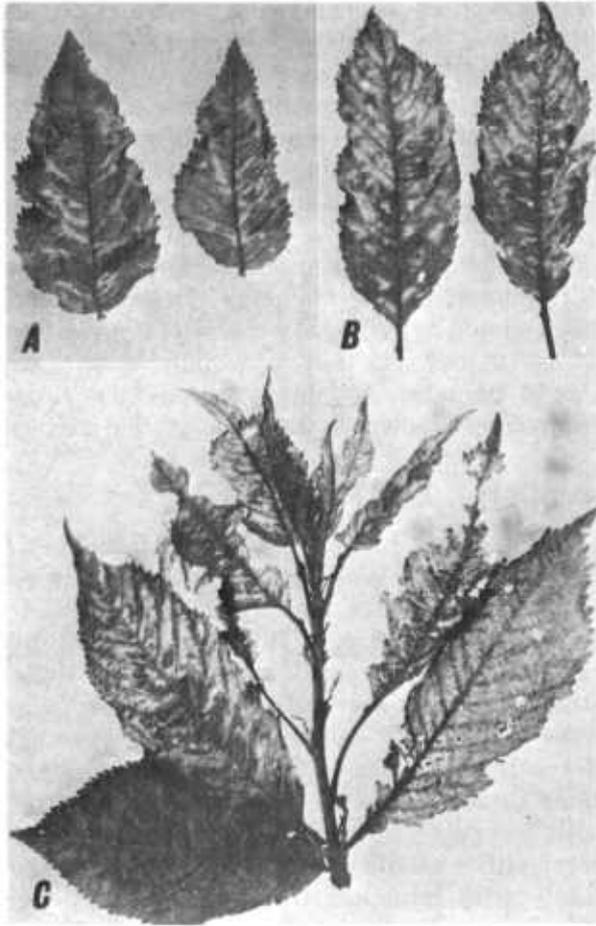
Ringspot is seed-transmitted (23, 28, 39) and is spread in the orchard by infected pollen (51). When nursery stock is propagated from infected materials, a poor set of buds and poor growth usually results (77).

The control of ringspot in commercial orchards is very difficult. The first essential is to start with virus-free nursery stock. To produce this, the nurserymen must have both virus-free seeds for rootstock and virus-free budwood. Because the ringspot virus is pollen-borne, new orchards will need to be sufficiently isolated from old orchards to prevent infections through pollen carried in by bees. The increased vigor and survival of trees during the early years of new orchards will pay for the extra expense of virus-free nursery stock.

## MOTTLE LEAF

Cherry mottle leaf occurs in localized areas of the cherry-growing regions of western United States and Canada (98, 103). Leaves on affected trees develop characteristic mosaic and mottled patterns and show variable amounts of distortion and dwarfing (98) (fig. 48). Fruit on trees with pronounced leaf symptoms is small, late to ripen, insipid in flavor, but usually not misshapen. Growth is stunted, giving affected trees a rosetted appearance.

All cherry cultivars, both sweet and sour, are susceptible, but 'Bing' and 'Napoleon' are the most severely affected cultivars. Variability in symptom expression is due not only to varietal tolerance but also to the fact that different strains of the virus induce mild or severe symptoms. Symptom expression is most pronounced in the spring and tends to become less so in summer and fall. Mild cases may become entirely masked late in the season, but



PN-3105

FIGURE 48.—A, 'Napoleon'; and B, 'Bing', cherry leaves affected by mottle leaf. C, Branch of 'Bing' cherry affected by severe mottle leaf, showing symptoms in the new tip growth.

they will develop characteristic symptoms in new growth the following year.

The prevalence of cherry mottle leaf is greatest in the interior valleys, near foothills, especially near native stands of wild bitter cherry, *Prunus emarginata* (Dougl.) Walp. The bitter cherry is a natural host of both the virus and the eriophyid mite, the vector that carries the causal virus to cultivated cherries (L. S. Jones, unpublished).

Mottle leaf can be efficiently controlled through avoidance of sites near native stands of bitter cherry or through removal of the bitter cherry before the new orchard is planted. Several of the newer herbicides have made

removal of wild-cherry stands feasible. Care should also be taken to insure that propagating wood is taken from trees free of mottle leaf.

## RUSTY MOTTLES

Several types of rusty mottles affect sweet cherries (69, 97, 103, 107). These are distinguished on the basis of their effect on different cultivars or on their total effect on trees. All induced mottled patterns are composed of rings, spots, and irregular lines, which are bordered by yellowish to rust-colored areas. Affected trees appear nearly normal in the spring but may show some delay in foliation and flowering. Rusty brown spots of varying size and shape develop on the older leaves 3 to 5 weeks after petal fall. Symptoms may develop rapidly in warm weather. The affected leaves become senescent and drop. Severity of leaf fall varies in different areas, in different cultivars, and with the different strains of the virus. The effect on fruit is generally proportional to the amount of defoliation. On moderately to severely affected trees, the crop is reduced. Fruit is retarded in maturity and fails to develop normal size and flavor, but it is not misshapen.

The rusty mottle originally described (97) from Washington and Oregon affects the major cultivars of sweet cherries, 'Bing,' 'Napoleon', and 'Lambert', about equally and generally does not kill the trees.

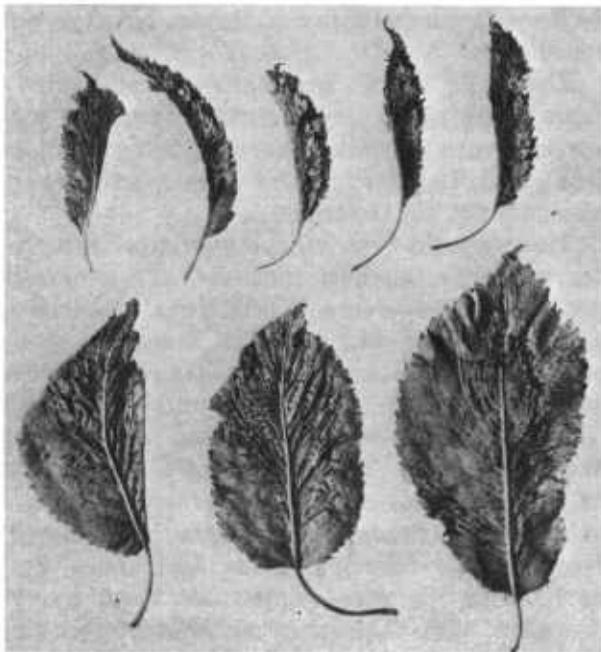
The necrotic type of rusty mottle (also referred to as Lambert mottle) (69) generally produces more severe effects, causing dieback and often death of trees. The 'Lambert' cultivar and certain mazzard seedlings are more severely affected than 'Bing' and 'Napoleon'. 'Black Tartarian' can be infected but does not show symptoms. The leaf spots usually begin as necrotic areas, with the surrounding tissue subsequently becoming chlorotic and colored. Necrosis also occurs in buds, leaf spurs, and bark. This damage results in bare, rangy branches with corresponding amounts of dieback, and sometimes with gum-filled blisters and cankers in the bark.

Selection of propagation materials from non-affected trees is the first essential for control.

There is little evidence indicating natural spread in orchards, but good evidence links outbreaks to propagation from diseased sources. Diseased trees produce light crops of inferior-quality fruit and, therefore, should be removed and replaced with good trees.

### RASP LEAF

Cherry rasp leaf occurs in all the sweet-cherry growing areas of the United States. It has caused severe losses in local areas in Washington, Colorado, and Oregon. The disease is characterized by enations that grow from interveinal tissue on the lower sides of the leaves. The enations consist of enlarged glands and various types of excrescences, from small tumors to outgrowths resembling serrated leaf edges (7, 9, 99). In severe cases, leaves may be drastically distorted. Where a number of serrated excrescences are parallel, they resemble somewhat the teeth on a coarse rasp, hence, the name rasp leaf (fig. 49). Trees may be partly or completely affected. Usually when the disease appears on one branch, it contin-



PN-3106

FIGURE 49.—'Napoleon' cherry leaves affected by rasp leaf, showing enations and distortions.

ues to spread in succeeding years until the whole tree is involved. Damage to diseased trees consists of retardation in growth and reduction in size and quality of the crop. Occasional enations are common on sweet-cherry leaves (7). Usually these occur on only a few leaves and are easily distinguished from rasp leaf.

Since rasp leaf essentially destroys the productiveness of sweet-cherry trees, diseased trees should be removed promptly. Spread does occur in orchards but is usually slow. Care should be taken to obtain propagation wood from trees known to be free of the disease.

### TWISTED LEAF

Twisted leaf has caused serious losses in a few orchards in Washington State and the adjoining areas of the Okanagan Valley of British Columbia (24, 68). It damages the 'Bing' cultivar, but the causal virus can also infect other sweet and sour cultivars. Affected 'Bing' trees are severely stunted and appear rosetted. Necrosis of tissues in the midrib and lateral veins causes leaves to be small and distorted, with irregular upward rolling. Mottling may occur either as small yellow spots or more profusely with irregular lines and blotches (fig. 50). Severe defoliation may occur in midsummer (99). Fruit on severely affected trees usually is small and misshapen, and ripens unevenly. Necrosis occurs both in the stem and in the misshapen fruit. Symptoms usually are mild on cultivars except 'Bing', and some infected hosts may be symptomless.

Control of cherry twisted leaf consists principally in the use of disease-free propagating materials. Spread in some orchards has been traced directly to grafts of infected pollinizer cultivars in which the disease was latent. Some slow natural spread has occurred. Severely affected 'Bing' trees are worthless and should be removed.

### BLACK CANKER

The symptoms of black canker are spectacular on sweet cherry, but this virus disease is relatively unimportant because of its limited occurrence and the fact that it does not spread

naturally in the orchard. Affected trees bear reasonable crops but suffer some from dieback, which reduces the fruiting wood. The disease affects most sweet-cherry cultivars but has been seen principally on 'Napoleon' in orchards propagated from diseased wood.

Cankers start on one-year-old twigs as swollen blisterlike areas, which eventually split lengthwise. These areas grow into rough, black cankers of variable size determined by the size of the affected branch (fig. 51). Some infected trees are severely cankered, whereas others may have relatively few lesions. No abnormal leaf or fruit symptoms have been observed (153).

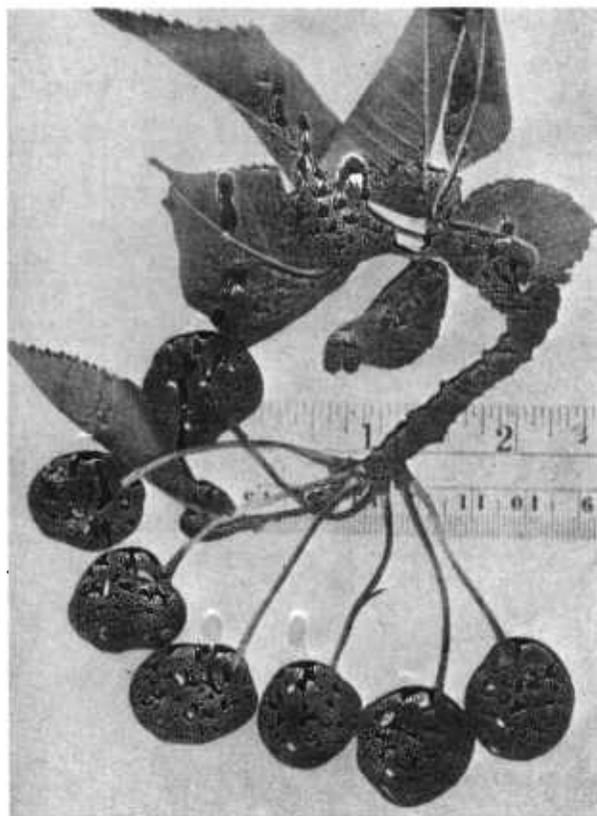
Black canker should be avoided in nursery propagation. Diseased trees need not be removed until they become unprofitable.

### SPUR-INDUCING VIROSIS

Interest in semidwarf, precocious, genetic, spur-type apples has focused attention on a search for this character in other fruits. In 1963, a 'Bing' tree with a spur-type habit was found in the Yakima Valley of Washington. Considerable local interest developed in making use of this apparent mutation. In 1965 Blodgett and others (8) and later Guengerich and Millikan (57) showed that the growth habit was virus-induced and was not genetic in nature. Although the virus appeared to have no appreciable effect on fruit size, quality, or productiveness of the 'Bing' cultivar, subsequent work has shown that it causes severe dwarfing on other sweet cherries, particularly 'Van', 'Windsor', 'Gil Peck', and 'Badacsoner'.

### SHORT-STEM VIROSIS

The stems of fruits on trees affected by short stem are approximately one-third to one-half the length of normal ones. They are usually distorted and twisted because of necrotic tissue in the vascular area. Fruits are also distorted and may have corky tissue in the stem end. Affected 'Bing' trees show reduced vigor. In the second and succeeding years of infection, they may develop dieback and bark blistering. 'Napoleon' is less affected than 'Bing' but also shows reduced vigor and dieback. Other culti-



PN-3107

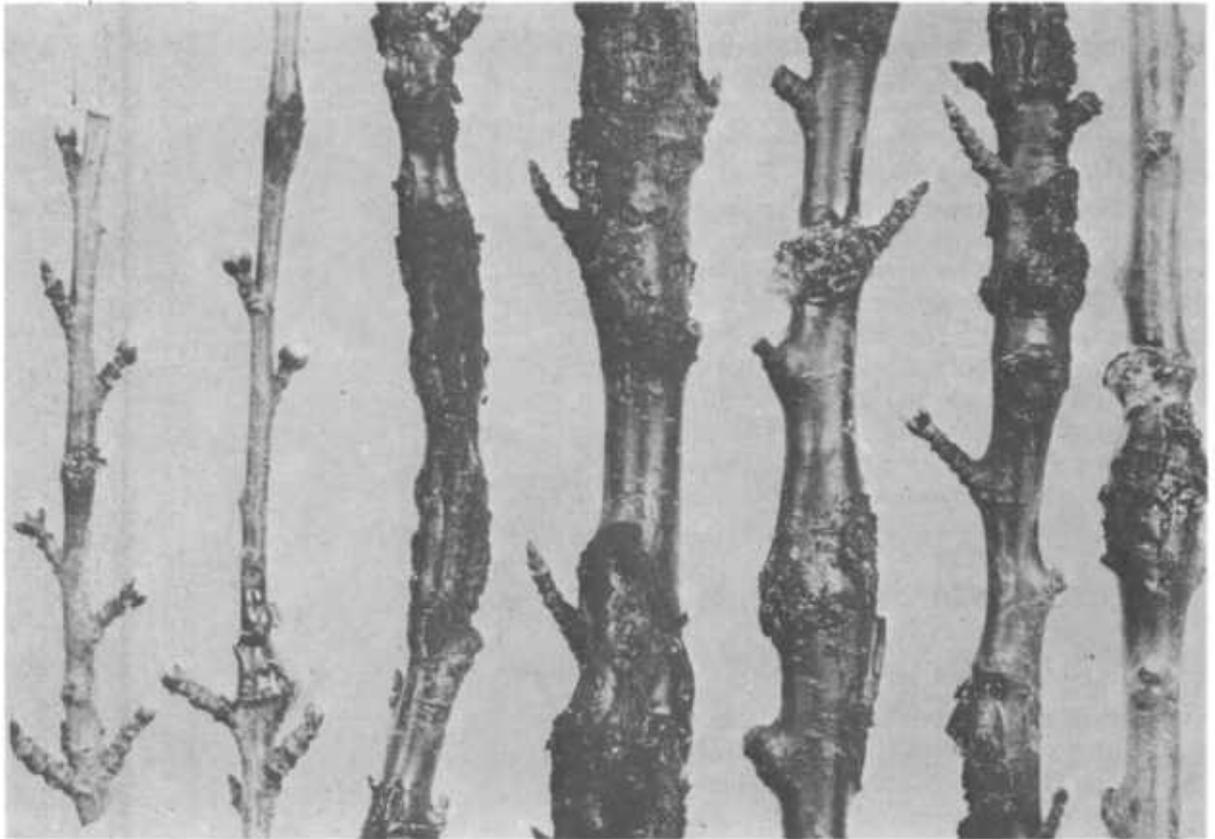
FIGURE 50.—'Bing' cherry leaves and fruits affected by twisted leaf disease.

vars have shown the short stem and leaf distortion, but there was less reduction in vigor.

The disease was originally described (1) in Montana, where it appears to spread slowly in orchards. It was found also in Oregon, and its host range was reported (22). Short stem is regarded as potentially serious; therefore, any diseased trees should be removed promptly.

### VIRUS DISEASES OF LESSER IMPORTANCE

Sweet cherries are susceptible to a large number of viruses that cause minor or no damage. Some of the recently recognized virus diseases are potentially serious but are of very limited distribution. Others, of wider distribution, either cause little damage or may exist without symptoms. Some may reduce vigor but induce no characteristic symptoms. Viruses that induce symptoms but cause minor dam-



PN-3108

FIGURE 51.—Two- to 4-year-old twigs of 'Napoleon' cherry affected by black canker disease.

age are: Mora (73), rugose mosaic (83), freckle fruit (142), a blossom anomaly (21), line pattern, rose mosaic, peach mottle, and cherry bark blister (122). Tobacco mosaic and cucumber mosaic viruses have been found naturally occurring in some orchard trees. Viruses that occur commonly but that may not cause symptoms in cherry species are sour-cherry yellows (84), green-ring mottle (48, 108), and prune dwarf. Undoubtedly sweet cherry is susceptible to some of the viruses described on other roseaceous hosts.

### CHERRY BORON ROSETTE

Cherry boron rosette is characterized by symptoms typical of boron deficiency. Symptoms include narrow leaves rolled upward toward the midrib and shortened rosetted growth (fig. 52). Affected branches bear no fruit. The disease was discovered in Oregon in 1966 (75)

and has subsequently been found in several localities in the Northwestern States. The disease has spread rapidly and has been transmitted with the black cherry and green peach aphids. A strain of cucumber mosaic virus has been isolated from several affected trees. Both foliage symptoms and lack of crop have been corrected with boron applied in the normal spray schedule.

### OTHER DISEASE PROBLEMS

New or different disease problems may occasionally occur on sweet cherries. They should be called to the attention of your local Extension Agent if they seem potentially dangerous to production in your area. The importance of preventing propagation of virus-infected trees, by planting only trees that have been grown under a supervised program, cannot be stressed too strongly.

## HARVESTING AND MARKETING<sup>18</sup>

Sweet cherries are among the most delectable of fruits, and their successful marketing depends on the fruit's having good quality when it reaches the consumer. Fruit with good quality has an attractive appearance and desirable texture and flavor.

To insure top quality for the consumer, cherries must be harvested at the right time and handled correctly from the orchard to the market.

For the fresh market, cherries are picked with stems attached. In picking, the stems are grasped near the bases with thumb and forefinger and turned back against the spur. Care should be exercised not to cause undue injury to the stems or break the fruit spurs.

If the stems are not injured in picking, they shrivel at a rate that depends on temperature and humidity, but they do not necessarily turn brown. If the stems are injured, rapid browning occurs as a result of enzymatic action (113).

Mechanical harvesting of sweet cherries for long-distance shipment has not appeared feasible with present machines and tree-training systems. The cherries tend to detach from the stems when shaken (121), and they are usually bruised too severely to withstand breakdown during the long transit and holding period (124). Both of these factors increase weight loss and shrinkage. Handlers usually require fruit with attached stems and use the stems as an index of condition of the fruit. However, sweet cherries that are to be brined immediately have been harvested successfully by machine (82, 118, 124). The chemical SADH (succinic acid 2,2-dimethyl hydrazide) hastens color development without loss of firmness (4, 111), and enhances uniformity of ripening. Ethephon (2, chloroethylphosphonic acid) enhances abscission of sweet-cherry fruit (144) and, consequently, may reduce bruising from reduced shaking force necessary. Either chemical should be applied on an experimental basis

<sup>18</sup> This section, except the parts on mechanical harvesting and chemical treatment, was prepared by H. A. Schomer, formerly plant physiologist, Market Quality Research Division, Agricultural Research Service, Wenatchee, Wash. Retired.

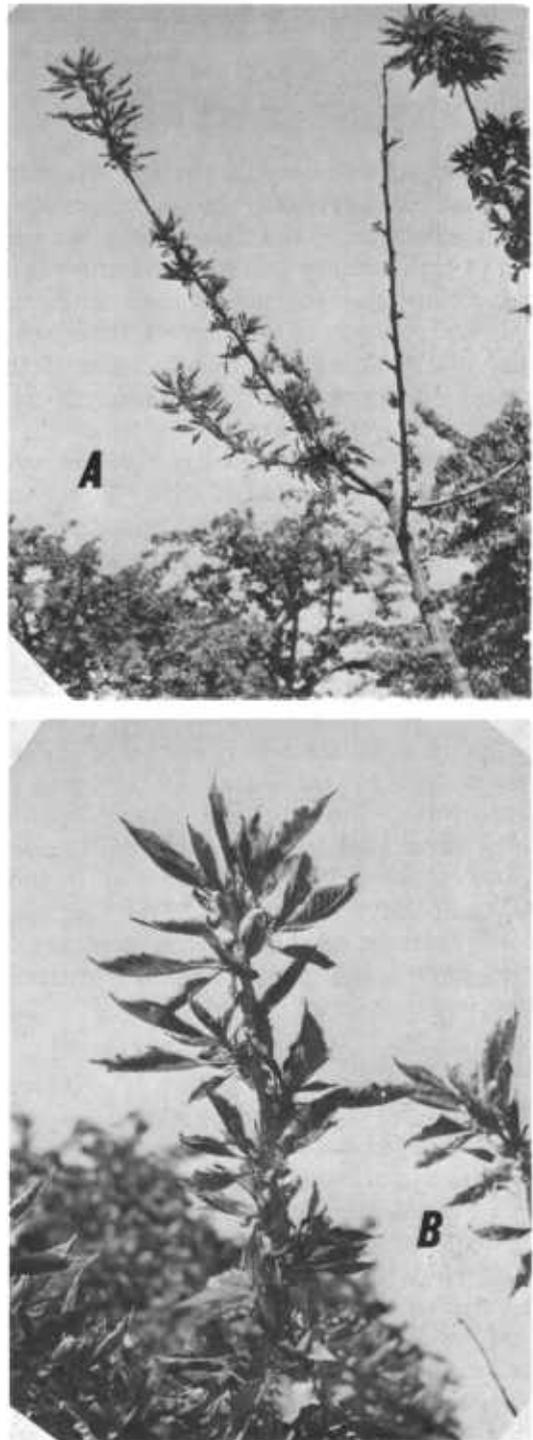


FIGURE 52.—Symptoms of cherry boron rosette: *A*, Sparse growth and dieback; *B*, long cup-shaped leaves.

only. Clearance of these chemicals for these uses on sweet cherries should be ascertained before either is applied to fruits to be marketed.

## PICKING MATURITY

The tonnage per acre and the dessert quality are influenced appreciably by the maturity of the fruit when harvested. Harvesting too early results in poor quality and loss of tonnage. Immature fruits are astringent and sour, and they shrivel severely after harvest. Sweet cherries are often picked too soon because of fear that rains during the harvest period will cause serious cracking of mature fruit.

Cherries picked when fully ripe or over-mature have a short shelf life. The stems darken severely and dry up, and the fruit soon becomes dull and aged in appearance (fig. 53). It loses flavor rapidly and is increasingly susceptible to decay.

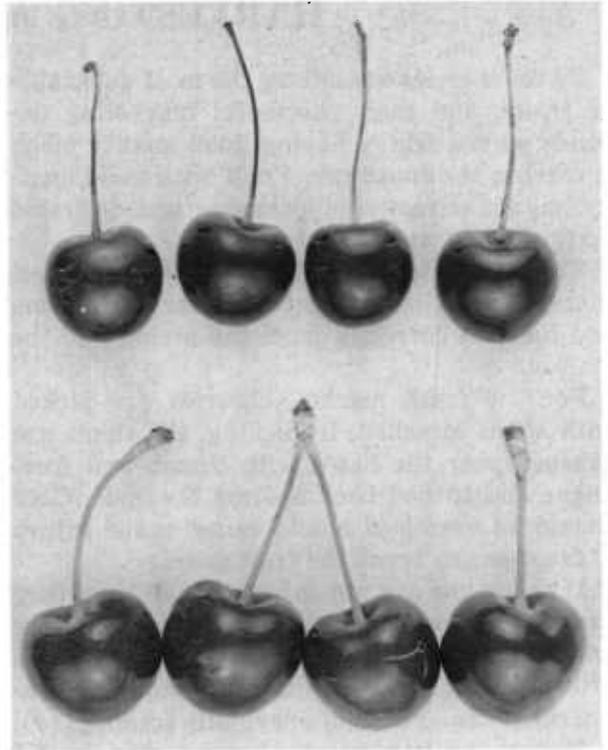
## INDICES OF MATURITY

The guide most commonly used for judging harvest maturity is color. Soluble solids, an additional guide, indicate the sugar content, which is correlated with dessert quality. Both color and soluble solids should be used in judging when to harvest cherries. The California State Department of Agriculture uses a color chart to show a minimum acceptable maturity for dark sweet cherries.

### Color

Color changes are definitely associated with maturity. The dark-colored cultivars of sweet cherries, such as 'Bing' and 'Lambert', change from light red through shades of dark red, mahogany, and even black during maturation. Color develops independently of sunlight; the inside, shaded cherries attain the same color as those exposed. A light mahogany to mahogany color at harvesttime is recommended for handling and shipping.

In the light-colored varieties, such as 'Napoleon', 'Corum', and 'Rainier', only part of the surface is colored by red blush, and the ground color is visible on the remainder of the fruit.



PN-3111

FIGURE 53.—Cherries with stems that have been allowed to shrivel (above), and with stems still green and turgid (below). Much of the moisture in a picked fruit is lost through the stem.

During maturation, the ground color changes gradually from green, through pale yellow, to light gold at full ripeness.

### Soluble Solids

Although the soluble-solids content of expressed juice is a fair index of maturity, in California, color is considered the more reliable index. In more than 800 samples from commercial orchards, soluble solids varied with the year of production, with the district in which the cherries were produced, and with the size of the crop on the trees.

Soluble solids are readily determined with a hand refractometer. Taste or flavor is a substitute for the actual measurement of solids because of the close association of flavor and sugar content. Quality in cherries does not improve after harvest, nor does the sugar content rise. For good quality in 'Bing' cherries, soluble

solids of about 19 percent are generally considered minimum, while 17 percent is satisfactory for 'Lambert'.

### Other Maturity Factors

Flesh firmness and elapsed time from full bloom both have been tested as methods of determining harvest maturity. Special pressure testers have been devised to determine the rate of softening of cherries as they approach maturity, but the rate of softening is so slow that the pressure test is not practical as a means of measuring maturity. Elapsed time from full bloom to optimum maturity is too variable from season to season to permit the employment of this factor, except to indicate approximately when harvesting operations should start.

Certain chemical treatments, in conjunction with nitrogen management, have potential for the control of harvest maturity and consequently more efficient use of available labor. SADH (succinic acid—2,2-dimethylhydrazide) at 500 to 2,000 p.p.m. advanced maturity of 'Lambert' cherries 4 or 5 days (4, 111). Similar advanced maturity was obtained from the same material at 1 or 2 lb. per 100 gal. water applied 2 weeks after bloom, but soluble solids were not increased correspondingly in unpublished Washington State experiments by Proebsting. Some deleterious side effects noted were slight advancement of blossoming, reduced fruit-bud hardiness, and increased fruit drop. In the same tests, gibberellic acid at 10 p.p.m. applied 3 weeks before harvest delayed maturity several days. These materials are not cleared for use at these timings, and any use should be experimental only. The apparent reduction in quality suggests caution until more suitable chemicals, concentrations, and timings are found for these potentially useful chemicals.

## FRUIT HANDLING

Cherries should be picked during the cool part of the day, if possible. In hot weather, transpiration from the trees is excessive. A water deficit may exist in the fruit late in the day, which will be expressed as severe pitting after a few days in storage or during market-

ing. To maintain fruit turgidity and minimize pitting, the orchard soil should be kept moist up to harvesttime.

After harvest, the cherries should be protected against moisture loss by keeping them in the shade while they are in the orchard. Covering them with moist canvas or other protective material is also advisable. If polyethylene is used to reduce moisture loss, an additional opaque cover should be used for shading the fruit (fig. 54). Exposure to sun or wind causes unnecessary transpiration and reduces the shelf life of the fruit. It is advisable not to leave the fruit in the orchard longer than necessary, but to haul it to the packing house or cold storage as promptly as is practical. The fruit should be covered during hauling, especially for long distances. Cherries hauled in open trucks may be covered with moistened canvas or similar materials (fig. 55). Sheets of plywood are effective protection against moisture loss when used as covers for pallet loads of cherries hauled in straddle carriers. Excellent results have been obtained by using closed trucks with blocks of ice for refrigeration and humidity. Upon delivery to the warehouse, the cherries should be placed immediately in cold storage and held there until they are packed. They should be covered in storage to reduce moisture loss.

Lugs of cherries that were covered with canvas and similar materials during the interval from harvest to packing lost from 0.4 to 1.0 percent of their weight through transpiration, while unprotected lugs of fruit lost from 1.8 to 2.1 percent of their weight during the same period (unpublished data). These figures vary with the climatic condition, the length of time the fruit remains in the orchard, the time during hauling, and the storage period before packing.

## PACKAGING

Cherries that are to be shipped to fresh-fruit markets are belt-sorted to remove rejects and are sized mechanically. The recent invention of cluster cutters has greatly advanced packing methods (fig. 56). As the fruit is carried along on moving belts, the clusters are cut apart by rotating saws or blades, and with

stems still attached, the individual cherries are then free to be mechanically sized by the use of diverging rollers (fig. 57).

Water is sprayed over the fruit for a lubricant during cutting and sizing, and it also functions as a wash. A fungicide is often in-

corporated into the final spray. Subsequent decay may be reduced 30 to 50 percent (87).

### Containers

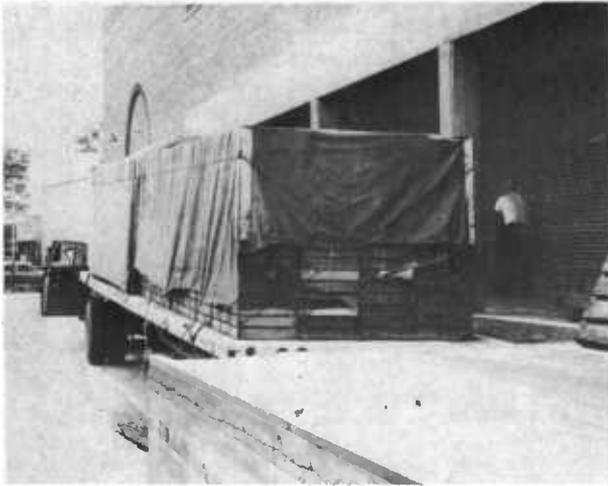
Most sweet cherries that are shipped for the fresh-fruit market from the western States are



PN-3112

FIGURE 54.—Harvesting cherries into a pallet bin. When bin is filled, the polyethylene film will be placed over fruit to reduce moisture loss, and the corrugated paper cover will be added to shade the fruit.

packed in boxes or lugs that hold 10 to 20 pounds of fruit. The double row-faced pack, which has been the standard pack in the west-

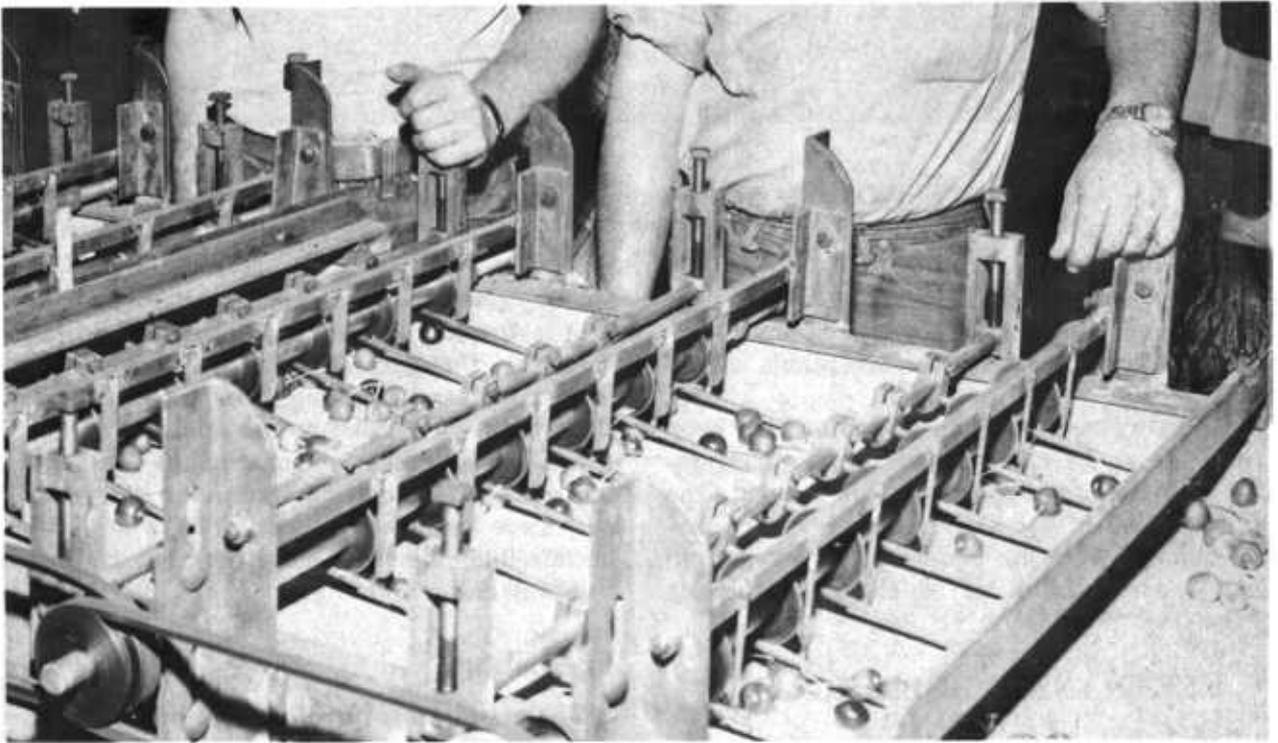


PN-3113

FIGURE 55.—Truckload of cherries covered with moistened canvas for protection during hauling to warehouse.

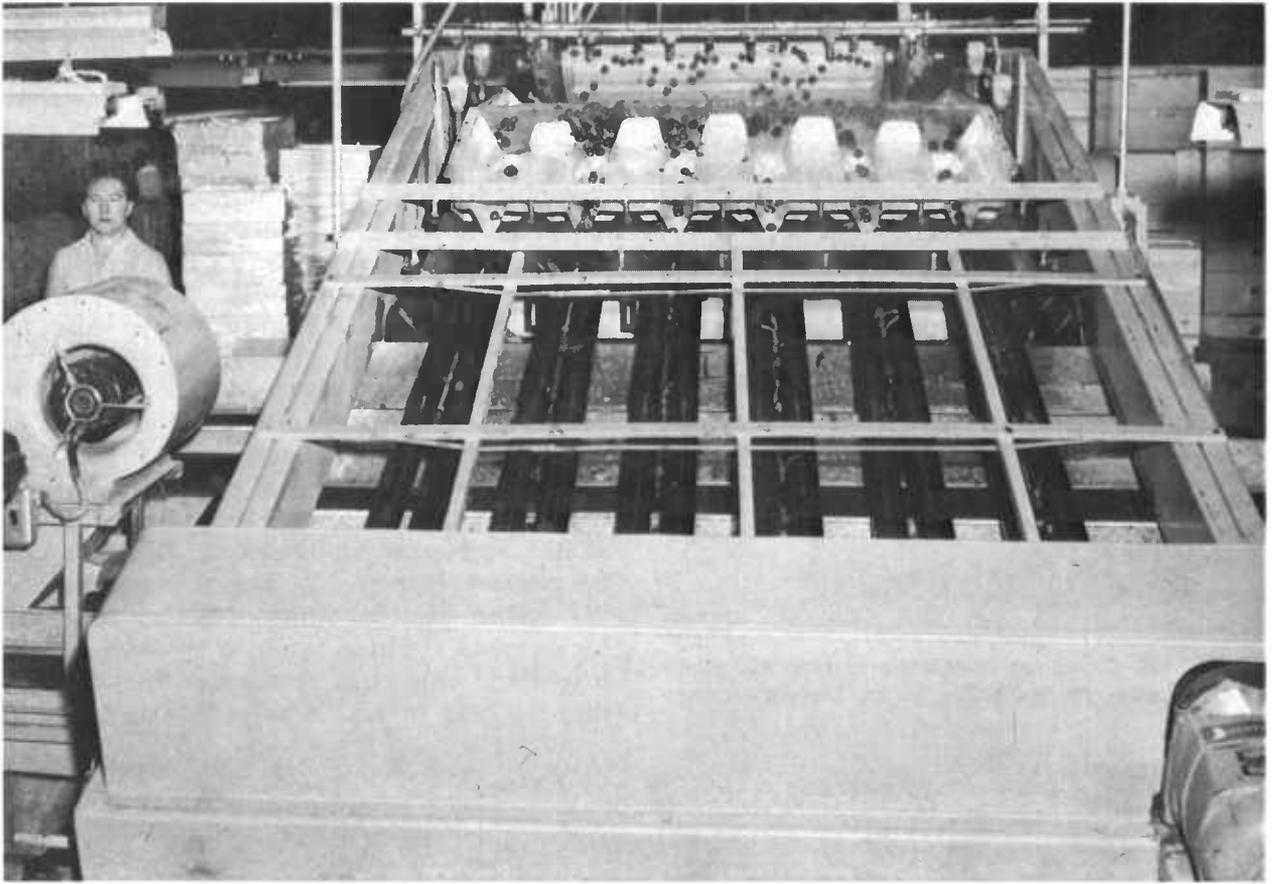
ern States for many years, holds 15 pounds of fruit and has inside dimensions of 3 x 11 x 18 inches. However, the automatic sizer lends itself to the easy and less expensive method of jumble packing from the belts that carry the sized cherries. Consequently, most cherries are now jumble packed into wooden boxes or divided fiberboard boxes that hold 20 pounds of fruit.

In the Pacific Northwest, sealed polyethylene liners are nearly always used with all types of boxes (fig. 58). Within the sealed "poly" liner, which is usually 1.25 or 1.5 mils thick, the atmosphere becomes modified as oxygen is consumed and carbon dioxide is liberated by the respiring fruit. Levels of carbon dioxide and oxygen within the sealed liners at 31° F. become stabilized at about 6.5 and 9.0 percent, respectively. Decay is retarded by the carbon dioxide, which, together with the high moisture within the liner, preserves fruit brightness and stem freshness. The cherries may be held in sealed polyethylene liners in



PN-3114

FIGURE 56.—Cherry-cluster cutter. The stems of the clusters ride up on the steel fingers and are cut apart by the rotating saws.



PN-3115

FIGURE 57.—Cherry sizer. The sized cherries drop through diverging rollers onto moving belts that carry fruit to the packing stations.

cold storage at 30° to 31° F. for 2 weeks after harvest and still be shipped by freight to eastern markets and arrive in acceptable condition.

The poly liners *must* be ripped or torn open when the packs are removed from refrigeration to higher temperatures. This prevents the accumulation of excessively high levels of carbon dioxide and the reduction of oxygen to very low levels, both of which are deleterious to the fruit (54, 55).

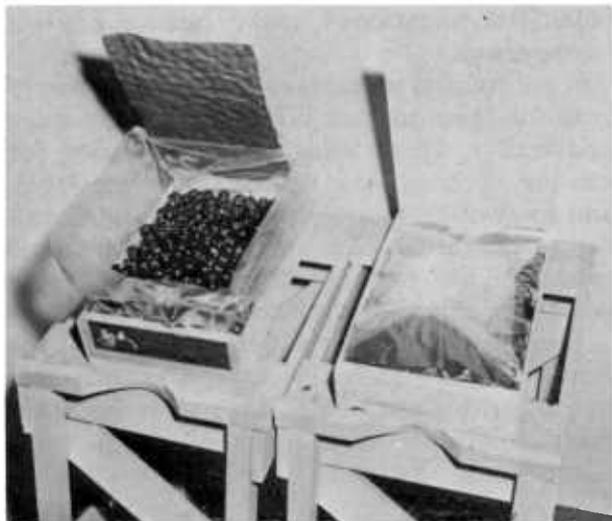
## PRETRANSIT HOLDING AND SHIPPING

Cherries should be cooled as soon as possible after harvest to provide the maximum length of storage life. Because cherries are very per-

ishable, prompt shipment after harvest is the best insurance of good quality to the consumer. However, the harvest season is short, and a large volume of fruit must be picked during a short time. To prevent market gluts, it is sometimes desirable to store some of the fruit until the marketing situation improves. In general, a storage period of about 14 days at 32° is permissible; this still allows enough time for shipping and marketing.

## Precooling

The rapid removal of field heat by refrigeration from produce before it is shipped is called precooling. It was advocated for western-grown sweet cherries in 1916 when it was observed that a substantial reduction in decay



PN-3116

FIGURE 58.—Lugs of cherries packed in polyethylene liners, before and after sealing.

occurred when cherries were precooled to 40° F. before a 10-day transit period (93).

The customary precooling procedure in the Pacific Northwest is to cool the lug boxes or bins of cherries overnight in cold-storage rooms to temperatures between 36° and 40° F. After they are packed the next day, the cherries are returned to cold storage, where they are cooled to approximately 32° before shipment. The rate of cooling is proportional to the air velocity. It is about 1.9 times faster in an air blast of 375 ft. per min. than in still air at 31° F. (53).

Pallet loads of cherries were cooled 1.9 to 6 times faster in a cooling tunnel where the air was passed over the fruit at a velocity of from 300 to 800 f.p.m. than in a room with auxiliary fans and an air velocity of 50 to 120 f.p.m. (112). When high-velocity air (1,790 to 2,685 f.p.m.) was directed into open, un-lidded individual lugs of cherries, the cooling rate was 9 to 40 times faster than room cooling.

Hydrocooling uses refrigerated water rather than air as the cooling medium. The fruit may be immersed into a tank of water, or water may be flooded over and through the fruit. The water may be cooled with crushed ice or with a mechanical refrigeration system. In either case,

the water temperature should be maintained as near 32° F. as possible. Loose cherries cool 145 times faster in ice water at 32° than packaged cherries in still air at 31° F. (53). Only seven minutes were required to cool cherries from 65° to 33.7° when they were immersed in an ice-water bath maintained at about 32°. There is some hesitancy by shippers to use hydrocooling for sweet cherries because of fear that the process may cause cracking and increase decay. However, cherries may be hydrocooled for at least 20 minutes without cracking or without appreciable increase in the amount of decay during subsequent transit at 40°. The appearance of the hydrocooled fruit is comparable to that of fruit cooled in air at 32° with a relative humidity of 85 percent (52).

Mechanically refrigerated cars are now available for much of the sweet-cherry crop of the western States. Although the cherries are usually at least partly precooled before they are loaded into cars, the mechanically cooled cars have sufficient refrigeration capacity to accomplish some additional cooling in transit.

## Shipping

About 28,000 tons of fresh sweet cherries are shipped from production areas in the Pacific Coast States in refrigerator cars during seasons of good crops. With the rapid increase in number of mechanical refrigeration cars in recent years, many are now available during the cherry-shipping season. By 1964, practically all the western-grown cherries were shipped in mechanical cars. Their use greatly simplifies shipping procedures, and their performance has been very satisfactory.

Before mechanical cars were available, standard and fan-equipped refrigerator cars were pre-iced to full bunker capacity before loading of the fruit was started. This was done to remove much of the heat from the car structure before the fruit was loaded into the car. The cherries were usually shipped under standard refrigeration, which means replenishing the ice at all regular icing stations en-route. Enough salt to equal 2 or 3 percent of the weight of ice placed in the bunkers was usually added at the initial icing and at each re-icing.

Formerly about 1,000 pounds of dry ice was placed in the doorway bracing after loading was completed, and additional dry ice was added to the bunkers at intervals in transit. The practice was primarily for the beneficial effects of the carbon dioxide gas, which evolved from the dry ice and which, if present in sufficient concentration, retarded decay development and preserved the bright color of the fruit. The effectiveness of the practice depended on the gas-tightness of the cars, little or no benefit being obtained in leaky cars.

The use of polyethylene liners in cherry packages, in which an effective level of carbon

dioxide is maintained, makes use of dry ice unnecessary.

A substantial percentage of the sweet-cherry crop for fresh market is transported by truck and trailer. Those vehicles that are used for hauling cherries long distances are insulated, and most of them are equipped with mechanical refrigeration. The refrigeration practices recommended for rail transportation apply equally to shipment by trucks.

Limited shipments of cherries from the Pacific Northwest to large terminal markets by air have been made. Such shipments are feasible only for large, premium-quality fruit.

## PROCESSING<sup>19</sup>

Sweet cherries are well adapted to a number of processing uses. About two-thirds of the total production in the United States is channeled into processing outlets. As high as 50 percent of the total production is brined. Therefore processing is an indispensable outlet to the industry. Particularly in areas where large fruit size is difficult to obtain for fresh markets, processing is the major, if not the only, outlet available. Even in the more favored producing areas, processing provides the necessary market for smaller sized fruit, which cannot be shipped profitably to distant fresh markets.

### BRINING

Brined cherries are properly matured, whole cherries of similar varietal characteristics packed in a solution of sulfur dioxide of sufficient strength to preserve the cherries, usually with the addition of hardening agents (136). The cultivars commonly used for brining are 'Bing', 'Lambert', 'Napoleon' (Royal Ann), and 'Republican'.

While it is possible to brine cherries at almost any stage of ripeness, best quality is obtained only at certain stages of maturity. Cherries for brining should not be overripe, since soft cherries may result, and blemishes

may reduce the amount of fruit suitable for U.S. No. 1 grade. If the cherries are picked too early, they will tend to have more seed in proportion to the amount of flesh and will be more difficult to pit cleanly.

Only cherries of good quality should be brined. Spoiled, damaged, belt-rejects, and other substandard fruit should not be used. Mildewed and overripe fruit will show blemished skin after brining and be difficult to bleach. Secondary bleaching permits salvage of blemished fruits, however. Fruits harvested mechanically should be brined immediately, in the orchard if possible (135).

### The Brine

Three brine formulations are in general use. Each is described in detail in ARS publication 74-123 (132). One method of formulating a suitable brine is described hereafter.

The following strengths of solutions have been found suitable for brining cherries:

Strength (percent)	SO <sub>2</sub> pounds per 100 gallons	Ca(OH) <sub>2</sub>
1	8.4	5
1¼	10.5	6¼
1½	12.6	7½

Hydrated lime should be fresh and unslaked. A lime with about 70 percent of available calcium oxide is suitable for this purpose. If SO<sub>2</sub> strength is lower than that desired, it will be necessary to add more SO<sub>2</sub>. The amount to add

<sup>19</sup> This section was prepared by H. Y. Yang, food technologist, Oregon Agricultural Experiment Station, Corvallis, Ore.

can be roughly calculated from the following formula:

$$\frac{\text{Percent difference} \times \text{gallons} \times 8.4}{100} = \text{lb.}$$

SO<sub>2</sub> to add, where percent difference is the percent SO<sub>2</sub> desired minus percent SO<sub>2</sub> found. Some briners modify this brine in anticipation of latent softening tendencies of the fruit, or simply as a safety factor against softening. This is usually done by use of additional calcium in the form of calcium hydroxide or calcium chloride. Great care must be exercised in altering the brine drastically. If too much calcium is used with firm brining fruit, the pits may cling so tightly that difficulty is encountered in the mechanical pitting operation. Drastic changes in pH of brine will be caused by excess lime, resulting in softening or cracking of fruit (147).

Where calcium chloride is used to provide extra calcium, in addition to that supplied by lime in the preparation of regular brine, the approximate amount to use will vary between 0.5 and 1.0 percent, that is, between 4 and 8

pounds of calcium chloride per 100 gallons. This is *in addition to the lime used*. The actual amount must depend on judgment concerning condition of the fruit.

Care should be taken to see that no iron comes in contact with the brine, since it will cause discoloration of the cherries during processing. Use stainless steel, wood, or concrete (fig. 59) for construction of tanks, vats, and equipment.

When the sulfur dioxide solution is made by bubbling, a perforated tubing is inserted to the bottom of the tank. Floating wooden lids may be used to keep the bubbles from breaking on the surface.

### Brining Process

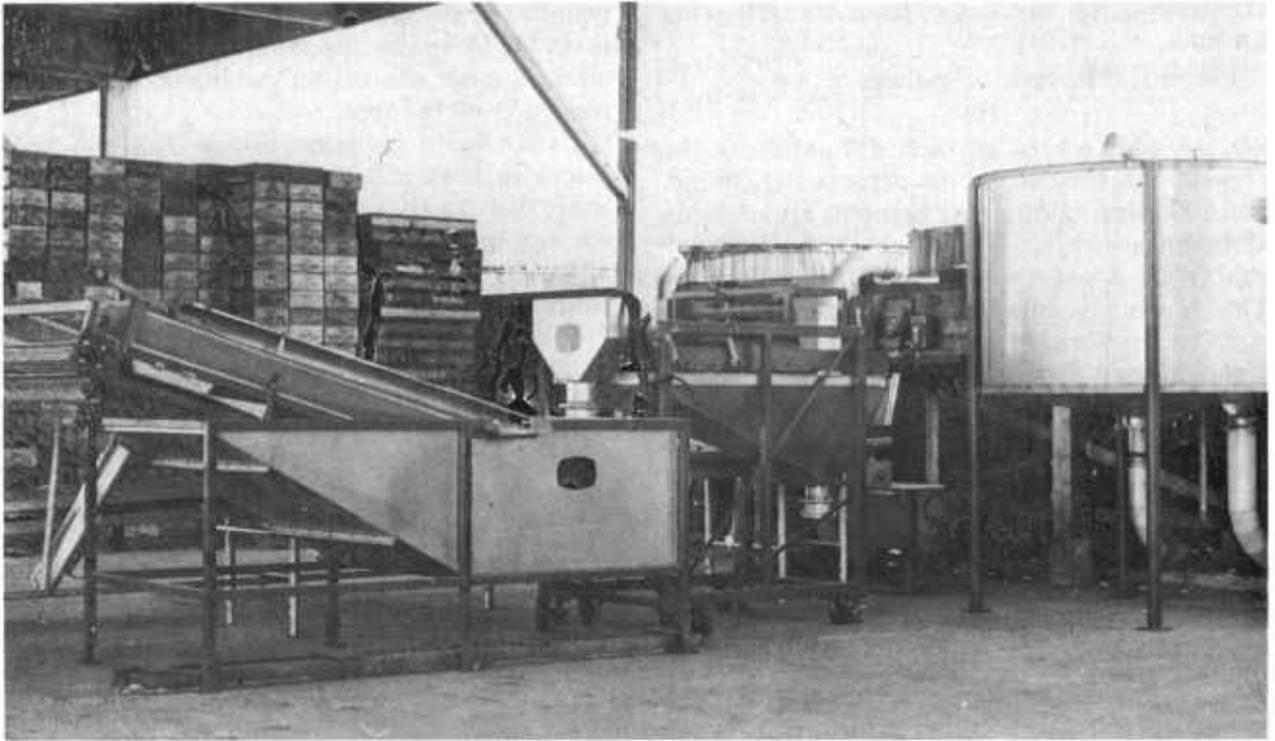
Cherries are washed with (fig. 60) or without detergent before they are placed into the brining solution.

In brining cherries, always partly fill the tank with brine before adding the fruit in order to minimize bruising or smashing the



PN-3117

FIGURE 59.—These storage tanks for brined cherries are constructed of redwood with fiberglass covers. The tanks stand on ground beneath the upper deck shown. They are 10 feet high and 16 feet in diameter. Each tank has a capacity of 13,000 gallons and holds 27 1/2 tons of cherries.



PN-3118

**FIGURE 60.**—In recent years, some cherry briners wash their cherries with dilute detergent solutions before brining. One type of washing equipment is shown here. Cherries are conveyed to the detergent tank shown in the center. They then go through a series of sprayers to remove the detergent before they are flumed to the brining tanks. Tank on right is for holding detergent solution.

fruit. Cherries should be covered with brine at all times. Because of temporary softening of cherries during the first 20 to 40 hours in brine, large tanks should only be half-filled until the fruits become firm. Otherwise cherries on the bottom of full tanks become distorted and damaged.

It is desirable to place a sheet of polyethylene film on the surface of the brine during the entire brining process. The film can be used on storage tanks of brined cherries that do not have permanent lids or on brine preparation tanks. It will prevent loss of sulfur dioxide by vaporization or dilution of the solution by rainwater. Place some  $\text{SO}_2$  solution or other suitable material on the polyethylene film to weight it down in order to maintain a good contact between the film and the brine surface. In windy areas, the film may have to be

cinched down by wooden frames or other devices. Use of the film cover depends on the individual briner's type of operation and physical setup. It is advisable to try the film first on one or two tanks to determine whether it is advantageous. Only high-quality food-grade polyethylene film should be used.

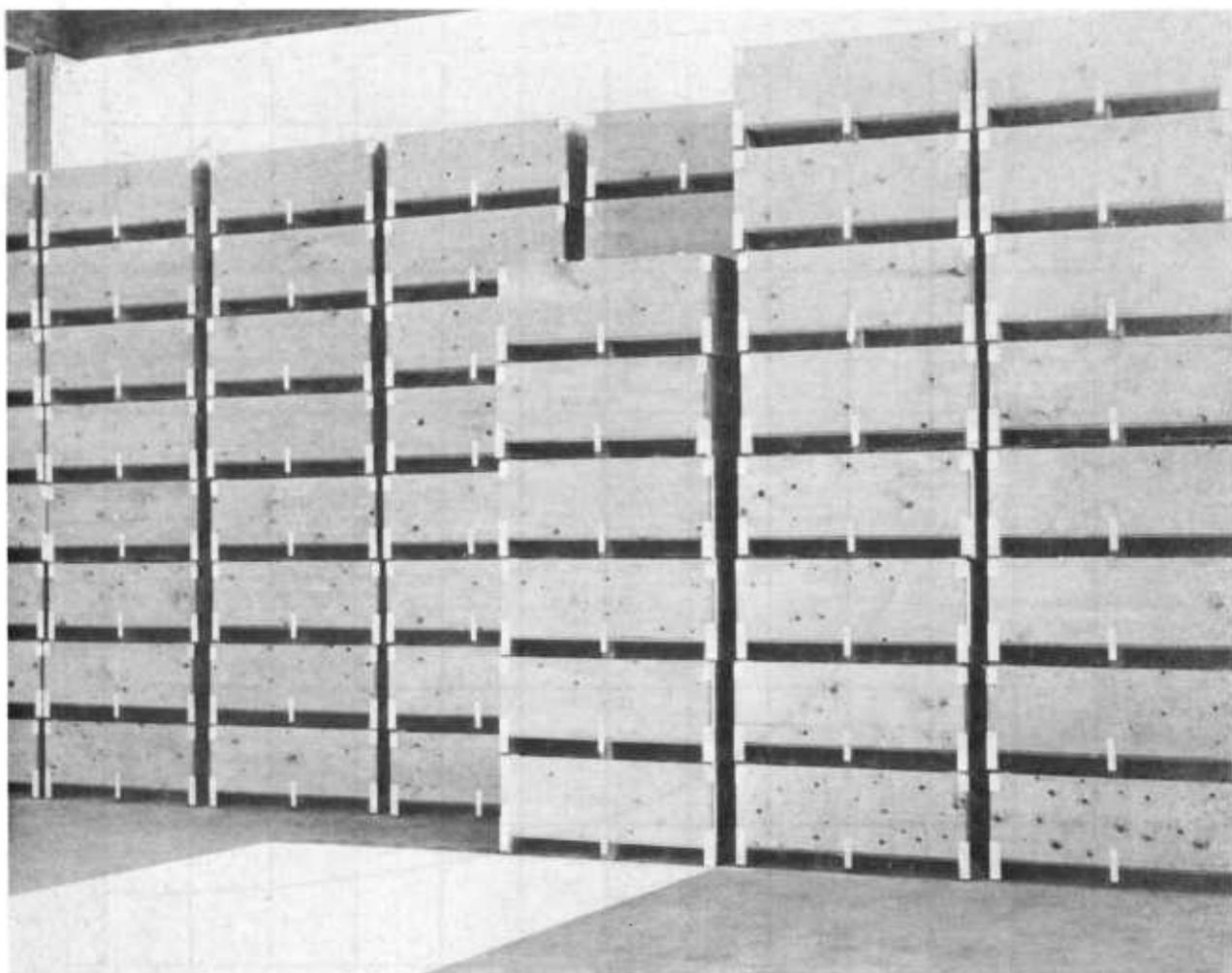
In recent years, some briners have used bulk boxes for holding and transporting brined cherries (fig. 61). These boxes are made of wooden staves, lined with heavy paper and 6-mil polyethylene film. A bung-hole is provided through the wooden lid to facilitate withdrawing or replenishing brine. Each box is about 4' x 4' x 2' high and holds approximately the equivalent of four barrels of brined cherries. The boxes are constructed for stacking and palleting. They are particularly useful when cherries are brined in the field.

### Testing the SO<sub>2</sub> Solution

Titration to determine the SO<sub>2</sub> content of brine often is done with 0.1 normal standard iodine solution, using a fixed amount of brine. Put 10 ml. of brine in a flask. Add 100 ml. of distilled water, a few drops of 1:3 sulfuric acid, and a few drops of starch indicator. Titrate with the iodine solution until a light blue color persists for about 30 seconds. One ml. of 0.1 normal iodine used is equivalent to 0.032 percent of SO<sub>2</sub> in the solution. By multi-

plying 0.032 by the number of ml. of iodine used, the percent of SO<sub>2</sub> in the brine is obtained.

An alternative method of testing the SO<sub>2</sub> solution can be used. Introduce 125 ml. of distilled water into a 500-ml. Erlenmeyer flask. Pipette 25 ml. of standard iodine solution (0.2 normal) into the flask. Add a few drops of starch solution (1 percent soluble starch) and titrate with the SO<sub>2</sub> solution from a burette or a graduated pipette. Shake the flask constantly. As the reaction nears completion, the color of the iodine solution becomes purple.



PN-3119

FIGURE 61.—Wooden tote boxes reinforced with corrosion-resistant metal brackets are used to hold and transport brined cherries. Heavy paper and plastic film are used as liners. Note that the boxes are constructed for stacking and palleting.

At this point, add the  $\text{SO}_2$  solution very slowly. At the point where one drop dispels the color from the iodine solution, stop the titration and read the volume used. Always read to the bottom of the curved surface of the  $\text{SO}_2$  solution in the burette or pipette.

Now refer to the chart (fig. 62) to obtain the strength of the  $\text{SO}_2$  solution. Move a pencil point to the right from the zero on the bottom line of the chart until the number of milliliters (ml.) of the  $\text{SO}_2$  solution used in the test is reached. Then move upward from the bottom of the chart until the curve is intersected. From this point of intersection, move the pencil point horizontally to the left edge of the

chart. Then read the strength of the  $\text{SO}_2$  solution from the vertical reference line at the left edge of the chart.

### Control and Observation

After cherries are brined, they should be observed daily (132). The  $\text{SO}_2$  content of the brine should be checked and the degree of bleach noted. Always keep in mind that there must be a quantity of free sulfur dioxide; otherwise, the product will spoil. Tying up all the sulfur dioxide with lime should, by all means, be avoided. The  $\text{SO}_2$  concentration should be maintained at about  $\frac{3}{4}$  percent during storage and shipping.

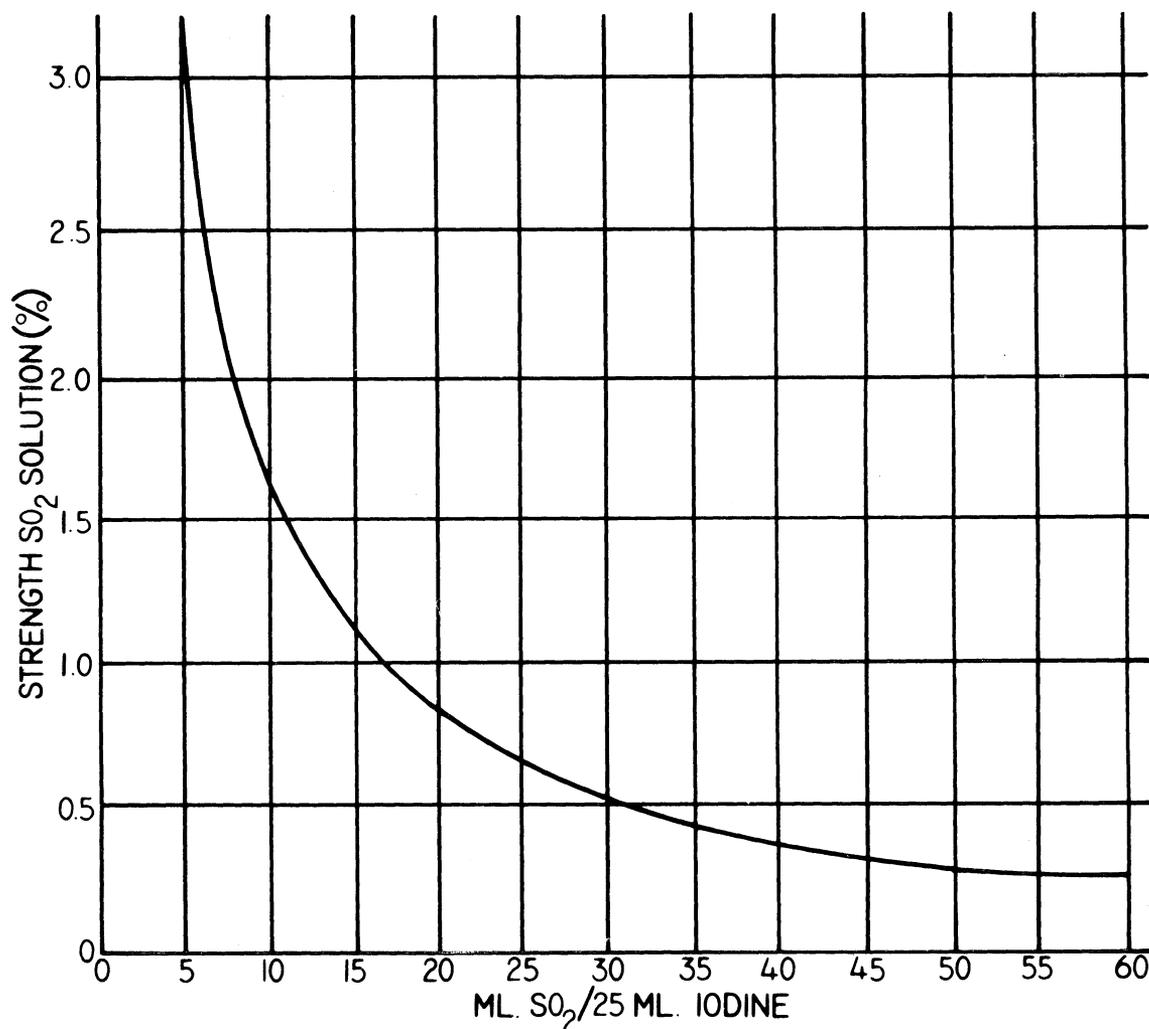


FIGURE 62.—Titration curve for  $\text{SO}_2$  solution. Strength of the  $\text{SO}_2$  solution is determined from milliliters of  $\text{SO}_2$  required to titrate 25 ml. of standard iodine solution (0.2 normal).

Calcium content and pH of the brine should be measured periodically (132).

## Secondary Bleaching

Secondary oxidative bleaching may be desirable for better decolorization of dark-fleshed cultivars of cherries such as 'Bing' and 'Windsor' and for the removal of browning caused by blemishes (130).

Sodium hypochlorite plus acetic acid yields snow-white cherries of good texture. Hydrogen peroxide, 1-percent level and pH 11.5, for 15 to 20 hours at room temperature was found satisfactory as a secondary bleach for SO<sub>2</sub>-bleached 'Windsor' cherries.

Sodium chlorite at 0.75 percent and pH adjusted to 4.0 to 6.0 with 1.0 N acetic acid has been found satisfactory for secondary bleaching of "Royal Ann" cherries, with no loss in texture or development of off-flavors in the finished product (5).

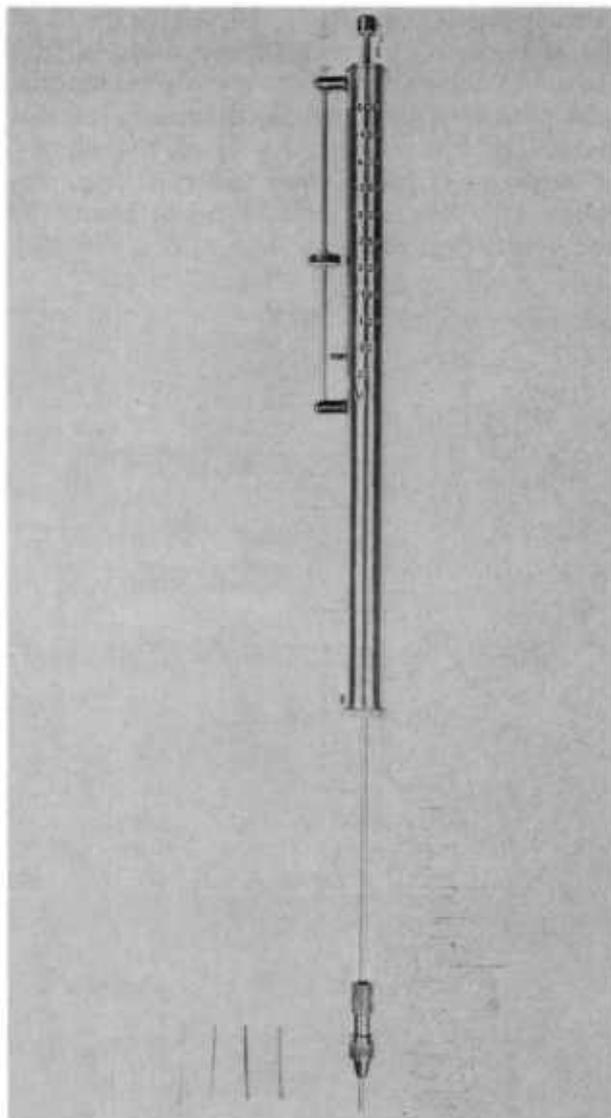
## Defects

Definition of some terms commonly used is necessary.

These are:

1. *Soft cherries*.—While a few soft cherries may normally be expected from each batch, severe softening of brined cherries has been observed occasionally (72, 110, 119). This type of softening has been attributed to a pectin-degrading enzyme. The pectic substances in the cherries are attacked by this enzyme during the brining storage period and then are so badly degraded that they are no longer capable of forming firm calcium pectate gels within the cherries (146, 148). Texture measurements enable the processor to follow the course of the firming process. If the rate of increase in firmness levels off too soon or the fruits start to soften, the processor is alerted to take corrective action.

Firmness of cherries may be checked with a puncture gage similar to the one shown (fig. 63). It is a spring-push gage with a scale of 0–500 g. or 0–1,000 g. pressure, complete with steel points of various sizes. To use the gage, follow directions supplied by the manufacturer. Test about 50 cherries from different parts of



PN-3120

FIGURE 63.—Texture tester, equipped with various sizes of steel points.

each tank and average the results. An arbitrary scale can be set up to show the relation between gage readings and cherry firmness as determined by observations.

2. *Mechanical Injury*.—Any open pitter hole, or holes measuring more than 1/8 inch across in the aggregate; any pitter hole where there is a material loss of flesh; any pitter tears; or any other mechanical injury that materially affects the appearance of the cherry.

3. *Surface Discoloration*.—Any light surface

discoloration exceeding in the aggregate  $\frac{1}{8}$  of the surface of the cherry; any dark surface discoloration exceeding in the aggregate the area of a circle  $\frac{3}{16}$  inch in diameter, but not exceeding in the aggregate  $\frac{1}{8}$  of the surface of the cherry. Electronic color-sorting machines (fig. 64) are used to reject blemished and unbleached cherries.



PN-3121

FIGURE 64.—Various types of electronic sorting machines are used for color sorting of brined cherries. This is a reflective measurement type, in which the cherries are fed through a vibrating tray to a chute, where they singulate by gravity. Three viewers, each with a changeable standard background  $120^\circ$  apart, compare the object in free fall. If a brined cherry has an unbleached or blemished area, it is ejected by a blast of compressed air signaled to occur  $1\frac{1}{2}$  inches after viewing.

4. *Rain Cracks*.—Any cracks in the stem basin more than  $\frac{1}{4}$  inch in length, or outside the stem basin more than  $\frac{3}{16}$  inch in length, measured on the circumference.

5. *Blemishes*.—Insect injury, bird peck, limb rub, hailmark, sunburn, solution crack, or any other blemish or combination of blemishes that materially affects the appearance of the cherry; also any cherry, the flesh of which is materially discolored.

## Sizes

The following sizes are considered as standards for all grades of brined cherries, except for halved cherries:

1. Extra Small: 14 mm. to, and including, 16 mm.
2. Small: 16 mm. to, and including, 18 mm.
3. Medium: 18 mm. to, and including, 20 mm.
4. Large: 20 mm. to, and including, 22 mm.
5. Extra Large: Over 22 mm.

Mechanical size-graders (fig. 65) are used to sort brined cherries into these size groups rapidly.

## Grades

Grade standards are described in "United States Standards for Grades of Sulfured Cherries", published in 1951 by U.S. Department of Agriculture, Agricultural Marketing Service and reprinted in Federal Register 7954, Dec. 9, 1953. The producing States use the Federal or slightly modified State grade standards. The processor should be familiar with all applicable grade standards for his area and comply rigidly with them. In general, these grades are separated as follows:

*U.S. Grade A*, or *U.S. Fancy*, consists of properly matured cherries from similar cultivars that are clean, firm, well-formed, and well-bleached. The cherries must be free from defects caused by mechanical injury, surface discoloration, rain cracks, blemishes, or other means.

*U.S. Grade B*, or *U.S. Choice*, consists of properly matured cherries from similar cultivars that are clean, fairly firm, well formed and fairly well bleached. The cherries shall be



PN-3122

FIGURE 65.—Size-grader. Brined cherries are graded for size over vibrating perforated screens. Graded cherries are discharged through separate chutes.

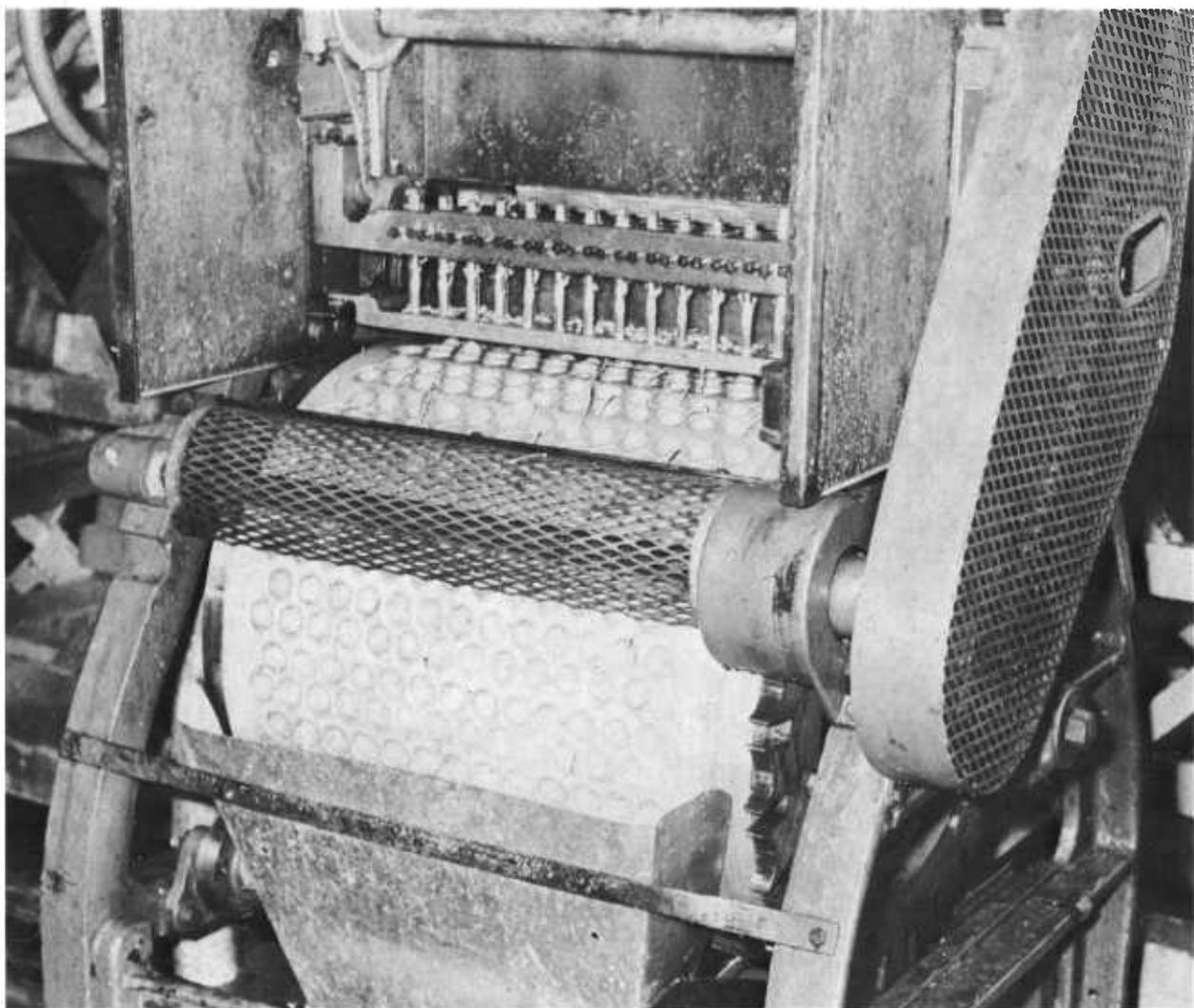
free from serious defects caused by mechanical injury, surface discoloration, rain cracks, blemishes, or other means.

Most cherry briners do not separate grades A and B, but offer a combination of the two grades. The combination grade must have at least 90 percent (by weight) of the cherries reasonably well colored and free from misshapen fruit or blemishes, and at least 50 percent with good color and free from misshapen fruit or blemishes.

*U.S. Grade D*, or "*seconds*", consists of cherries that are clean, but for other reasons fail to qualify for *U.S. Grade B*.

## MARASCHINO

After 4 to 6 weeks of storage, brined cherries are ready for processing into maraschino cherries (60, 67). They are removed from the brine and rinsed in water. The cherries are then pitted (fig. 66) and stemmed (fig. 67), although in some instances stems are left on the cherries intentionally. Unstemmed cherries are called cocktail style. The pitted fruit is leached in running water to remove the  $\text{SO}_2$ . A rubber or plastic tube is inserted to the bottom of the container, and a stream of water is allowed to flow through it for about 24 hours or until the desired level of  $\text{SO}_2$  is reached.



PN-3123

**FIGURE 66.**—Cherry pitter. Brined cherries are pitted before leaching. Cherries are seated in the rubber cups, and the plungers remove pits one row at a time. This machine pits 700 pounds of large cherries and 400 pounds of small cherries, with an average of 500 pounds, per hour.

The cherries are then dyed (19) with a food dye such as erythrosine (known as FD&C Red No. 3). Erythrosine is soluble at a pH of 4.5 or higher and precipitates in the tissue of fruit at lower pH. This means that the color will not leach out or "bleed" to color other fruits with which the cherries may be used (14), in such mixtures as canned fruit salad or cocktail. The pH adjustment can be made with sodium bicarbonate to increase, and citric acid to decrease, the pH. The cherries are boiled for about 20

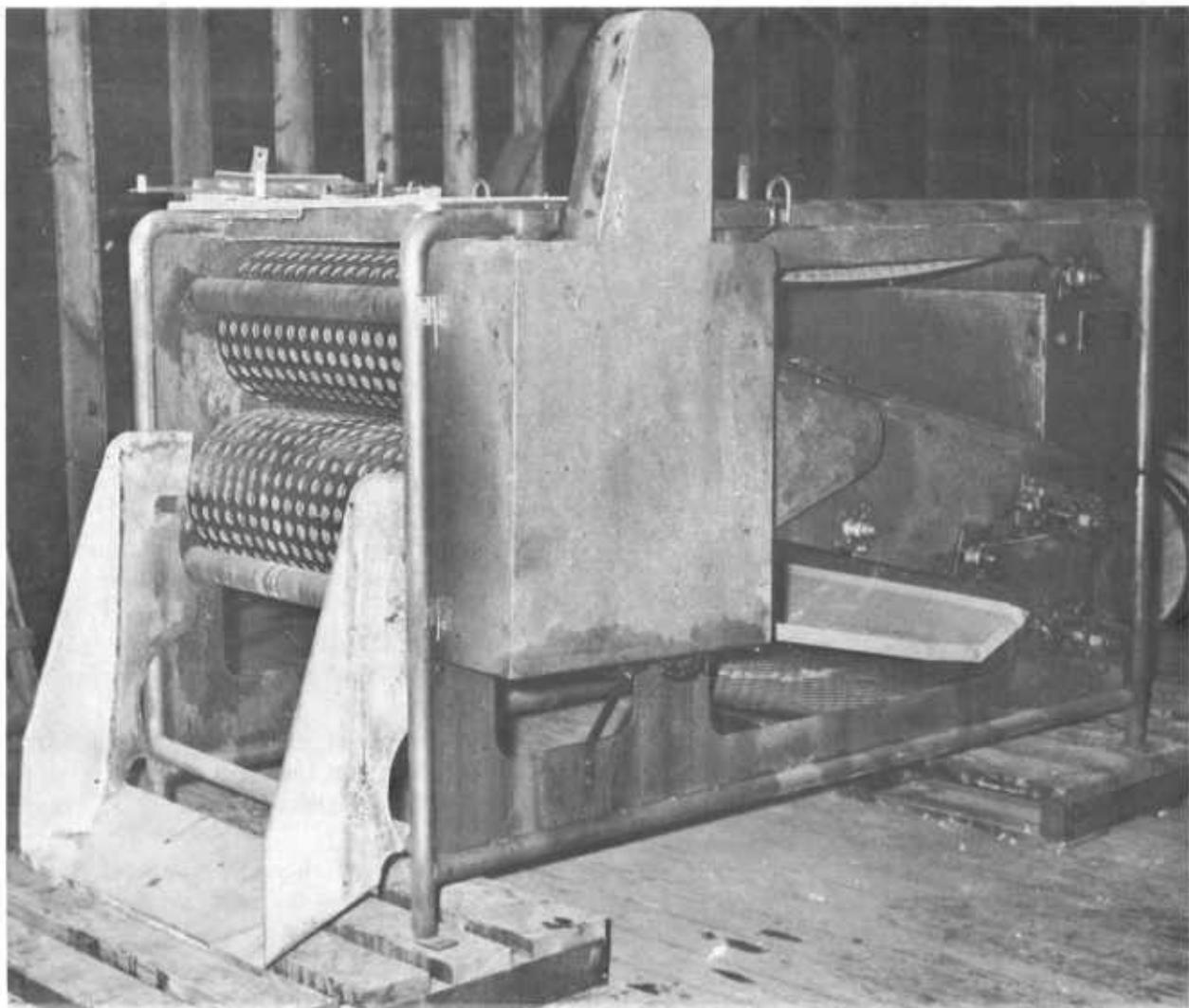
minutes in a 0.025 to 0.050 percent erythrosine solution of pH 4.5 or higher. Use enough solution to cover all the cherries. After cherries and dye solution have cooled together for 24 hours, 0.25 to 0.50 percent citric acid by weight is added to bring the pH of the solution to 4.2, and the boiling and standing procedures are repeated in order to set the dye. The cherries are then rinsed in water to remove all dye particles from the surface and pit cavities. The dyed cherries are now boiled in a 30° Brix

sirup for 5 to 10 minutes, then are left to stand for 24 hours, during which time the sirup is absorbed. The sirup is removed by draining, sugar is added to it to increase the Brix reading to 40°, and imitation maraschino cherry flavor is added. The sirup is returned to the cherries, and the entire content is brought to boiling, then is packed hot and sealed in glass jars. Sodium benzoate, 0.1 percent or less, may be used as a preservative, if necessary.

If the cherries are to be used with other

fruits, as in canned fruit salad or cocktail, they are not siruped, but are sliced or quartered after dyeing.

FD&C Red No. 4 (Ponceau SX) has been used for coloring maraschino cherries for some time. It has a brilliant red color with unusual resistance to the destructive influences of food ingredients and heat. Presently, the FDA legal status for Red No. 4 is as follows: "It may be used in food only for the coloring of maraschino cherries at a level not to exceed



PN-3124

FIGURE 67.—Stem remover. While several types of stem removers are available, this one is widely used on brined cherries. Rubber cups on the large rotating rollers hold cherries while the small rollers knock the stems off the fruit. Cherries are then inspected on belts.

150 parts per million by weight of the maraschino cherries. Such weight shall not include packing media, or in the case of candied maraschino cherries, added sugar." Users of food colors should consult with the FDA regarding the current status of such colors, since regulations are changed frequently.

Ponceau is a soluble dye. It can be dissolved in the sirup directly. A 30° Brix sirup containing 0.5 percent citric acid is prepared and the desired amount of Ponceau added (note FDA rule given previously). The bleached cherries are boiled with the sirup for 5 to 10 minutes and are left to stand for 24 hours. After that, the same procedure described above for erythrosine is followed.

A dye called Allura Red recently was approved by FDA for coloring maraschino cherries. This color is said to be sensitive to sulfur dioxide residue in brined and leached cherries. Likewise FDA should be consulted before this dye is used.

The presence of artificial flavor, approved color, citric acid, and sodium benzoate (if used) must be declared on the label.

## GLACÉ

The manufacture of glacé cherries may be considered as a continuation of the maraschino process. Before the flavoring material is added, the sirup buildup procedure is repeated on succeeding days, with an increase of 10° Brix each day until the sirup has reached approximately 72° Brix. Sucrose and dextrose (or corn sirup) are used in equal weights to increase the sirup concentration. The cherries are held in the 72° Brix sirup at least three weeks for the sirup to penetrate into the cherries. Dextrose is used because it prevents the cherries from becoming hard and granular (123).

The cherries are then dried with a thin coat of the sirup on them. Drying is done on screens at 120° to 140° F., until the cherries are no longer sticky.

Various modifications have been introduced in the preparation of glacé cherries, mainly to shorten the sirup-penetration process from one day to a few hours. It is done by maintain-

ing the sirup at 140° to 150° F. instead of room temperature (3).

## CANNING

Sweet cherries such as 'Napoleon', 'Bing', 'Lambert', 'Van', and 'Black Republican' cultivars are canned without pitting (20). They are, however, stemmed by hand or by mechanical stemmers. Following the stemming, the fruit is thoroughly washed (116).

The cherries are usually graded for the following sizes:  $2\frac{0}{32}$  (16 mm.),  $2\frac{2}{32}$  (17 mm.),  $2\frac{3}{32}$  (18 mm.),  $2\frac{6}{32}$  (20 mm.),  $2\frac{8}{32}$  (22 mm.), and  $3\frac{3}{32}$  (26 mm.) inch.

Cherries are canned in sirups ranging in concentration from 0° to 35° Brix. They are exhausted for about 10 minutes at 165° to 185° F. Type L cans are used to eliminate corrosion (71). Plain tin cans are often used for light-fleshed cultivars such as 'Napoleon' and 'Rainier'.

Filled and sealed cans are heated for 12 to 25 minutes at 212° F. The length of sterilization depends primarily on the size of the can: For No. 303 cans, 12 minutes; No. 2 cans, 15 minutes; No. 2½ cans, 18 minutes, and No. 10 cans, 25 minutes.

The standard of quality for canned cherries is as follows:

(1) For pitted cherries, not more than 1 pit is present in each 20 ounces of canned cherries;

(2) For unpitted cherries, the weight of each cherry in the container is not less than  $\frac{1}{10}$  ounce;

(3) For unpitted cherries, the weight of the largest cherry in the container is not more than twice the weight of the smallest cherry therein;

(4) For unpitted cherries, the total weight of pits is not more than 12 percent of the weight of drained cherries; and

(5) Not more than 15 percent by count of the cherries in the container are blemished with scab, hail injury, discoloration, scar tissue, or other abnormality. A unit showing skin discoloration having an aggregate area not exceeding that of a circle  $\frac{3}{16}$  inch in diam-

ter and not extending into the fruit tissue shall not be considered as blemished.

If the quality of canned cherries falls below the standard prescribed above, the label shall bear the general statement of substandard quality.

### FREEZING

While most frozen cherries are of the sour cultivars, sweet cherries such as 'Bing' and 'Black Republican' may be frozen for commercial distribution (56, 109).

The cherries are pitted and packed with 1 part of dry sugar to 3 to 4 parts of cherries. Containers such as barrels, large friction-top cans, large plastic bags in strong paper cartons, are suitable for this purpose. Cherries should be frozen quickly (150) and stored at 0° F. or lower.

### DEHYDRATING

Sweet cherries, being higher in soluble solids content, may be blanched without collapsing as do the sour cultivars. Blanch the washed and pitted cherries in steam for about seven minutes at 180° to 200° F. before dehydration. Blanching will take the place of sulfuring ordinarily employed for sour cherries (137).

Cherries are dehydrated on trays in tunnel dehydrators with wet-bulb temperature maintained at 90° to 92° F. and dry-bulb 145° to 150° F. The drying time is from 18 to 27 hours, depending on tray load, air velocity, and other factors involved in the construction

of the dehydrator (79). Sweet cherries should be dried to a moisture level of 18 to 22 percent.

It is important to keep the trays clean to prevent the dehydrated cherries from sticking.

### PICKLING

Washed and pitted cherries may be pickled with or without stems attached, by boiling in a solution containing sugar, vinegar, and spices such as cinnamon stick, allspice, mace, clove, and ginger root. The amount of each ingredient can be varied according to taste. Recipes used for cucumber pickles may be adapted for this purpose. Put whole spices in a cloth bag to facilitate removal from the solution. Solubilized spice oils and extracts are also available and may be used in place of whole spices if desired. Pack boiling hot into jars and let stand for about two weeks to become well-blended before using.

### OTHER USES

Although cherry juice, cider, and wine are made from sour cherries such as the 'Montmorency' cultivar, a blend of sweet and sour cultivars will also produce a desirable product. It is not necessary to remove the pits before pressing for juice. The pit of cherries provides a characteristic almond flavor, which is enjoyed by many, to the juice.

Cherry cider or wine is pressed from fruit after fermentation. Straight sweet cherries do not contribute the characteristic cherry flavor and should be used only as a blend with sour cherries for making wine (149).

### LITERATURE CITED

- (1) AFANASIEV, M. M., and HAMILTON, R. I. 1965. SHORT STEM VIROSIS OF SWEET CHERRIES. U.S. Dept. Agr., Plant Dis. Rprtr. 49: 253-255.
- (2) ANDERSON, H. W. 1956. DISEASES OF FRUIT CROPS. 501 pp. McGraw Hill, N.Y.
- (3) ATKINSON, F. E., and STRACHAN, C. C. 1940. CANDYING OF FRUIT IN BRITISH COLUMBIA WITH SPECIAL REFERENCE TO CHERRIES. Fruit Prod. Jour. 20: 132-135, 166-169, 199-201, 229-232, 262-264, 310-312.
- (4) BATJER, L. P., WILLIAMS, M. W., and MARTIN, G. C. 1964. EFFECTS OF N-DIMETHYL AMINO SUCCINAMIC ACID (B-NINE) ON VEGETATIVE AND FRUIT CHARACTERISTICS OF APPLES, PEARS AND SWEET CHERRIES. Amer. Soc. Hort. Sci. Proc. 85: 11-16.
- (5) BEAVERS, D. V., and C. H. PAYNE. 1969. SECONDARY BLEACHING OF BRINED CHERRIES WITH SODIUM CHLORITE. Food Tech. 23: 175-177.

- (6) BLANE, F. L., and KEIFER, H. H.  
1955. THE CHERRY FRUIT FLY IN NORTH AMERICA. Calif. State Dept. Agr. Bul. 44 (2): 77-78.
- (7) BLODGETT, E. C.  
1943. THE RASP LEAF OF SWEET CHERRY. Phytopathology 33: 620-622.
- (8) ——— JENKINS, PHIL, and AICHELE, MURIT D.  
1965. A SPUR TYPE GROWTH OF BING CHERRY CAUSED BY A VIRUS. U.S. Dept. Agr., Plant Dis. Rptr. 49 (11): 910.
- (9) BODINE, E. W., and NEWTON, J. W.  
1942. THE RASP LEAF OF SWEET CHERRY. Phytopathology 32: 333-335.
- (10) BRADT, O. A., RICKETSON, C. L., and OTHERS.  
1968. NEW FRUIT CULTIVARS FROM ONTARIO, CANADA. Fruit Vars. & Hort. Digest 22 (4): 73-75.
- (11) BROOKS, R. M., and GRIGGS, W. H.  
1964. FIVE NEW SWEET CHERRY VARIETIES RECOMMENDED FOR COMMERCIAL TRIAL. Calif. Agr. Expt. Sta. Bul. 806, 22 pp.
- (12) ——— and OLMO, H. P.  
1972. REGISTER OF NEW FRUIT AND NUT VARIETIES. 2d ed. 708 pp. Univ. Calif Press, and suppl. lists 21-27 HortScience 6: 439-442, 1971 and 7: 455-460, 1972.
- (13) BULLOCK, R.M.  
1952. A STUDY OF SOME INORGANIC COMPOUNDS AND GROWTH PROMOTING CHEMICALS IN RELATION TO FRUIT CRACKING OF BING CHERRIES AT MATURITY. Amer. Soc. Hort. Sci. Proc. 59: 243-253.
- (14) BUTLAND, P.  
1952. DARKENING OF MARASCHINO AND GLACÉ CHERRIES. Food Tech. 6: 208-209.
- (15) CAMERON, H. R.  
1962. MODE OF INFECTION OF SWEET CHERRY BY *p. syringae*. Phytopathology 52: 917-921.
- (16) ———  
1962. DISEASES OF DECIDUOUS FRUIT TREES INCITED BY *pseudomonas syringae*. Oreg. Agr. Expt. Sta. Tech. Bul. 66, 64 pp.
- (17) ———  
1970. PSEUDOMONAS CONTENT OF CHERRY TREES. Phytopathology 60: 1343-1346.
- (18) ———  
1971. EFFECT OF ROOT OR TRUNK STOCK ON SUSCEPTIBILITY OF ORCHARD TREES TO *pseudomonas syringae*. U.S. Dept. Agr., Plant Dis. Rptr. 55: 421-423.
- (19) CAMPBELL, C. H.  
1950. CAMPBELL'S BOOK: A MANUAL ON CANNING, PICKLING AND PRESERVING. Ed. 3, 222 pp. Vance Publishing Corp., Chicago.
- (20) CARTER, G. H., INGALSHE, D. W., and OTHERS.  
1955. FRESH-FRUIT AND CANNING QUALITIES OF SOME SWEET CHERRY VARIETIES. Wash. State Hort. Assoc. Proc. 51: 102-105.
- (21) CHENEY, P. W., and PARISH, C. L.  
1969. A GRAFT-TRANSMISSIBLE BLOSSOM ANOMALY OF CHERRY. (Abstract) Phytopathology 59: 10.
- (22) ——— PARISH, C. L., and COYIER, D. L.  
1970. HOST RANGE STUDIES OF THE CHERRY SHORT STEM VIRUS FROM OREGON. U.S. Dept. Agr., Plant Dis. Rptr. 54: 651-655.
- (23) COCHRAN, L. C.  
1946. PASSAGE OF THE RINGSPOT VIRUS THROUGH MAZZARD CHERRY SEEDS. Science 104: 269-270.
- (24) COE, D. M.  
1943. REPORT OF THE 1942 STONE FRUIT VIRUS SURVEY IN WASHINGTON. Wash. State Dept. Agr. Bul. 2, 19 pp. illus.
- (25) COE, F. M.  
1945. CHERRY ROOTSTOCKS. Utah Agr. Expt. Sta. Bul. 319, 43 pp.
- (26) CRANE, M. B., and LAWRENCE, W. J. C.  
1947. THE GENETICS OF GARDEN PLANTS. Ed. 3, 299 pp., MacMillan & Co., Ltd., London.
- (27) CROSSE, J. E.  
1966. EPIDEMIOLOGICAL RELATIONS OF THE PSEUDOMONAD PATHOGENS OF DECIDUOUS FRUIT TREES. Ann. Rev. Phytopath. 4: 291-310.
- (28) DAVIDSON, T. R., and GEORGE, J. A.  
1964. SPREAD OF NECROTIC RINGSPOT AND SOUR CHERRY YELLOWS VIRUSES IN THE NIAGARA PENINSULA ORCHARDS. Canad. Jour. Plant Sci. 44:471-484.
- (29) DAY, L. H.  
1951. CHERRY ROOTSTOCKS IN CALIFORNIA. Calif. Agr. Expt. Sta. Bul. 725, 31 pp.
- (30) DE CANDOLLE, A.  
1890. ORIGIN OF CULTIVATED PLANTS. 207 pp. Appleton Inc., New York.
- (31) DE VAY, J. E., LINDEN, S. L., and OTHERS.  
1968. PORIA ROOT AND CROWN ROT OF CHERRY TREES. Phytopathology 58: 1239-1241.
- (32) ——— LUKEZIE, F. L., and OTHERS.  
1968. CERATOCYTTIC CANKER OF DECIDUOUS FRUIT TREES. Phytopathology 58: 949-956.
- (33) DICKSON, G. H.  
1959. THREE NEW SWEET CHERRY VARIETIES FROM CANADA. Fruit Vars. & Hort. Digest 13 (4): 61.
- (34) EASTHAM, J. W.  
1941. REPORT OF THE PROVINCIAL PLANT PATHOLOGIST. Brit. Columbia Dept. Agr. Ann. Rpt. 35: 49-56.

- (35) EATON, G. W.  
1959. A STUDY OF THE MEGAGAMETOPHYTE IN *P. avium* AND ITS RELATION TO FRUIT SETTING. *Canad. Jour. Plant Sci.* 39: 466-476.
- (36) ———  
1963. FURTHER STUDIES ON SWEET CHERRY EMBRYO SACS IN RELATION TO FRUIT SETTING. *Ont. Hort. Expt. Sta. and Prod. Lab. Rpt.* 1962: 26-38
- (37) EICHMANN, R. D.  
1936. THE CHERRY APHID AND CHERRY MAGGOT OF THE FLATHEAD VALLEY. *Mont. Agr. Expt. Sta. Bul.* 313, 40 pp.
- (38) ELLIOTT, H. N.  
1961. THE STARLING THREAT IN THE NORTHWEST. *Wash. State Hort. Assoc. Proc.* 57: 97-99.
- (39) FLEISHER, Z., BLODGETT, E. C., and AICHELE, M. D.  
1964. PRESENCE OF VIRUS (NECROTIC RINGSPOT) IN MAZZARD AND MAHALEB SEEDLINGS GROWN IN THE PACIFIC NORTHWEST FROM VARIOUS SEED SOURCES. *U.S. Dept. Agr., Plant Dis. Rptr.* 48: 280-281.
- (40) FOGLE, H. W.  
1955. GIRDLING SWEET CHERRY SEEDLINGS FOR EARLY FRUIT PRODUCTION. *Fruit Vars. & Hort. Digest* 10 (4): 55-56.
- (41) ———  
1958. INHERITANCE OF FRUIT COLOR IN SWEET CHERRIES (*P. avium*). *Jour. Hered.* 49: 294-298.
- (42) ———  
1958. EFFECTS OF DURATION OF AFTER-RIPENING, GIBBERELLIN AND OTHER PRETREATMENTS ON SWEET CHERRY GERMINATION AND SEEDLING GROWTH. *Amer. Soc Hort. Sci. Proc.* 72: 129-133.
- (43) ———  
1962. CURRENT STATUS OF THE NEWER STONE FRUIT VARIETIES. *Wash. State Hort. Assoc. Proc.* 58: 35-38.
- (44) ——— HANSON, K. W., and OTHERS  
1961. SOURCES OF PROPAGATING WOOD FOR CHERRY VARIETIES AND SPECIES IN THE UNITED STATES AND CANADA. *Fruit Vars. & Hort. Digest* 16: 2-11.
- (45) ——— and McCrory, C. S.  
1960. EFFECTS OF CRACKING, AFTER-RIPENING AND GIBBERELLIN ON GERMINATION OF LAMBERT CHERRY SEEDS. *Amer. Soc. Hort. Sci. Proc.* 76: 134-138.
- (46) FOSTER, W. R., and LOTT, T. B.  
1947. LITTLE CHERRY, A VIRUS DISEASE. *Sci. Agr.* 27: 1-6, illus.
- (47) FRICK, K. E., SIMKOVER, H. G., and TELFORD, H. S.  
1954. BIONOMICS OF THE CHERRY FRUIT FLIES IN EASTERN WASHINGTON. *Wash. Agr. Expt. Sta. Tech. Bul.* 13, 66 pp.
- (48) FRIDLUND, P. R.  
1963. PREVALENCE OF GREEN RING MOTTLE VIRUS IN WASHINGTON SWEET CHERRY ORCHARD TREES AND IN FOREIGN CHERRY INTRODUCTIONS PRIOR TO 1953. *U.S. Dept. Agr., Plant Dis. Rptr.* 47: 345-347.
- (49) ———  
1965. RELEASE OF VIRUS-INDEXED PRUNUS BUDWOOD FROM THE INTERREGIONAL REPOSITORY. *U.S. Dept. Agr., Plant Dis. Rptr.* 49: 187-188.
- (50) ———  
1967. THE RELATIONSHIP OF INOCULUM-RECEPTOR CONTACT PERIOD TO THE RATE OF GRAFT TRANSMISSION OF TWELVE PRUNUS VIRUSES. *Phytopathology* 57: 1296-1299.
- (51) GEORGE, J. A., and DAVIDSON, T. R.  
1963. POLLEN TRANSMISSION OF NECROTIC RINGSPOT AND SOUR CHERRY YELLOWS FROM TREE TO TREE. *Canad. Jour. Plant Sci.* 48: 278-288.
- (52) GERHARDT, F., ENGLISH, H., and SMITH, E.  
1945. CRACKING AND DECAY OF BING CHERRIES AS RELATED TO THE PRESENCE OF MOISTURE ON THE SURFACE OF THE FRUIT. *Amer. Soc. Hort. Sci. Proc.* 46: 191-198.
- (53) ——— and HUKILL, W. V.  
1945. THE STORAGE RESPONSE OF BING CHERRIES TO AIR MOVEMENT, TEMPERATURE AND HYDROCOOLING. *Refriger. Engin.* 49: 275.
- (54) ——— SCHOMER, H., and WRIGHT, T. R.  
1956. SEALED FILM LUG LINERS FOR PACKING BING CHERRIES. *U.S. Dept. Agr. AMS-121*, 8 pp.
- (55) ——— SCHOMER, H., and WRIGHT, T. R.  
1957. FILM LUG LINERS LENGTHEN MARKET LIFE OF SWEET CHERRIES. *U.S. Dept. Agr. AMS-177*, 2 pp.
- (56) GERLACH, G.  
1955. FREEZING OF SWEET CHERRIES. *Canad. Comm. Fruits & Veg. Preserv. Rpt.*: 19-20.
- (57) GUENGERICH, H. W., and MILLIKAN, D. F.  
1966. BUD TRANSMISSION OF DWARFING IN SWEET CHERRY. *U.S. Dept. Agr., Plant Dis. Rptr.* 50: 367-368.
- (58) HEDRICK, U.P.  
1915. THE CHERRIES OF NEW YORK. 371 pp. J. B. Lyon Co., Albany, N.Y.
- (59) HELTON, A. W.  
1961. BEHAVIOR OF WESTERN X-VIRUS IN WELL ROGUED PEACH AND CHERRY ORCHARDS. *Phytopathology* 51: 488-489.

- (60) HURST, H.  
1957. MARASCHINO CHERRIES MADE FASTER, EASIER IN BARRELS. *Food Packer* 38: 14.
- (61) JENSEN, M. C., MIDDLETON, J. E., and PRUITT, W. O.  
1970. SCHEDULING IRRIGATION FROM PAN EVAPORATION. *Wash. Agr. Expt. Sta. Cir.* 527. 13 pp. (Revised)
- (62) JENSEN, D. D., and THOMAS, H. E.  
1954. LEAFHOPPER TRANSMISSION OF NAPA STRAIN OF CHERRY BUCKSKIN VIRUS TO PEACH. (Abstract) *Phytopathology* 44: 494.
- (63) ——— and THOMAS, H. E.  
1955. TRANSMISSION OF THE GREEN VALLEY STAIN OF CHERRY BUCKSKIN VIRUS BY MEANS OF LEAFHOPPERS. (Abstract) *Phytopathology* 45: 694.
- (64) JOLEY, L. E.  
1962. TWO NEW EARLY CHERRY VARIETIES, EARLY BURLAT AND MOREAU. *Fruit Vars. & Hort. Digest* 16: 75-76.
- (65) LAPKINS, K. O.  
1965. THE LAMBERT COMPACT CHERRY. *Fruit Vars. & Hort. Digest* 19: 23-24.
- (66) ———  
1970. THE STELLA CHERRY. *Fruit Vars. & Hort. Digest* 24: 19-20.
- (67) LEE, F. A., and BEAVENS, E. A.  
1941. HOW TO MAKE NATURALLY FLAVORED MARASCHINO-TYPE CHERRIES. *Food Indus.* 13: 52-55.
- (68) LOTT, T. B.  
1943. TRANSMISSIBLE "TWISTED LEAF" OF SWEET CHERRY. *Sci. Agr.* 23: 434-441.
- (69) ———  
1945. "LAMBERT MOTTLE", A TRANSMISSIBLE DISEASE OF SWEET CHERRY. *Sci. Agr.* 25: 776-779.
- (70) MANN, A. J., and KEANE, F. W. L.  
1953. THE SAM CHERRY. *Fruit Vars. & Hort. Digest* 8: 43-44.
- (71) MARSHALL, R. E.  
1954. CHERRIES AND CHERRY PRODUCTS. 283 pp. (Econ. Crops Vol. V) Interscience Pub., Inc., New York.
- (72) MCCREADY, R. M., and MCCOMB, E. A.  
1954. TEXTURE CHANGES IN BRINED CHERRIES. *West. Canner & Packer* 46: 17-19.
- (73) MILBRATH, J. A.  
1952. THE MORA VIRUS DISEASE OF SWEET CHERRY. *Phytopathology* 42: 347-348.
- (74) ———  
1961. THE RELATIONSHIP OF STONE-FRUIT RINGSPOT VIRUS TO SOUR CHERRY YELLOWS, PRUNE DWARF AND PEACH STUNT. *Tidsskr for Planteavlusudv.* 65: 125-133.
- (75) ——— BOLWYN, B., and COMPTON, O. C.  
1966. A DISEASE OF SWEET CHERRY IN WHICH A VIRUS AND A BORON DEFICIENCY ARE INVOLVED. (Abstract) *Phytopathology* 56: 150.
- (76) ——— and ZELLER, S. M.  
1948. INDEXING FRUIT TREES FOR VIRUS. *Amer. Nurs.* 88: 7-8.
- (77) MILLIKAN, D. F.  
1953. THE INFLUENCE OF RINGSPOT VIRUS ON GROWTH OF 1-YEAR-OLD SWEET CHERRY NURSERY TREES. (Abstract) *Phytopathology* 43: 480.
- (78) MILLS, W. D., and LEPLANTE, A. A.  
1951. DISEASES AND INSECTS IN THE ORCHARD. *N.Y. State Agr. Expt. Sta. Bul.* 711: 65-71.
- (79) MRAK, E. M., PHAFF, H. J., and FRIAR, H. P.  
1943. DEHYDRATION OF CHERRIES. *Fruit Prod. Jour.* 22: 198-201.
- (80) NEWCOMBER, E. J.  
1950. ORCHARD INSECTS OF THE PACIFIC NORTHWEST AND THEIR CONTROL. *U.S. Dept. Agr. Cir.* 270. 63 pp.
- (81) NIELSON, M. W., and JONES, L. S.  
1954. INSECT TRANSMISSION OF WESTERN-LITTLE-CHERRY VIRUS. *Phytopathology* 44: 218-220.
- (82) NORTON, R. A., CLAYPOOL, L. L., and OTHERS.  
1962. MECHANICAL HARVESTING OF SWEET CHERRIES. *Calif. Agr.* 16: 8-10.
- (83) NYLAND, GEORGE.  
1954. VARIATIONS IN THE SWEET CHERRY RUGOSE MOSAIC COMPLEX. (Abstract) *Phytopathology* 44: 500.
- (84) ——— and LOWE, S. K.  
1966. SIMILAR YELLOW LEAF SYMPTOMS IN MONTMORENCY CAUSED BY CHERRY RUGOSE MOSAIC, RECURRENT RINGSPOT AND SOUR CHERRY YELLOWS VIRUSES. (Abstract) *Phytopathology* 56: 150.
- (85) OGAWA, J. M., ENGLISH, W. H., and WILSON, E. E.  
1954. SURVEY FOR BROWN ROT OF STONE FRUITS IN CALIFORNIA. *U.S. Dept. Agr., Plant Dis. Rptr.* 38: 254-257.
- (86) PHILP, G. L.  
1947. CHERRY CULTURE IN CALIFORNIA. *Calif. Agr. Expt. Sta. Cir.* 46, 51 pp. (Revised).
- (87) PIERSON, C. F.  
1958. FUNGICIDES FOR REDUCTION OF POST HARVEST DECAY OF SWEET CHERRIES. *Wash. State Hort. Assoc. Proc.* 54: 115-116.
- (88) POSNETTE, A. F.  
1965. DETECTION OF LITTLE CHERRY VIRUS DISEASE IN EUROPE. (Plant Protection) *Zastita Bilja:* 431-434.

- (89) ——— and CROPLEY, R.  
1958. A LITTLE CHERRY DISEASE IN ENGLAND. East Malling Res. Sta. Rpt. for 1957, 122-123.
- (90) PRICE, D. W.  
1968. THE WASHINGTON SWEET CHERRY INDUSTRY AND ITS MARKETING ORDER. Wash. Agr. Expt. Sta. Bul. 701, 16 pp.
- (91) PROEBSTING, E. L., JR.  
1969. PROGRESS REPORT ON GROWTH RETARDANTS (SOFT FRUITS). Wash. State Hort. Assoc. Proc. 65: 140.
- (92) PUTNAM, W. L.  
1939. THE PLUM NURSERY MITE. 7th Ann. Rpt. Ent. Soc. Ont.: 33-39.
- (93) RAMSEY, H. J.  
1916. THE HANDLING AND SHIPPING OF FRESH CHERRIES AND PRUNES FROM THE WILLIAMETTE VALLEY. U.S. Dept. Agr. Bul. 331. 28 pp.
- (94) RAWLINS, T. E., and HORNE, W. T.  
1931. "BUCKSKIN" A DESTRUCTIVE GRAFT INFECTIOUS DISEASE OF THE CHERRY. Phytopathology 21: 331-335, illus.
- (95) ——— and PARKER, K. G.  
1934. INFLUENCE OF ROOTSTOCKS ON THE SUSCEPTIBILITY OF SWEET CHERRY TO BUCKSKIN DISEASE. Phytopathology 24: 1029-1031.
- (96) ——— and THOMAS, H. E.  
1941. THE BUCKSKIN DISEASE OF CHERRY AND OTHER STONE FRUITS. Phytopathology 31: 916-925, illus.
- (97) REEVES, E. L.  
1940. RUSTY MOTTLE, A NEW VIRUS OF CHERRY. (Abstract) Phytopathology 30: 789.
- (98) ———  
1941. MOTTLE LEAF, A VIRUS-DISEASE OF SWEET CHERRY. Jour. Agr. Res. 62: 555-572.
- (99) ———  
1943. VIRUS DISEASE OF FRUIT TREES IN WASHINGTON. Wash. State Dept. Agr. Bul. 1: 1-25, illus.
- (100) ———  
1963. FLOWERING CHERRIES AS SYMPTOMLESS HOSTS OF LITTLE CHERRY VIRUS. 5th European Symposium of Fruit Tree Virus Dis. Phytopath. Mediter. 2: 184-188.
- (101) ——— and CHENEY, P. W.  
1956. FOLIAGE SYMPTOMS ON SWEET CHERRY INFESTED WITH LITTLE CHERRY-TYPE VIRUS OBTAINED FROM KWANZAN AND SHIROFUGEN ORIENTAL FLOWERING CHERRIES. U.S. Dept. Agr., Plant Dis. Rptr. 40: 408-409.
- (102) ——— CHENEY, P. W., and MILBRATH, J. A.  
1955. NORMAL APPEARING KWANZAN AND SHIROFUGEN ORIENTAL FLOWERING CHERRIES FOUND TO CARRY A VIRUS OF THE LITTLE CHERRY TYPE. U.S. Dept. Agr., Plant Dis. Rptr. 39: 725-726.
- (103) ——— and RICHARDS, B. L.  
1946. A RUSTY MOTTLE-LIKE DISEASE OF THE SWEET CHERRY IN UTAH. (Abstract) Phytopathology 36: 409.
- (104) RICHARDS, B. L.  
1945. THE RED LEAF CHOKE CHERRY VIRUS AS A POSSIBLE CAUSE OF WILT IN SWEET CHERRY AND OF DIEBACK IN THE SOUR CHERRY. Utah Acad. Sci. Arts and Letters Proc. 22: 9.
- (105) ——— and COCHRAN, L. C.  
1956. VIRUS DISEASES OF STONE FRUITS. Utah Agr. Expt. Sta. Bul. 384: 1-130, illus.
- (106) ——— HUTCHINS, L. M., and REEVES, E. L.  
1949. WESTERN "X" VIRUS, A CAUSE OF LITTLE CHERRY IN UTAH. (Abstract) Phytopathology 39: 19.
- (107) ——— and WADLEY, B. N.  
1950. UTAH DIXIE RUSTY MOTTLE OF SWEET CHERRY. (Abstract) Phytopathology 40: 969.
- (108) RODRIQUEZ, S. B., and GILMER, R. M.  
1963. THE INCIDENCE OF NECROTIC RINGSPOT, SOUR CHERRY YELLOWS AND GREEN RING MOTTLE VIRUSES IN COMMERCIAL SWEET CHERRY PLANTINGS IN NEW YORK. U.S. Dept. Agr., Plant Dis. Rptr. 47: 381-383.
- (109) ROGERS, A. J.  
1940. HOW TO QUICK FREEZE CHERRIES SUCCESSFULLY. Refrig. Engin. 40: 215-216.
- (110) ROSS, E., YANG, H. Y., and BREKKE, J. E.  
1958. PRELIMINARY REPORT ON THE BRINED CHERRY PROJECT, 1962 SEASON. Wash. Agr. Expt. Sta. Cir. 340. 3 pp.
- (111) RYUGO, K.  
1966. PERSISTENCE AND MOBILITY OF ALAR AND ITS EFFECTS ON ANTHOCYANIN METABOLISM IN SWEET CHERRIES, *Prunus avium*. Proc. Amer. Soc. Hort. Sci. 88: 160-166.
- (112) SAINSBURY, G. F.  
1951. IMPROVED FRUIT COOLING METHODS. Refrig. Engin. 59: 464-469.
- (113) SIEGELMAN, H. W.  
1953. BROWN DISCOLORATION AND SHRIVEL OF CHERRY STEMS. Amer. Soc. Hort. Sci. Proc. 61: 265-269.
- (114) SIMONS, R. K., and CARLSON, R. F.  
1968. CHARACTERISTICS AND PROPAGATION OF ROOTSTOCKS FOR DECIDUOUS FRUITS IN THE NORTH CENTRAL REGION 1966-67. Hort-Science 3: 221-225.

- (115) SKOTLAND, C. B.  
1969. VERTICILLIUM WILT OF SWEET CHERRY. (Abstract) *Phytopathology* 59: 1050.
- (116) SORENSON, V. L.  
1958. PLANNING EFFICIENT OPERATIONS FOR CHERRY PROCESSING PLANTS. *Jour. Farm Econ.* 40: 408-416.
- (117) STANBERRY, C. O., and CLORE, W. J.  
1950. THE EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZERS ON THE COMPOSITION AND KEEPING QUALITIES OF BING CHERRIES. *Amer. Soc. Hort. Sci. Proc.* 56: 40-45.
- (118) STEBBINS, R. L., CAIN, R. F., and OTHERS.  
1967. MECHANICAL HARVESTING OF SWEET CHERRIES IN OREGON. *Proc. Oreg. Hort. Soc.* 59: 84-91.
- (119) STEELE, W. F., and YANG, H. Y.  
1960. SOFTENING OF BRINED CHERRIES BY POLYGALACTURONASE, AND THE INHIBITION OF POLYGALACTURONASE IN MODEL SYSTEMS BY ALKYL ARYL SULFONATES. *Food Technol.* 14: 121-126.
- (120) STODDARD, E. M.  
1947. THE X-DISEASES OF PEACH AND ITS CHEMOTHERAPY. *Conn. Agr. Expt. Sta. Bul.* 506, 19 pp.
- (121) STOSSER, R., RASMUSSEN, H. P., and OTHERS.  
1969. A HISTOLOGICAL STUDY OF ABSCISSION LAYER FORMATION IN CHERRY FRUITS DURING MATURATION. *J. Amer. Soc. Hort. Sci.* 94: 239-243.
- (122) STOUT, G. L.  
1949. CHERRY BARK BLISTER. *Calif. Dept. Agr. Bul.* 38: 257-260.
- (123) STRACHAN, C. C., and ATKINSON, F. E.  
1955. EFFECT OF SUCROSE-INVERT AND HIGH CONVERSION GLUCOSE SYRUPS IN THE PREPARATION OF CANDIED CHERRIES. *Food Technol.* 9: 518-520.
- (124) THIENES, J., LARSEN, R. P., and KESNER, C.  
1969. FRUIT REMOVAL AND QUALITY OF MECHANICALLY HARVESTED SWEET CHERRIES. *Mich. Agr. Expt. Sta. Res. Rpt.* 88. 6 pp.
- (125) UNITED STATES DEPARTMENT OF AGRICULTURE.  
[1973.] VIRUS DISEASES OF STONE FRUITS. (Revised.) U.S. Dept. Agr. Handb. 347. (In press.)
- (126) VERNER, LEIF.  
1931. PHYSIOLOGICAL STUDIES OF THE CRACKING OF SWEET CHERRIES. *Idaho Agr. Expt. Sta. Bul.* 184. 15 pp.
- (127) \_\_\_\_\_  
1938. REDUCTION OF CRACKING IN SWEET CHERRIES FOLLOWING THE USE OF CALCIUM SPRAYS. *Amer. Soc. Hort. Sci. Proc.* 35: 271-274.
- (128) \_\_\_\_\_  
1946. THE LAMIDA, EBONY AND SPALDING SWEET CHERRIES. *Idaho Agr. Expt. Sta. Cir.* 109. 4 pp.
- (129) WADLEY, B. N.  
1952. SYMPTOMS OF SWEET CHERRY PRODUCED BY WESTERN X-DISEASE VIRUS FROM PEACH. (Abstract) *Phytopathology* 42: 519.
- (130) WAGENKNEZHT, A. C., and VAN BUREN, J. P.  
1965. PRELIMINARY OBSERVATIONS ON SECONDARY OXIDATIVE BLEACHING OF SULFITED CHERRIES. *Food Technol.* 19: 658-661.
- (131) WASHINGTON AGRICULTURAL EXPERIMENT STATION.  
1960. CHINOOK AND RAINIER, NEW CHERRY VARIETIES. *Wash. Agr. Expt. Sta. Cir.* 375. 4 pp.
- (132) WATTERS, G. G., BREKKE, J. E., and OTHERS.  
1963. BRINED CHERRIES, ANALYTICAL AND QUALITY CONTROL METHODS. U.S. Dept. Agr. ARS 74-123 (Revised).
- (133) WAY, ROGER, and LAMB, R. C.  
1964. NEW FRUIT VARIETIES NAMED BY GENEVA STATION. *Farm Res* 30: 8-9, Sept.-Dec.
- (134) WESTWOOD, M. N., and BJORNSTAD, H. O.  
1970. SOME FACTORS AFFECTING RAIN CRACKING OF SWEET CHERRIES. *Oreg. Hort. Soc. Yearbook* 61: 70-75.
- (135) WHITTENBERGER, R. T., LEVIN, J. H., and GASTON, H. P.  
1968. MAINTAINING QUALITY BY BRINING SWEET CHERRIES AFTER HARVEST. *Mich. Agr. Expt. Sta. Res. Rpt.* 73. 4 pp.
- (136) WIEGAND, E. H.  
1946. THE BRINED CHERRY INDUSTRY. *West. Canner and Packer* 38: 60-63.
- (137) \_\_\_\_\_, LITWILLER, E. M., and HATCH, M. B.  
1945. DEHYDRATION OF CHERRIES AND SMALL FRUITS. *Fruit Prod. Jour.* 25: 9-14, 23.
- (138) WILDE, W. H. A.  
1960. INSECT TRANSMISSION OF THE VIRUS CAUSING LITTLE CHERRY DISEASE. *Canad. Jour. Plant Sci.* 40: 707-712.
- (139) WILKS, JACK M., and MILBRATH, J. A.  
1956. COMPARATIVE STUDIES OF THE VIRUS DISEASES, WESTERN X LITTLE CHERRY AND LITTLE CHERRY. *Phytopathology* 46: 596-599.
- (140) \_\_\_\_\_ and REEVES, E. L.  
1960. FLOWERING CHERRIES, A RESERVOIR OF LITTLE CHERRY VIRUS. *Phytopathology* 50: 188-190.
- (141) \_\_\_\_\_ and WELCH, MAURICE F.  
1961. HOST RANGE STUDIES OF THE LITTLE CHERRY DISEASE VIRUS. *Canad. Jour. Plant Sci.* 41: 544-548.
- (142) WILLIAMS, H. E., and MILBRATH, J. A.  
1955. FRECKLE FRUIT OF SWEET CHERRY. (Abstract) *Phytopathology* 45: 696.
- (143) WILSON, E. E.  
1953. BACTERIAL CANKER OF STONE FRUITS. *In Plant Diseases, U.S. Dept. Agr. Yearbook* 1953: 727-729.

- (144) WITTENBACH, V. A., and BUCKOVAC, M. J.  
1971. PHYSIOLOGICAL ASPECTS OF CHERRY FRUIT  
ABSCISSION. *HortScience* 6: 286.
- (145) WORMALD, H.  
1954. THE BROWN ROT DISEASES OF FRUIT TREES.  
*Minn. Agr. Fisheries Tech. Bul.* 3: 113.  
London.
- (146) YANG, H. Y.  
1958. BREAKDOWN OF SWEET CHERRIES DURING  
BRINING. *Oreg. State Hort. Soc. Ann.*  
Rpt. 50: 61-62.
- (147) ——— ROSS, E., and BREKKE, J. E.  
1959. SUGGESTIONS FOR CHERRY BRINING. *Oreg.*  
*Agr. Expt. Sta. Cir. Inform.* 597. 5 pp.
- (148) ——— STEELE, W. F., and GRAHAM, D. J.  
1960. INHIBITION OF POLYGALACTURONASE IN  
BRINED CHERRIES. *Food Technol.* 14:  
644-647.
- (149) ——— and WIEGAND, E. H.  
1949. PRODUCTION OF FRUIT WINES IN THE  
PACIFIC NORTHWEST. *Fruit Prod. J.* 29:  
8-12, 27, 29.
- (150) ZAROTSOHENZEFF, M. T.  
1934. QUICK-FREEZING CHERRIES BY THE "Z"  
PROCESS. *Ice and Refrig.* 86: 57-58.
- (151) ZELLER, S. M., and MILBRATH, J. A.  
1948. THE RECOVERY OF WESTERN X-DISEASE OF  
PEACH FROM MONTMORENCY CHERRY AND  
ITS RELATION TO BUCKSKIN OF SWEET  
CHERRY. *Phytopathology* 40: 707-711.
- (152) ——— MILBRATH, J. A., and CORDY, C. B.  
1944. ALBINO CHERRY, A VIRUS DISEASE IN  
SOUTHERN OREGON. (Abstract) *Phytopa-*  
*thology* 34: 937.
- (153) ——— MILBRATH, J. A., and KIENHOLZ, J. R.  
1947. BLACK CANKER OF SWEET CHERRY. (Ab-  
stract) *Phytopathology* 37: 366.
- (154) ZIELINSKI, Q. B.  
1961. THE CORUM SWEET CHERRY. *Oreg. Agr.*  
*Expt. Sta. Cir. Inform.* 609. 2 pp.

## ADDITIONAL SELECTED REFERENCES

- (155) ALLEN, F. W.  
1941. CHERRY MATURITY INVESTIGATIONS. *Calif.*  
*Agr. Expt. Sta. Progress Rpt. (Mimeo.)*  
4 pp.
- (156) ANTHONY, R. D., SUDDS, R. H., and YEKES, G. E.  
1937. ORCHARD TESTS OF MAZZARD AND MAHALEB  
CHERRY UNDERSTOCKS. *Amer. Soc. Hort.*  
*Sci. Proc.* 35: 415-418.
- (157) ATKINSON, F. E., MOYLS, A. W., and KITSON,  
J. A.  
1952. IMPROVEMENTS IN THE CANDYING OF  
FRUITS. *Food Tech.* 6: 431-436.
- (158) ——— and STRACHAN, C. C.  
1963. SULFUR DIOXIDE PRESERVATION OF FRUITS.  
*Canad. Dept. Agr. Pub.* 1176. 31 pp.
- (159) BATJER, L. P.  
1965. FRUIT THINNING WITH CHEMICALS. *U.S.*  
*Dept. Agr. AIB* 289, 27 pp.
- (160) BLODGETT, E. C.  
(n.d.) VERTICILLIUM WILT OF STONE FRUIT IN  
WASHINGTON. *Wash. Agr. Expt. Sta.*  
*Cir.* 425, 9 pp.
- (161) ——— and WRIGHT, C. M.  
1948. THE LITTLE CHERRY DISEASE PROBLEM IN  
WASHINGTON. *Wash. State Dept. Agr.*  
*Cir.* 1. 4 pp.
- (162) BOWMAN, F. T.  
1937. CHERRY POLLINATION AND VARIETY IN-  
VESTIGATIONS IN NEW SOUTH WALES 1930-  
34. *New South Wales Dept. Agr. Bul.*  
55. 51 pp.
- (163) CAESAR, L., and SPENCER, G. J.  
1915. CHERRY FRUIT FLIES. *Ont. Dept. Agr.*  
*Bul.* 227, 30 pp.
- (164) CAMERON, H. R.  
1960. DEATH OF DORMANT BUDS IN SWEET  
CHERRY. *U.S. Dept. Agr., Plant Dis.*  
*Rptr.* 44: 139-143.
- (165) CLARKE, W. S., and ANTHONY, R. D.  
1946. AN ORCHARD TEST OF MAZZARD AND MA-  
HALEB CHERRY ROOTSTOCKS. *Amer. Soc.*  
*Hort. Sci. Proc.* 48: 200-208.
- (166) COCHRAN, L. C., and REEVES, E. L.  
1953. VIRUS DISEASES OF STONE FRUITS. *U.S.*  
*Dept. Agr. Yearbook* 1953: 714-721.
- (167) COE, F. M.  
1934. CHERRY POLLINATION STUDIES IN UTAH.  
*Utah Agr. Expt. Sta. Bul.* 245. 53 pp.
- (168) ———  
1935. CHERRIES OF UTAH. *Utah Agr. Expt. Sta.*  
*Bul.* 253: 72 pp.
- (169) CRANE, H. L.  
1931. EFFECTS OF PRUNING ON GROWTH AND  
YIELD OF CHERRY TREES. *W. Va. Agr.*  
*Expt. Sta. Bul.* 240. 20 pp.
- (170) CULLINAN, F. P.  
1937. IMPROVEMENT OF STONE FRUITS: CHERRIES.  
*U.S. Dept. Agr. Yearbook* 1937: 724-737.
- (171) DOWDY, A. C.  
1960. FRUIT INSECTS IN MICHIGAN. *Mich. Agr.*  
*Ext. Bul.* 372, 40 pp.
- (172) DURUZ, W. P.  
1922. HARVESTING AND HANDLING CALIFORNIA  
CHERRIES FOR EASTERN SHIPMENT. *Calif.*  
*Agr. Expt. Sta. Cir.* 232. 19 pp.
- (173) EATON, G. W.  
1959. TWIN OVULES IN *P. AVIUM* L. *Canad.*  
*Jour. Bot.* 37: 1203-1205.

- (174) EDGERTON, L. J.  
1955. CHERRY GROWING IN NEW YORK. Cornell Ext. Bul. 787, 22 pp.
- (175) EINSET, O.  
1932. EXPERIMENTS IN CHERRY POLLINATION. N.Y. State Agr. Expt. Sta. Bul. 617, 13 pp.
- (176) FOGLE, H. W.  
1957. VAN AND SAM CHERRIES IN CENTRAL WASHINGTON. Fruit Vars. & Hort. Digest 11: 56-57.
- (177) \_\_\_\_\_  
1961. INHERITANCE OF SOME FRUIT AND TREE CHARACTERISTICS IN SWEET CHERRY CROSSES. Amer. Soc. Hort. Sci. Proc. 78: 76-85.
- (178) \_\_\_\_\_ and OVERLEY, F. L.  
1954. WINTER HARDINESS OF STONE FRUIT VARIETIES IN IRRIGATED CENTRAL WASHINGTON. Wash. Agr. Expt. Sta. Bul. 553, 19 pp.
- (179) \_\_\_\_\_ PROEBSTING, E. L., and OTHERS.  
1962. FIRST-YEAR PRODUCTION RECORDS FROM A CHERRY ROOTSTOCK STUDY. Wash. State Hort. Assoc. Proc. 58: 71-75.
- (180) FRENCH, A. P.  
1943. PLANT CHARACTERS OF CHERRY VARIETIES. Mass. Agr. Expt. Sta. Bul. 401, 23 pp.
- (181) FRIDLUND, P. R.  
1961. THE IMPORTANCE OF GREEN RING MOTTLE VIRUS DETECTION IN A PRUNUS VIRUS INDEXING PROGRAM. U.S. Dept. Agr., Plant Dis. Rprtr. 45: 687-689.
- (182) GARDNER, V. R.  
1913. A PRELIMINARY REPORT ON THE POLLINATION OF THE SWEET CHERRY. Oreg. Agr. Expt. Sta. Bul. 116, 40 pp.
- (183) \_\_\_\_\_  
1946. THE CHERRY AND ITS CULTURE. Orange Judd. Pub. Co., New York (Revised), 146 pp.
- (184) GRIGGS, W. H.  
1953. POLLINATION REQUIREMENTS OF FRUITS AND NUTS. Calif. Agr. Expt. Sta. Cir. 424, 35 pp.
- (185) GRUBB, W. H.  
1949. CHERRIES. Crosby Lockwood & Sons Ltd., London, 186 pp.
- (186) HAGOOD, M. A.  
1964. IRRIGATION SCHEDULING FROM EVAPORATION REPORTS. Wash. Agr. Expt. Sta. Ext. Cir. 341, 6 pp.
- (187) HARTMAN, H.  
1925. PRELIMINARY STUDIES RELATING TO THE HARVESTING AND CANNING OF SWEET CHERRIES. Oreg. Agr. Expt. Sta. Cir. 61, 22 pp.
- (188) \_\_\_\_\_ and BULLIS, D. E.  
1929. INVESTIGATIONS RELATING TO THE HANDLING OF SWEET CHERRIES, WITH SPECIAL REFERENCE TO CHEMICAL AND PHYSIOLOGICAL ACTIVITIES DURING RIPENING. Oreg. Agr. Expt. Sta. Bul. 247, 38 pp.
- (189) HICKEY, K. D., WORLEY, P. H., and HOFFMAN, M. B.  
1962. TREE FRUIT PRODUCTION RECOMMENDATIONS. N.Y. State Agr. Expt. Sta. Ext. Serv. Pub. 121-124.
- (190) HOWE, G. H.  
1927. MAZZARD AND MAHALEB ROOTSTOCK FOR CHERRIES. N.Y. State Agr. Expt. Sta. Bul. 544, 14 pp.
- (191) \_\_\_\_\_  
1942. CHERRY GROWING IN NEW YORK. N.Y. State Agr. Expt. Sta. Cir. 145. (Revised.) 12 pp.
- (192) ILLINGSWORTH, J. E.  
1912. CHERRY FRUIT FLIES AND HOW TO CONTROL THEM. Cornell Univ. Bul. 325: 190-204.
- (193) JONES, A. L., THOMPSON, W. W., and OTHERS.  
1971. 1971 FRUIT SPRAYING CALENDAR. Mich. Agr. Expt. Sta. Ext. Bul. 154, pp. 42-43.
- (194) KEIL, H. L.  
1961. CHERRY LEAF-SPOT AND ITS CONTROL. U.S. Dept. Agr. Leaflet 489, 6 pp.
- (195) KERR, E. A.  
1963. INHERITANCE OF CRINKLE, VARIATION, AND ALBINISM IN SWEET CHERRY. Canad. Jour. Bot. 41: 1395-1404.
- (196) KERTESZ, Z. I., and NEBEL, B. R.  
1935. OBSERVATION ON THE CRACKING OF CHERRIES. Plant Physiol. 10: 763-772.
- (197) KINMAN, C. F.  
1930. A STUDY OF SOME UNPRODUCTIVE CHERRY TREES IN CALIFORNIA. Jour. Agr. Res. 41: 327-335.
- (198) KLOS, E. J., and FRONEK, F. R.  
1964. CHEMICAL ERADICATION OF CHERRY LEAF SPOT FUNGUS. Mich. Agr. Expt. Sta. Quart. Bul. 47: 65-68.
- (199) LAMB, R. C.  
1953. NOTES ON THE INHERITANCE OF SOME CHARACTERS IN THE SWEET CHERRY. Amer. Soc. Hort. Sci. Proc. 61: 293-298.
- (200) LUCE, W. A.  
FERTILIZER RECOMMENDATIONS FOR FRUIT ORCHARDS IN CENTRAL WASH. Wash. Agr. Expt. Sta. Mimeo. (Unnumbered). 3 pp.
- (201) MANN, A. J., and KEANE, F. W. L.  
1949. THE VAN CHERRY. Fruit Vars. & Hort. Digest 4: 12-13.
- (202) \_\_\_\_\_ and KEANE, F. W. L.  
1949. THE STAR CHERRY. Fruit Vars. & Hort. Digest 4: 71-72.

- (203) McCLINTOCH, J. A.  
1930. AMERICAN MAZZARD CHERRY SEEDLINGS AS ROOTSTOCKS FOR CULTIVATED CHERRIES. *Amer. Soc. Hort. Sci. Proc.* 26: 82-85.
- (204) MINK, G. I., and PARSONS, J. L.  
1965. THE PREVALENCE OF SOME LATENT VIRUSES IN SWEET CHERRY TREES OF VARIOUS AGE GROUPS IN ORCHARDS OF SOUTHCENTRAL WASHINGTON. *U.S. Dept. Agr., Plant Dis. Rptr.* 49: 143-145.
- (205) NORTON, R. A., CLAYPOOL, L. L., and OTHERS.  
1961. MECHANICAL HARVESTING OF SWEET CHERRIES RESEARCH PROGRESS REPORT. Univ. of Calif. (Davis), unnumbered, 2 pp.
- (206) \_\_\_\_\_ HANSEN, C. J., and OTHERS.  
1963. ROOTSTOCKS FOR SWEET CHERRIES. *Calif. Agr. Expt. Sta. Leaflet* 159, 5 pp.
- (207) OLDEN, E. J.  
1959. VAXTFORADLING AV KORSBAR VID BALS GARD. *Sveriges Pomol. F6r. 6rsskr* 1958: 47-60. Stockholm.
- (208) OREGON STATE UNIV.  
1971. 1971 SPRAY PROGRAM FOR STONE FRUITS IN OREGON. *Oreg. Agr. Ext. Cir.* 675. (Revised annually).
- (209) OVERLEY, F. L.  
1951. ORCHARD TREE SPACING AND RENEWAL. *Wash. Agr. Expt. Sta. Cir.* 140, 7 pp.
- (210) POWERS, W. L., and BOLLEN, W. B.  
1947. CONTROL OF CRACKING OF FRUIT BY RAIN. *Science* 105: 334-335.
- (211) PROEBSTING, E. L.  
1958. FERTILIZERS AND COVERCROPS FOR CALIFORNIA ORCHARDS. *Calif. Agr. Expt. Sta. Cir.* 466, 19 pp.
- (212) ROGERS, A. J., JR.  
1927. STUDIES IN ORCHARD MANAGEMENT WITH SPECIAL REFERENCES TO CHERRY PRODUCTION. *Mich. Agr. Expt. Sta. Spec. Bul.* 166, 43 pp.
- (213) SCHUSTER, C. E.  
1925. POLLINATION AND GROWING OF THE CHERRY. *Oreg. Agr. Expt. Sta. Bul.* 212, 40 pp.
- (214) SHULL, W. W., and WAKELAND, C.  
1941. THE MINEOLA MOTH OR DESTRUCTIVE PRUNE WORM. *Idaho Agr. Expt. Sta. Bul.* 242, 7 pp.
- (215) SHULTIS, A.  
1961. FACTORS AFFECTING FUTURE PROFIT IN CHERRY PRODUCTION. Univ. of Calif. Ext. Mimeo, 3 pp.
- (216) SMEETS, L.  
1956. SOME EFFECTS OF THE PHOTOPERIOD ON THE SHOOT GROWTH OF CHERRY SEEDLINGS. *Euphytica* 5: 238-244.
- (217) \_\_\_\_\_  
1962. A NOTE ON FLOWER INITIATION IN THE CHERRY. *Inter. Hort. Cong. Proc.* 16: 413-415.
- (218) SNYDER, J. C., BRANNON, D. H., and HARRIS, M. R.  
1963. SWEET CHERRY GROWING IN EASTERN WASHINGTON. *Wash. Agr. Expt. Sta. Mimeo.* 1682. (Revised.) 11 pp.
- (219) THORNE, D. W., and WANN, F. B.  
1950. NUTRIENT DEFICIENCIES IN UTAH ORCHARDS. *Utah Agr. Expt. Sta. Bul.* 338, 29 pp.
- (220) TOYAMA, T. K., FOGLE, H. W., and OTHERS.  
1964. THREE-YEAR PRODUCTION RECORDS FROM A CHERRY ROOTSTOCK STUDY. *Wash. State Hort. Assoc. Proc.* 60: 119-120.
- (221) TRESSLER, D. K., and JOSLYN, M. A.  
1961. FRUIT AND VEGETABLE JUICE PROCESSING TECHNOLOGY. *Avi. Pub. Co., New York*, 486 pp., illus.
- (222) TUCKER, L. R.  
1934. A VARIETAL STUDY OF THE SUSCEPTIBILITY OF SWEET CHERRIES TO CRACKING. *Idaho Agr. Expt. Sta. Bul.* 211, 19 pp.
- (223) TUFTS, W. P., and PHILP, G. L.  
1925. POLLINATION OF THE SWEET CHERRY. *Calif. Agr. Expt. Sta. Bul.* 385, 28 pp.
- (224) TUKEY, H. B.  
1935. IDENTIFICATION OF MAZZARD AND MAHALEB CHERRY ROOTSTOCKS. *N.Y. State Agr. Expt. Sta. Cir.* 117 (report), 12 pp.
- (225) UNITED STATES DEPARTMENT OF AGRICULTURE.  
1959. DAMAGE AND RECOVERY IN DECIDUOUS ORCHARD TREES FROM MAJOR FREEZES. *U.S. Dept. Agr. ARS Spec. Rpt.* 22-29.
- (226) \_\_\_\_\_  
1964. MECHANIZING THE HARVESTING AND ORCHARD HANDLING OF FRUITS. *U.S. Dept. Agr. ARS Spec. Rpt.* 22-88.
- (227) \_\_\_\_\_  
1968. SUGGESTED GUIDE FOR THE USE OF INSECTICIDES TO CONTROL INSECTS AFFECTING CROPS, LIVESTOCK, HOUSEHOLDS, STORED PRODUCTS, FORESTS, AND FOREST PRODUCTS-1968. *U.S. Dept. Agr. Handb.* 331, pp. 39-43.
- (228) VERNER, L.  
1930. EXPERIMENTS WITH A NEW TYPE OF PRESSURE TESTER ON CERTAIN STONE FRUITS. *Amer. Soc. Hort. Sci. Proc.* 27: 57-62.
- (229) \_\_\_\_\_  
1939. THE NATURE OF CRACKING IN SWEET CHERRIES AND POSSIBLE SOLUTIONS OF THE PROBLEM. *Wash. State Hort. Assoc. Proc.* 35: 54-57.

- (230) WASHINGTON STATE UNIVERSITY.  
1971. 1971 SPRAY RECOMMENDATIONS FOR TREE FRUITS IN EASTERN WASHINGTON. Wash. Agr. Expt. Bul. 419, 36 pp. (Revised annually.)
- (231) WAY, R. D., and GILMER, R. M.  
1958. POLLEN TRANSMISSION OF NECROTIC RING SPOT VIRUS IN CHERRY. U.S. Dept. Agr. Plant Dis. Rptr. 42: 1222-1224.
- (232) WELLINGTON, R., and LAMB, R. C.  
1950. SWEET CHERRY BREEDING. Amer. Soc. Hort. Sci. Proc. 55: 263-264.
- (233) WILHELM, S., NYLAND, G., and CHARLES, F.  
1954. VERTICILLIUM WILT OF SWEET CHERRY IN CALIFORNIA. U.S. Dept. Agr., Plant Dis. Rptr. 38: 438.
- (234) YANG, H. Y., and WIEGAND, E. H.  
1952. HOME PROCESSING OF FRUIT AND VEGETABLE JUICES. Oreg. Agr. Expt. Sta. Bul. 515, 23 pp.
- (235) ZELLER, S. M.  
1934. CHERRY MOTTLE LEAF. Oreg. State Hort. Soc. Rpt. 26: 92-95.
- (236) ZIELINSKI, Q. B., SISTRUNK, W. A., and MELLENTHIN, W. M.  
1959. SWEET CHERRIES FOR OREGON. Oreg. Agr. Expt. Sta. Bul. 570, 19 pp.
- (237) ZUROSKE, C. H., and BLACK, J. A.  
1960. CENTRAL WASHINGTON SWEET CHERRY PRODUCTION COSTS. Wash. Agr. Expt. Sta. Cir. 378, 10 pp.