CHERRY ROOTSTOCKS

IN CALIFORNIA

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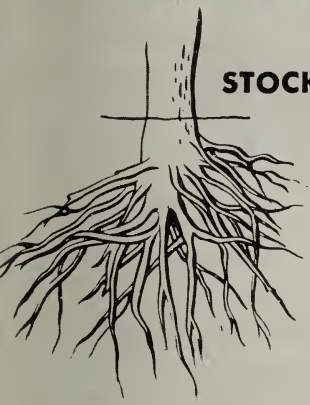

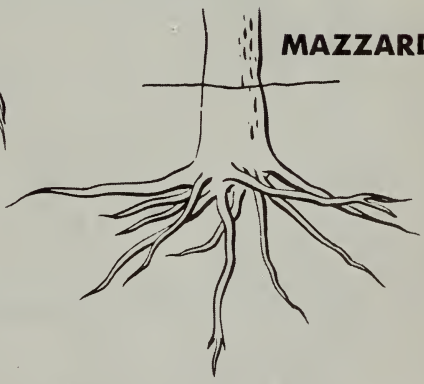

THIS BULLETIN DISCUSSES THE SOURCE, METHOD OF PROPAGATION, AND BEHAVIOR OF SWEET CHERRIES ON THE THREE ROOTSTOCKS COMMONLY USED IN CALIFORNIA

Three rootstocks

are commonly used in California cherry orchards:

Mazzard This species usually results in the largest trees of the three rootstocks. It is also semi-resistant to oak fungus root rot.

Mahaleb Trees on this root are the most tolerant to drought and unirrigated conditions.

Morello This stock is most useful in soils likely to become too wet. It can also be used to produce smaller trees for economical harvesting of fruits or for home gardens.

THIS BULLETIN is a summary of 25 years of observations and experiments on the behavior of these rootstocks with various cherry varieties, their relative susceptibility to diseases, insects and animal pests, and their reaction to soil conditions and deficiencies.

The observations were made at the University of California Experiment Station at Davis and in various cherry-growing districts throughout the state. Some of the orchards observed were planted 50 to 80 years ago.

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I. Rootstock species used for cherry varieties

ONLY THE SWEET CHERRY is grown commercially in California. The sour or pie cherries and the duke cherries—hybrids of the sweet and sour species—are raised mainly in home gardens.

In California three rootstock species are in general use. From fairly reliable estimates, about 65 per cent of the cherries grown in the state are grafted on mazzard (*Prunus avium*) ; 30 per cent are on mahaleb (*P. mahaleb*) ; and 5 per cent on morello (*P. cerasus*). Each has advantages in adapting the cherry tree to various cultural and environmental conditions.

The merits for sweet cherries of the two principal stocks, mazzard and mahaleb, have been under discussion since the beginning of commercial cherry growing in California. Climate, soils, methods of cultivation, diseases, soil insects, rodents, and nematodes have played a part in the experiences of growers both in this state and in widely separated areas throughout the country.

The general opinion in California is that mahaleb tends to dwarf the sweet cherry tree, but not nearly to the extent that Stockton Morello does. In some situations mahaleb makes as large a tree as does mazzard. Possibly, however, mazzard-rooted trees are retarded in growth in certain situations particularly favorable to mahaleb.

In a number of the eastern states mahaleb is said to make for short-lived trees. It is likely that in some of these areas heavy, wet soil has interfered with healthy growth of the trees on this root. In California some of the oldest trees are on mahaleb roots.

At the Utah Agricultural Experiment Station, Coe (1945), following systematic orchard surveys of the rootstock used there and as a result of a 13-year test in the station orchard, concludes that mahaleb is the best stock, at least for the arid climate and porous soil conditions found in most orchards of that state.

The rapid spread of certain virus diseases in Utah cherry orchards during the last few years may greatly change the rootstock preferences there.

The morello or sour cherry root has been used to only a limited extent in California to adapt sweet cherry varieties to heavy, wet soils; or, in light soils, to prevent the trees from growing too big for economical harvesting of fruit. For this purpose the Stockton strain of morello is the only one in use. It is a vigorous selection grown from suckers that spring up between the rows of trees in orchards on this rootstock (See fig. 12, p. 16). Seedlings produced from seeds of this and other sour cherry varieties are variable in vigor in the nursery. Therefore nurserymen have been unwilling to depart from the established custom of growing them from suckers.

Preliminary experiments at the Davis Station indicate that, by discarding the dwarfish seedlings in the seed bed and transplanting to the nursery only the vigorous ones, nurserymen might grow morello seedlings satisfactory for sweet cherry orchards. A few trees of this combination, 10 years old, are growing at Davis. Seedling rootstocks should not be adopted for extensive plantings until testing on a large scale has proved their value and shown which varieties produce the best seedlings.

II. How to identify cherry rootstock species

The rootstock species on which cherry trees are growing in the orchard can usually be identified by inspection of suckers bearing either leaves, flowers, or fruits. In the absence of such suckers, there are several methods of distinguishing the three rootstocks:

By the color of a water extract of the bark. This applies also to nursery trees.

By the contour of the graft union of trees in the orchard.

By observation of the color of the inner bark near and at the graft union of trees after several years in the orchard.

All of these methods will be discussed.

By leaves, flowers, fruit, or suckers

Morello rootstocks may usually be distinguished from the other two because morello is very prone to send up suckers between the rows, rather than only at the crown as with mazzard and mahaleb. Mazzard does not sucker so freely below the union as mahaleb. Neither one suckers freely when the graft union is at least slightly below ground. If suckers do occur at the crown, the difference in leaf size will readily identify them.

The distinguishing features of the three stocks in leaves, flowers, and fruits are shown in figures 1, 2, and 3. The size of the leaves varies considerably within each species but seldom to such an extent that the three species cannot be identified by this character. Hybrid duke cherries, however, sometimes have leaves as small as morello.

The mahaleb fruit is small, seldom over ¼ inch long, blackish when ripe, firm, bitter, and astringent. Flowers and fruit are borne in racemes, while the pedicels of mazzard and morello emerge from one point. The flowers are small—less than one half the diameter of those of the other two species. Twigs are slender, and leaves are small, curved, and shiny.

The morello fruit (sour cherry) is considerably larger than that of mahaleb, though seldom attaining the size of even a small sweet variety. Fruit is dark red to black, sour but usually edible when fully ripe. The "pie" cherry varieties are selected seedlings of this species. Duke cherries, also used for pies, are hybrids between sour and sweet cherries.

Fruit of mazzard seedlings is usually small like the morello, black, red, or light-colored when ripe, and often sweet enough to be edible. An occasional mazzard seedling may have fruit as large as the sweet cherry varieties, which are themselves selected mazzard seedlings.

By color of water extract of bark

If shavings of bark of mazzard or morello are placed in a glass with a little water, a yellowish substance may be observed within a few seconds to begin oozing out of the shavings. The water soon takes on a yellow to orange color; after a few hours it becomes dark orange. Practically no color results from similar shavings of mahaleb bark.

By examination of the graft union

In the orchard the rootstock upon which the trees are growing can usually be determined readily, even though there are no suckers from the root. This is done by examination of the union, or of the inner bark color above and below the union.

Between sweet cherry and mahaleb the union is almost always at least slightly rough or bulged; the trunk immediately below the union is slightly smaller than above. This constriction, however, is seldom as great as with morello (See fig. 8, p. 13, and 13, p. 16). The union is usually so perfect between the sweet cherry and mazzard that there are no external evidences of it.


MAZZARD
STOCKTON MORELLO
MAHALEB
INCHES


STOCKTON MORELLO
MAZZARD
MAHALEB


INCHES
INCHES

By color of the inner bark

In certain graft combinations the inner bark tissues of the scion and root are different in color. A distinct line is seen if the bark across the union is lightly shaved to remove the dead outer layers.

The inner bark of the mahaleb root is white; upon exposure it quickly oxidizes to a cinnamon color. That of mazzard and Stockton Morello has a faintly yellowish or buff tinge, turning to a dark orange.

The varieties of sweet, sour, and duke cherries all have a buff color similar to the mazzard and morello roots. This color difference, extending only slightly beyond the root crown, is not present in nursery trees but develops a year or more after they are transplanted to the orchard.

If the inner bark tissue below the union is the same color as that of the scion variety, the rootstock is either mazzard or morello. It is mahaleb if this tissue is white or pink, and if it immediately begins to change color on exposure while the tissues above the union do not begin to change for a quarter to a half minute later.

III. Characteristics of the three root systems

In mature trees the mazzard root system is stocky and spreading in habit. The main roots of the mahaleb are more slender and much more deeply penetrating (See figs. 4, 5, and 6). They are tough and harder to cut with a knife than mazzard roots. The root systems of very old trees on mahaleb root become very large, and the trees are difficult to pull by tractor.

Mazzard seedlings produce more fibrous roots than do the mahaleb. Mazzard-rooted trees are prone to send up small laterals and fibrous roots in large numbers into the surface soil. They are therefore particularly sensitive to drought and to deep cultivation, both of which cause dieback in the tops of the trees.

Sometimes masses of feeding roots are turned up by the disc even at moderate depths. Dieback conditions have frequently been observed in orchards with alternating rows of mahaleb and mazzard roots. The dieback was confined to the rows on mazzard root, undoubtedly because the latter do not tolerate deep cultivation.

The root system of the mature Stockton Morello is in general more like that of the mazzard than the mahaleb. When pulled by tractor the roots seem to be more brittle than those of either mazzard or mahaleb. But trees on Stockton Morello are not so easily injured by deep cultivation as are those on mazzard root.

Reactions to covercrops

Permanent covercrops without cultivation have been used to advantage in some orchards on mazzard roots in sandy and well-drained soils, where dieback had apparently been caused by deep cultivation. This sometimes required careful irrigation to avoid creating waterlogged conditions on top of clay subsoils. Even where the clay subsoil was as much as 5 or 6 feet below the surface, trees were sometimes severely injured, especially those on mahaleb roots.

One orchard on mazzard root was ob-

Figs. 1, 2, and 3. Top: current season's growth. Center: blossom clusters. In Stockton Morello the peduncle from which the flower pedicels arise grows out much longer than that of mazzard, with small leaves at the base of the pedicels. Bottom: fruits of mazzard, mahaleb, and Stockton Morello. Fruit size of mazzard seedlings varies with each tree and may be either smaller or larger than Morello fruits.

Fig. 4. A five-year-old mazzard root. This photo illustrates clearly the horizontal spreading habit of this variety.

Fig. 5. Photo of a five-year-old mahaleb root, showing the vertical tendency of growth. The tree pictured was grown in the same soil as the mazzard shown above.

served in San Joaquin County that has been in permanent cover for 12 years without cultivation. The covercrop is kept down by sheep. There is no evidence of dieback, whereas cultivated orchards nearby on mazzard root have severe dieback.

In a shallow soil in Placer County a permanent covercrop, maintained by a sprinkling system, caused mazzard rootlets to accumulate in large numbers close to the surface.

Dieback conditions in the variety orchard at the Davis station were greatly relieved by a change from deep, clean cultivation to an alfalfa covercrop. Bacterial gummosis, which had been doing considerable damage in this orchard, was also less severe after this change in cultural methods.

Tolerance to wet situations

Mazzard roots tolerate excess soil moisture and heavy soils better than do mahaleb but not so well as morello. For the sake of comparison, it can be stated that mazzard are possibly slightly more resistant to saturated soils and to crown rot infection in wet soils than are peach roots, while mahaleb is at least as susceptible as peach if not more so.

In order of sensitivity to high water tables in the soil, mahaleb is most sensitive, mazzard intermediate, and morello least sensitive. Possibly the deep-rootedness of mahaleb has some bearing on its sensitivity to high water tables.

Many trees on mazzard and mahaleb roots have been injured, and some even killed, by standing in water-logged soils over a period of only a few days during the spring and early summer. Whether the injury was due to exclusion of air by water or to crown rot infections (See p. 27) was not determined in these cases.

Trees on Stockton Morello have been seen to stand in similar situations over much longer periods without apparent injury. Stockton Morello root is more tolerant of wet soils than are peach and apricot, but less so than plum and pear root.

In one orchard in Sutter County a few morello-rooted trees in a low wet area

Fig. 6. This is a root of Stockton Morello, pulled up at the end of 14 years. Note the horizontal growth of the root system.

were killed in the prolonged rainy season in the winter and spring of 1938. The injury was confined to the root-crown (crown rot) rather than to the deeper roots, and the cankers did not extend up to the graft union, which was well above the soil surface.

A Yuba County orchard of sweet cherry trees on Stockton Morello roots was not injured by flood waters, though nearby prune trees on peach roots were all killed.

Trees on Stockton Morello have been injured where the soil remained saturated throughout the spring and up into May. In one such case the cherry trees and adjacent peach trees all died, while pear trees survived.

The scion variety has some influence on the susceptibility to injury. In one orchard on mazzard root, Bing and Black Tartarian withstood the wet soil conditions better than did Lambert and Deacon on mazzard.

Tolerance to dry situations

Possibly due to their deep-rooting habits, mahaleb-rooted trees are more drought-resistant than are mazzard and Stockton Morello. Dieback of trees on mazzard root in shallow, unirrigated soils is much more common than with mahaleb-rooted trees.

Figure 7 shows a Royal Ann cherry tree about 50 years old on mazzard root. At least two-thirds of the top has been lost from dieback of large branches, following winters of scant rainfall and possibly from deep cultivation. This was in a non-irrigated orchard near Vacaville, Solano County.

Trees on mahaleb were not so seriously affected by years of drought. They do better in certain hot sandy soils of the interior valleys than do trees on the other two roots. Stockton Morello usually does poorly in sandy situations, where it often makes such a small root system that the trees require staking to anchor them.

Fig. 7. A Royal Ann cherry tree on mazzard root. Photo shows dieback of the large branches.

Newly planted trees on Stockton Morello root have to be kept well watered and the trunks protected from sunburn for an inch or more below the soil line. Some failures in establishing an orchard on this stock have apparently been due to lack of drought resistance, especially in unirrigated sections and in sandy or gravelly soils that do not supply enough moisture without frequent watering.

Sunburning of the trunks has been common under drought conditions. Bacterial gummosis of the sweet cherry on this root is especially common. The Stockton Morello trunk is more easily sunburned than is that of mazzard.

The mahaleb trunk does not sunburn so easily as do those of the mazzard and Stockton Morello. If it does become sunburned, it apparently is not so likely as the others to be injured by the flat-headed borer (*Chrysobothris* sp.). Some growers, especially in unirrigated orchards, have nevertheless found it necessary to protect newly top-worked mahaleb seedlings from sunburn.

Relative winter hardiness of cherries on the three stocks

Mahaleb-rooted sweet cherries are more tolerant than those on the other two species to low winter temperatures. This fact might make them particularly useful in some of California's high mountain areas and east of the Sierras and the Cascades, where there has been damage to trees on mazzard roots.

The resistance of mahaleb-rooted trees to cold injury is attributed by some to the fact that in cold regions trees on mahaleb root go dormant earlier in the fall than they do on mazzard.

Lambert is more resistant to cold than Bing and Royal Ann and has been used in some orchards of eastern Oregon, budded low on both mazzard and mahaleb roots. In that region Bing and Royal Ann top-worked high upon Lambert scaffolds are said to be more resistant to the low winter temperatures than they are when directly on mazzard roots. Also the greater resistance of Lambert to bacterial gummosis (Barss, 1925) enhanced the usefulness of this variety as a framework stock in eastern Oregon. In recent years mahaleb has been preferred to mazzard for Lambert in that area.

Tolerance to soils previously used for trees

Cherry seedlings can seldom be grown successfully in nurseries whose soil has recently been occupied by nursery or orchard trees. Mahaleb is affected less than mazzard by such conditions. Mahaleb seedlings and even mahaleb-rooted nursery trees grow better as replants in cherry orchards than do mazzard seedlings and mazzard-rooted nursery trees. In contrast, nurserymen find they can replant nursery soil several times with almond and myrobalan plums.

Response to zinc deficiency in the soil

Mahaleb-rooted trees are not so subject to zinc deficiency (little-leaf) in the San Joaquin Valley as are those on mazzard root.

Response to excess lime

Trees on both mahaleb and mazzard roots in highly calcareous soils are subject to lime-induced chlorosis. In some sections of Santa Clara Valley they seem to be less affected by this type of chlorosis than are apricots, pears, and quinces.

In San Joaquin County in a soil of very high lime content severe chlorosis has been observed on trees with mazzard rootstocks. On the other hand no chlorosis is evident in some orchards in this area with moderately calcareous subsoils.

Effects on time of blossoming and ripening

In California there seems to be little if any difference in blossoming and ripening time of sweet cherries on the three rootstocks.

Coe (1945) states that in Utah trees on Stockton Morello roots ripen their fruits about a week earlier than on the other stocks, except when they are overloaded with fruit. In New York State, Howe (1927) reports that "sweet cherries and dukes, as a rule, bloom earlier on mahaleb than on mazzard stock."

IV. Behavior of sweet cherry varieties on the three rootstocks

Behavior on mazzard

Since mazzard is the same species as the cultivated sweet cherry varieties, it makes a more congenial union with them than do mahaleb and Stockton Morello. This does not signify that mazzard is always the best root, however.

Certain soil, climatic, and cultural conditions make mahaleb a better choice; and in some situations Stockton Morello root is more satisfactory.

Even though trees on mazzard grow larger and are reputed to be longer-lived, some growers prefer either mahaleb or Stockton Morello on account of earlier bearing, smaller trees, and heavier set of fruit.

The cost of harvesting is considerably less with the smaller trees. Trees on the two latter stocks can be planted closer than those on mazzard roots, thus partially making up for the smaller bearing surface per tree.

Where the planting distance is too close the cherry, particularly on mazzard roots, is prone to grow upwards. Under these conditions orchards require careful pruning to direct the branches outwardly to occupy the available space between trees.

Cherries on long branches of trees on mazzard roots scar and bruise worse in windy weather than with the smaller trees on mahaleb and Stockton Morello roots.

Behavior on mahaleb

Some of our oldest cherry orchards today are on mahaleb roots. Many unirrigated mazzard-rooted orchards have long since died out. Some of the old trees planted on mahaleb root have grown variety roots (mazzard) above the graft union so that they now have two types of roots, a deep and a shallow. Possibly this has in some cases been an advantage to the trees. But the effect of drought, nonirrigation, and deep cultivation in such cases has not been adequately studied.

With the exception of certain varieties that bear entirely too heavily under some conditions, the fruits on mahaleb root are as large as on mazzard. In the case of Stockton Morello roots, unless pruning and other cultural conditions are carefully planned, the trees often overbear, with the result that the fruit is small.

Mahaleb seedlings do not make as perfect unions with the sweet cherry varieties as do the mazzards. The smoothness of the union seems to vary from seedling to seedling; the same variety overgrows some seedlings to a much greater extent than it does others.

The early heavy bearing of some varieties on mahaleb no doubt accentuates the dwarfish tendency. It has been observed both in the nursery and in the orchard that sweet cherries on mahaleb often grow faster the first few years than they do on mazzard. The wood union is strong so that trees do not break in the wind.

The union between mahaleb root and Bing, Longstem Bing, Lambert, Royal Ann, Elton, and Knight is usually fairly smooth. The other varieties commonly used in California overgrow this stock to a conspicuous extent. In spite of the overgrowth, they make successful orchard trees. Figure 8 is a photograph of Black Tartarian grafted in the scaffold branches of a mahaleb seedling.

Fig. 8. Black Tartarian, top-worked in scaffold branches of mahaleb seedling about 8 years old. Note overgrowth of this variety.

Fig. 9. Black Tartarian of 55 years on mahaleb roots. Graft union is inconspicuous at ground level.

The constriction below the union of nursery-budded trees becomes less noticeable as the tree grows older, provided they are in soil suitable to this root. Thus the point of union can scarcely be found in figure 9, a photograph of a tree of this variety about 55 years old budded at the ground on mahaleb root.

This tree was grown in Sacramento County without irrigation the first 45 years. Most of the trees in the orchard, on mazzard roots, died before 1932, possibly because of both drought and deep cultivation. This tree is still producing heavily (1951) at 71 years, though considerable dieback has occurred in other trees on mahaleb. Trees on mahaleb root are still bearing well at 50 years of age in Santa Clara County.

In some situations, Black Tartarian on mahaleb bears too heavily, with consequent small fruit. Burbank and Chapman fail to make good unions with some individual mahaleb seedlings. In these cases they produce too heavily, and the fruit does not attain good size. Burbank especially fails to grow thriftily, and early decline of the trees is more common than with Chapman. Black Republican sometimes also bears too heavily. Black Tartarian usually sizes its cherries despite heavy sets of fruit.

Intermediate stocks. A few growers are trying intermediate stocks in an attempt to adapt the mahaleb root to varieties with which it is not entirely compatible. In one orchard 6-year grafts of Chapman and Burbank on branches of Black Republican appear to be successful. One grower has a few trees of the variety Knight between mahaleb and Chapman. Another has 12-year-old Chapman and Royal Ann grafts, each with Black Tartarian as the intermediate stock.

Chapman, with Longstem Bing as the intermediate, is producing in another orchard larger Chapman fruits than are trees with this variety directly upon mahaleb roots. Bing makes very good unions; one grower is trying it as an intermediate stock for Black Tartarian and other varieties.

Growers show great interest in intermediate stocks for mahaleb seedlings in districts where the cherry buckskin disease is present (See fig. 20, p. 28). In addition to certain congenial sweet cherry varieties as intermediate stocks, vigorous mahaleb strains are being tried in the same capacity. These are budded in the nursery on mahaleb seedlings and later transplanted to the orchard. When 3 or 4 years old, they are top-worked to the desired sweet cherry varieties.

Fig. 10. Mazzard seedling inarched into sweet cherry on mahaleb, above the graft union. The rough union between the mahaleb root and sweet cherry is clearly evident.

Top-working mahaleb seedlings. Some growers believe that to be long-lived on mahaleb Chapman must be top-worked in the orchard on the main branches of mahaleb seedlings.

Others who use nursery-budded trees consider that with buds placed at the root-crown and with the union slightly below ground, there are larger fruit sizes, better growth, and less constriction than with trees budded above the ground in the nursery row. It is likely that as soil becomes banked up around the crown rooting of sweet cherry varieties above the union often occurs, and this sometimes causes the constriction to disappear.

Since mahaleb-rooted trees are prone to produce suckers and watersprouts below the union, one would expect trouble of this nature in seedlings top-worked in the orchard. But this tendency is readily overcome by systematic pruning begun in early summer after the trees are planted and followed up at each winter pruning.

Care is taken to cut very closely to remove much of the enlargement or collar tissue at the base of the sprouts. As mahaleb is practically immune to bacterial gummosis, one need not be concerned with any appearance of gumming that may appear around the cuts.

In the orchard at Davis a mazzard seedling tree was top-worked at 6 years to a mahaleb seedling selection of good characteristics. It was growing well when it was removed at 12 years, though the mahaleb was greatly bulged above the union.

At the same time an English Morello 6 years old was top-worked to another vigorous mahaleb selection. Though the union was smooth, it was an uncongenial combination and had grown poorly, though still alive when the tree was pulled out in the twelfth year.

Inarching. A few cases have been observed of successful inarching of mazzard seedlings into mahaleb-rooted trees (See fig. 10) to correct some weakness—uncongenial unions, soil conditions unfavorable to mahaleb roots, or rodent injury. The process has been used to invigorate trees of poor vigor because of incompatibility between rootstock and scion.

Behavior on Stockton Morello

Sweet cherry varieties are usually budded with the Stockton Morello root in the nursery. But some orchards have been planted to this stock and later budded or grafted in the trunks or in the scaffold branches.

Growers who have tried top-working Stockton Morello in the orchard seem to agree that it is best to place the grafts in the trunk at the ground level rather than higher in the tree (See fig. 11). They then short-prune annually to increase branching, because trees on this root tend to early fruiting rather than to forming enough low, spreading branches. Scion varieties high-worked in the trunk are more likely to grow dwarfishly than those with the unions at the ground.

Nursery-budded trees on Stockton Morello, if planted in the orchard with the union below ground, will form roots from the variety above the union. This of course tends to defeat the dwarfing pur-

pose for which the Stockton Morello stock is used. Also, on heavy, wet soils the scion roots might die and conduct wood-rotting fungi into the trunks.

Perhaps there would be a place for morello seedlings for sweet cherries in California if some seed trees had been tested long enough to prove good results.

Sweet cherry trees are more distinctly dwarfed on Stockton Morello than on mahaleb roots. The tree seldom grows more than 15 to 20 feet high. With some varieties, if not properly trained by judicious pruning, the early and heavy bearing tendency may produce fruits too small to market (except for Maraschino processing).

Several orchardists report that profits have been greater than with their trees on mahaleb and mazzard. The trees began bearing much younger, and their small stature permitted more economical harvesting, while the close planting gave good tonnage. For home gardens, dwarf

Fig. 11. This is an eight-year-old Bing, on Stockton Morello root. It was grafted in the orchard, at the ground, and short-pruned annually to increase branching.

trees on this root might often be very acceptable, especially in heavy, wet soil.

In poor or shallow soils the proper planting distance of trees on Stockton Morello root seems to be about 20 × 20 feet. In richer soils, where they grow larger, the trees require 22 × 22 feet or even greater distances.

In some very rich soils trees 22 × 22 feet apart have been found, with the horizontal branches overlapping in the centers of the rows and the central branches growing so high as to defeat the purpose for which they were used—economical harvesting. In these cases a planting distance of 24 or 25 feet would have been better.

All sweet cherry varieties overgrow the Stockton Morello stock. Bing (See fig. 12), Lambert, and Schmidt make the least overgrowth, sometimes giving an almost smooth union; while Black Tartarian, Mezel, Royal Ann (Napoleon) (See fig. 13), Early Purple, Black Republican, Chapman, and Burbank often greatly overgrow it.

With all varieties the wood union is strongly knit so that the trees do not break off in the wind. Burbank makes perhaps the greatest overgrowth of any variety, yet it does particularly well on this root. Perfectly smooth unions have been observed with Bing, though usually there is considerable overgrowth. Bing is a shy bearer on Stockton Morello; hence its fruits are of good size. This is true in both interior and coastal climates.

Black Republican usually bears too heavily, producing fruit below normal size, though with careful pruning this variety has been made commercially satisfactory. Chapman trees have occasionally been reported to sicken and die on Stockton Morello stock, even when intermediate stocks of Bing and Burbank have been used. At Davis Chapman has done well on Stockton Morello.

It is possible that certain virus diseases (See p. 27), which are difficult to detect in Stockton Morello nursery trees, may account for some cases of failure of sweet cherries on this stock.

V. Rootstocks for sour and duke cherries

English Morello, Early Richmond, Montmorency, and other sour cherries are generally propagated on mazzard roots, as are also the dukes (hybrids between sweet and sour cherries, such as May Duke, Royal Duke, and Late Duke).

But they also do well on both mahaleb and morello, the latter adapting them to heavy or poorly drained soils. Reports from various experiment stations in the United States and England indicate that sour cherries make larger trees on mahaleb and mazzard rootstocks than on roots of their own species. In Michigan, Colorado, and Utah sour cherries have made larger trees and survived low winter temperatures better on mahaleb than on mazzard.

VI. Rootstocks for ornamental flowering cherries

Ornamental or flowering cherries are grown almost exclusively on mazzard roots in California. Seedlings of the oriental species *Prunus serrulata* (to which nearly all the oriental flowering cherries belong) are sometimes used. (Seedlings of *P. serrulata* are reported to make fairly good stocks for sweet cherries.)

Russell (1934) states that varieties of *Prunus yedoensis* and *P. subhirtella* do better on mazzard, though either stock will do for varieties of the species *P. sieboldii, sargentii,* and *campanulata.*

The hardier oriental flowering cherries do not propagate well by cuttings but have been grown in the Orient by layering methods.

To make taller trees of the dwarfish

and weeping ornamental cherries, these are sometimes grafted high upon the branches of mazzard seedling trees. This procedure will not, of course, affect the weeping habit of the top.

Shiro-fugen and Kwanzan flowering cherries (both varieties of *P. serrulata*) are grown on mazzard seedlings. These are very sensitive to some of the viruses and are being used by plant pathologists for detecting virus diseases in sweet cherry trees.

VII. Source and propagation of rootstocks

Source of mazzard

Sweet cherry varieties are selected seedlings of this species. It is a native of Europe and western Asia. In many places in the eastern part of the United States it has run wild in fence rows for possibly 200 years, and the seeds are gathered for nursery purposes.

Very few California nurserymen raise their own mazzard seedlings. Most seedlings are propagated in Oregon and Washington by nurserymen who get some seed locally, although much of it comes from the eastern states and some from Europe. The European sources, however, had become negligible even before the first World War.

McClintock (1929), Clarke and Anthony (1946), and Brase (1945, 1947) have reported that seed from *selected* local run-wild mazzard trees in the eastern states have made seedlings as good as those from seed imported from France, if not better. Clarke and Anthony (1946) state that in Pennsylvania "generations of natural selection have isolated strains of wild mazzards that now withstand temperatures of –20 to –30 degrees F without serious injury."

The late Dr. W. L. Howard, of the California Station, observed the wild black mazzard cherry (See fig. 14) growing along the roadside and in the forest,

Figs. 12 and 13. A typical 15-year-old Bing tree on Stockton Morello root. Note rootstock suckers in the foreground. Right: a typical Royal Ann tree on Stockton Morello root. This tree is 15 years old and its size can be compared with the hat.

near Aunay, St. Georges, in northern France. Many of these trees were 40 to 50 feet tall, and 14 to 15 inches in diameter near the ground.

In France the wild mazzards are said to make superior long-lived rootstocks for sweet cherry varieties. It is there that collectors secured much of the mazzard cherry seed formerly used in the United States. But since the genuine wild trees are very scarce, the great majority of seeds sold to the trade were not wild mazzard at all but came from cultivated varieties. This latter fact may partially account for the poor quality and lack of uniformity often found in nurseries propagating mazzard seedlings brought in from Europe.

Garner and Grubb (1938) state that in Europe the silver-barked mazzard, native to the Harz Mountains of Germany, makes particularly good rootstocks, producing large and long-lived sweet cherry trees. Some preliminary experiments were made with this stock, brought to the Davis Station by Dr. Howard in 1925. Sweet cherry on it planted near Penryn, in Placer County, were probably not more resistant to bacterial gummosis than were those on other mazzard stocks, since all were killed by this disease.

The following varieties top-worked onto 5-year-old seedlings of this stock at Davis in 1934 made smooth unions and have performed normally to date: Black Tartarian, Bing, Royal Ann, Black Republican, Lambert, Chapman, Burbank, and Emperor Francis.

Seeds of a number of common commercial sweet cherries were planted in the test nurseries at Davis. Those from Lambert, Bing, and Black Republican, especially the latter, made good nursery stocks. Downer, a less common variety, gave very high percentage germination and good nursery seedlings. The latter have been used every year in our nursery for 20 years. In preparation for nursery planting a stratification period of about 90 days at 36 to 40° F is required to break the rest period of Downer seeds.

Downer seedlings and silver-barked mazzard compared. In an orchard test of Downer and silver-barked mazzard seedlings (9 each, planted alternately in the row) the latter were much the larger at the end of 3 years, when they were pulled by tractor. The average

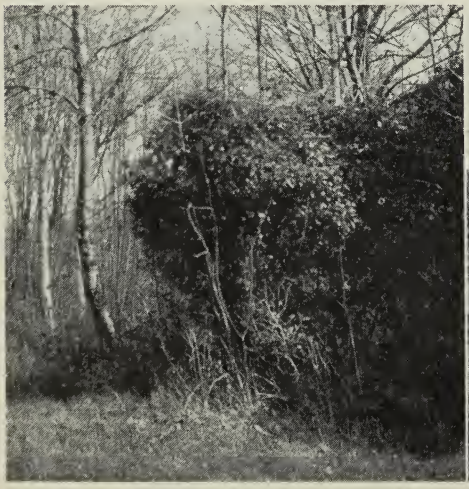

Fig. 14. A wild mazzard seedling growing in a mixed forest in northern France. (Photos courtesy the late Dr. W. L. Howard.)

Fig. 15. A wild mahaleb seedling growing in southeastern France at 3000 feet elevation. These trees have a pronounced taproot.

circumference of the Downer seedlings was 5 inches, and that of the silver-barked mazzard was 6½ inches. Even the smallest of the silver-barked seedlings had a more extensive root system than the largest of the Downer seedlings.

Selected mazzard seedlings were reproduced at Davis by layering, but the sweet cherry varieties did not propagate readily by this method. Neither did they strike root from stem cuttings, but a small percentage grew by root cuttings.

Source of mahaleb

The mahaleb cherry is native to certain parts of Europe and Asia, where it seems to prefer dry, gravelly, sunny hill slopes. Howard (1921) reported having seen it in dry, hard soils in the southeastern part of France at elevations of 3500 feet in the Alps Mountains (See fig. 15). It had a distinct tap root, and the trees were uniform in growth.

Hedrick (1915) in *The Cherries of New York* states that the use of this species as a cherry rootstock in America became quite common about 1860, and except in recent years American nurserymen obtained their seeds or seedlings from European dealers, who in turn gathered them from wild trees.

Today most of the California stock comes as small seedlings from Oregon and Washington, where they are grown largely from seeds locally produced and from California sources. Near Ceres, Stanislaus County, California, is an orchard of two acres of mahaleb and mazzard seedlings that are harvested for the seed trade.

Propagation of mahaleb

Mahaleb seedlings exhibit considerable variation in type and vigor. But they are more easily propagated and handled in the nursery than are mazzard seedlings. They transplant from the seed bed to the nursery row with less loss, and the conditions for good budding are more easily maintained.

In several districts growers have shown that replants of mahaleb seedlings and of nursery-budded trees on this root in old orchards have been more successful than mazzard seedlings or nursery-budded trees on mazzard root. This is perhaps because of mahaleb's deeper rooting, which gives greater resistance to sunburn and drought.

Top-working mahaleb seedlings in the orchard. A considerable percent of mahaleb seedlings planted in the orchards for top-working are either too slow-growing or too spreading in habit to make a shapely tree when grafted (See figs. 16 and 17).

Also some individual seedlings do not unite as well as others with sweet varieties. To overcome these difficulties several growers have budded selected vigorous, upright mahalebs onto mahaleb seedlings in the nursery and planted the resulting trees in the orchard. Some of these trees are now old enough to indicate that this system is satisfactory where it is necessary to top-work mahalebs, as in the case of the buckskin disease (See p. 59).

Experiments of this kind were begun in 1941 at the Davis Station. Four vigorous upright mahaleb seedlings with naturally wide-angled crotches were selected from the orchard for this test. These were budded in the nursery onto one-year-old mahaleb seedlings, which were all from seeds of a vigorous mahaleb in the orchard at Davis.

At one year of age 5 trees of each budded selection were set in an orchard row, with an unbudded selected seedling of the same trunk diameter (⅔ inch) planted alternately with each budded tree for comparison. These comparison seedlings were taken from the same nursery row in which the budded trees were grown, hence were 2 years old. At 5 years of age the budded selections had far outgrown the unbudded seedlings.

Figure 18 shows the difference in growth with the most vigorous of these

Fig. 16. A 13-year-old mahaleb seedling of unusual vigor, with wide-angle crotches. Five years after photo was taken, this tree was 22 inches in diameter and 35 feet high. Buds from this tree were used on the mahaleb seedling shown in fig. 17.

Fig. 17. Left: a 5-year-old vigorous mahaleb budded at the ground in the nursery onto a mahaleb seedling. Right: a 5-year-old, unbudded mahaleb seedling selected from the same nursery row. In orchard practice, both trees should have been top-worked to sweet cherry varieties at about 3 years of age.

Fig. 18. Stockton Morello seedling (center) compared with two average Stockton Morello trees grown vegetatively from suckers. These trees were planted in the spring of 1941 and photographed in the spring of 1949.

selections, California Selection 32–36, at 5 years of age. They have now been top-worked to sweet varieties. There has been less tendency for watersprouts to grow from the trunks of No. 32–36 than from the seedlings or from the three other vigorous mahaleb selections used as intermediate stocks in this test.

Several orchards have been observed in which the growers have found it best to allow mahaleb seedling replants to become 4 or 5 years old before top-working. Such trees come into mature bearing condition earlier than do those top-worked at one or two years of age. Grafts should not be placed in branches over 1½ inches in diameter because large wounds are readily infected with wood-rotting fungi.

There is considerable evidence that sweet cherries top-worked high on mahaleb seedlings do not grow as fast as those budded at the ground in the nursery. This was also noted by Brase (1945, 1947) at the New York State Experiment Station in cases where sweet and sour cherries were budded high on the trunk in the nursery. However, some growers believe that the variety Chapman grows larger when top-worked in the scaffold branches of mahaleb.

Propagation by cuttings and by layering. Not much success has been had at Davis in propagating selected mahaleb seedlings by root and stem cuttings nor by trench layers. But several workers in other places have reported fair success with layering selected seedlings and with soft-wood cuttings under glass.

Propagation of mahaleb by seeds. The mahaleb seeds used required about 100 days of stratification to break their rest period. At Davis, stratified seeds were planted directly in the nursery row and were grown to budding size by August or September. However, it was found best to broadcast them in the row

in a band about 6 inches wide. The thickly growing seedlings produced in this manner made small plants for lining-out in the nursery the following spring.

In the loam soil at Davis, which crusts badly following heavy rains and drying north winds, most success was obtained with cherry seeds planted in a thin layer of peat moss and then covered with about ¾ inch of soil. In seasons when the soil layer became too crusted to permit the sprouting seeds to push through, it was necessary to break up the crust with a rake.

Another method that worked well on crusting soils was a covering of black building paper, retained until the sprouts began to push through the soil. This paper comes in strips 3 feet wide and 100 feet long. The rolls were sawed into 12-inch widths.

Besides protection from beating rains and drying winds, the paper mulch also provided against growth of weeds along the row and protected the seeds from mice and squirrels. This method was of advantage for other small seeds—mazzard, morello, pear, and apple.

For larger seeds such as myrobalan plums, normally planted a little deeper, the soil can be rounded up to a depth of about 2 inches above the level of the surrounding soil surface, after the seeds are planted shallowly. When the sprouts begin to grow up into this layer, it can be raked off to the general level without many being broken. With care, this method can be used with cherry seeds.

In irrigating nursery trees, there is less baking of soil when the water seeps across from furrows on either side than when the soil is flooded or sprinkled. Seedlings grow faster if the soil is not allowed to become baked around them.

Source of Morello

This species is native to Asia and perhaps to southeastern Europe. A number of selected or improved varieties are in cultivation and are known as sour or pie cherries, such as Montmorency, Early Richmond, and English Morello.

All sweet cherry orchards planted on the sour cherry root in California are on a strain known as Stockton Morello. This variety was brought from Illinois to Courtland in the Sacramento River Delta region by Sol Runyon about 1860. It is reported still in use in Illinois, where it is commonly referred to as the American Morello, although it was originally brought from England. It seemed useful as a stock for sweet cherries in the wet soils of the Delta region and was propagated from suckers by a nurseryman on Grand Island until about 1875.

Its use was thereafter largely in orchards in heavy, wet soils east of Stockton. Growers in this area propagated it for themselves from suckers. The Vistica Nursery, then located near Stockton, began propagating it 25 years ago from suckers gathered in the orchards. They offered it to the trade under the name of Stockton Morello—a name suggested by W. L. Howard of this station. Since then it has been tried in various districts.

Nursery trees of sweet cherries on Stockton Morello roots are harder to establish in the orchard than those on mazzard and mahaleb. Unless they are kept growing by regular irrigation and by proper protection of the trunks they grow poorly, and the trunks become sunburned and infested with flat-headed borers at the ground level.

Nursery trees are acquired by grubbing up suckers that grow between the rows of trees on this root. These are reputed to be more satisfactory than seedlings grown in the nursery from seeds of sour cherry. But because of the scarcity of sprouts in the old orchards on this root, nurserymen may either have to propagate from seed (rejecting the weaker seedlings in the seedbed) or use some other method of vegetative propagation. By the use of virus-free Stockton Morello parent stocks, the above methods should insure freedom from virus diseases.

Experimental trials of morello seedlings. Preliminary trials of sour cherry seedlings have been made at Davis. The variety Homer gave better germination of seeds and stronger nursery seedlings than did English Morello, Montmorency, and Stockton Morello, though the latter were satisfactory after the dwarfish types had been culled out.

Seven Stockton Morello seedlings were planted in the orchard, in a row alternately with six Stockton Morello nursery trees grown from suckers. After eight years' growth in the orchard, the seedlings are comparable in size to the vegetatively grown ones. Two seedlings grew dwarfishly, and one of the vegetatively produced ones also grew slowly. The three largest trees of this planting are seedlings.

Fig. 19. An 8-year-old Bing on seedling of Stockton Morello, budded at the ground in the nursery. This tree is 16 feet high.

Figure 18 is a photograph of three of these trees at the beginning of their ninth year. The middle one is a seedling of Stockton Morello, the two at the sides Stockton Morello vegetatively grown from suckers.

Six trees of Bing and two of Chapman, nursery budded on Stockton Morello seedlings, were transplanted to the orchard in 1941. In their tenth year they are growing well and have borne several good crops. Two of the Bings were smaller than their companions. Figure 19 is one of the larger ones.

The exact status of Stockton Morello in relation to certain virus diseases, especially necrotic rusty mottle, recently found in orchards on this stock, is not yet known. It is possible that a large proportion of this stock may carry these diseases.

Several propagators have lately reported that sweet cherry buds on Stockton Morello rootstocks in the nursery often fail to grow. They also say that to get a good stand of sweet cherry buds on this stock it is necessary to get the buds from orchard trees already established on Stockton Morello roots.

If these observations are correct, this may be because some virus was latent in the Stockton Morello they were using.

To avoid virus diseases in Stockton Morello rootstocks, it may become necessary to find virus-free trees of this variety—using if necessary for quantity production some method other than propagation by the use of suckers.

Stockton Morello did not root well by trench and mound layers in experiments at the Davis Station. But in one test 40 per cent of short root cuttings from nursery trees grew when planted in the lath house. Probably long scions of this variety grafted onto short root pieces would be successful. Also there is the possibility of seedling propagation.

Bing and Chapman varieties on Stockton Morello seedlings at Davis (discussed above) are apparently free from virus. On the other hand, Bing, Black Tartarian, Lambert, and a large number of hybrid seedlings of sweet cherries, top-worked at Davis on Stockton Morello grown from suckers are reported by Brooks and Hewitt (1949) to have developed virus diseases. The bud sources of these varieties and hybrid seedlings were virus-free.

VIII. Other cherry species as rootstocks

The cherry is the only stone fruit propagated satisfactorily on the three stocks discussed thus far. Likewise cherry roots are the only ones found suitable for the commercial cherry varieties. Testing of various cherry and other *Prunus* species for possible usefulness as rootstocks or as intermediate stocks may have future value if they prove resistant to some diseases, nematode species, or other pests, or if they prove useful for dwarfing stocks for home orchards.

Wild cherry species in California

Of the five wild cherry species of California apparently only two, the western bitter cherry, *P. emarginata,* and the western choke-cherry, *P. demissa,* have been reported to have been used by the early settlers as a stock for sweet cherries.

Western bitter cherry. In one test at Davis the western bitter cherry made good growth on both mazzard and mahaleb roots. At 8 years it was as large as it ever becomes in the wild state. Grafted upon a 10-year-old mazzard tree it grew well for 6 years, after which it died.

Experimenters have not had good success in germinating seeds of *P. emarginata* nor of the closely allied and larger-growing *P. mollis* (*P. emarginata mollis*). The latter made good growth on both mazzard and mahaleb roots. Two-year-old grafts of Bing, Black Tartarian, and Royal Ann are growing well on 3-year-old trees of *P. mollis,* which in turn are on mazzard roots. One grower has 10-year-old intermediate stocks of *P. mollis,* with good unions with the mahaleb and several cherry varieties—Bing, Parkhill, Elkhorn, and Chapman.

Western chokecherry. Wickson (1926) in his *California Fruits* states that the western chokecherry, *P. demissa,* proved of some value "as a stock for grafting in early days when better stock was not available." This species failed to grow well at Davis when top-worked upon a 10-year-old mazzard seedling. In the nursery it grew fairly well one year upon mahaleb seedlings; but another year, after making excellent growth, the scion as well as root died during June.

The western bitter cherry made rather poor unions on seedlings of the western chokecherry; two trees transplanted to the orchard were growing dwarfishly when removed at 3 years of age.

Hollyleaf cherry

The native evergreen or hollyleaf cherry, *P. ilicifolia,* does not make a successful union with sweet cherries. This is unfortunate, since the species is highly resistant to oak fungus root rot.

Western sand cherry

This species (*P. besseyi*) is native to the Rocky Mountain area and neighboring Plains States. Sweet cherries are reported to grow very dwarfishly and poorly on it; but some plums, peaches, and apricots grow fairly well, though dwarfishly. It is sometimes used for growing dwarf trees of these fruits in home gardens. At Davis a few trees of Santa Rosa and Beauty plums, French prunes, and Blenheim apricots grew slowly and were less than one-half standard size at 18 years.

The unions were strong, and the *besseyi* root-crown was inclined to grow a little faster than the scion. The diameter of the *besseyi* trunk immediately below the apricot graft was 9 and 10 inches respectively in the two trees. One of the Beauty plums grew roots above the graft, and these took the lead over the original root. All had such small root systems at first that it was necessary to stake to prevent blowing over; later they withstood heavy winds.

The two French prune trees grew healthily until 10 years of age, when they began to die back in the tops—apparently because of overbearing. It is interesting that a species as dwarfish as *P. besseyi* can be grown quickly to a large diameter through the influence of vigorous scions of entirely different species. One season peach on *besseyi* seedlings made good growth in the nursery, but some of them died in the late summer. However, peach has been reported to make good dwarfs for home gardens and for espalier training on this root.

On its own roots bushes of this species are said to be drought-resistant in light or sandy soils in the northern Great Plains region, but to do poorly on heavy, rich soil except when budded on plum roots. Dr. N. E. Hansen at the South Dakota Station reported that *besseyi* makes a good stock for the hybrid plums of low growth, but that the tall varieties often blow over as they come into heavy bearing.

The surface of the roots of *P. besseyi* is about the same shade of red (blood or beet red) as that of apricot roots. But there is not the same violet and red violet coloration in the epidermis as there is in the apricot. *P. besseyi* on both apricot and myrobalan plum roots in the orchards at Davis are larger at five years than they ever grow on their own roots.

Oriental species

The Tangsi (early Chinese) cherry, *P. pseudo-cerasus* (P.I. 18587), is growing well on mazzard root at 25 years of age in Davis. In China edible varieties of this species are grown on their own seedlings and on mazzard; but they are mostly propagated by trench layerage.

P. tomentosa, an oriental cherry, made vigorous growth and strong unions in the nursery trees at Davis with myrobalan and St. Julien plum roots, and vigorous growth but weak unions with peach and almond seedlings. In the orchard two *P. tomentosa* trees about ten years old on the wild Chinese peach, *Amygdalus davidiana,* roots were growing fairly well when the orchard was pulled out. The union was rough but strong, and the trunk of the rootstock was greater in diameter than that of the scion. Such a condition as the latter is usually a favorable one with any graft combination. One nurseryman reported that *P. tomentosa* makes a good dwarfing stock for flowering almonds of the species *Amygdalus triloba.*

Miscellaneous cherry species

For future work with cherry rootstocks and intermediate stocks, the following cherry species native to various parts of the world are growing in the rootstock test orchards and other locations at the Davis Station: *Prunus besseyi, capuli, demissa, emarginata, fontanesiana, fruticosa, ilicifolia, lyonii, maackii, maximowiscii, mollis, padus, padus commutata, pilosiuscula, pseudocerasus, pumila, tomentosa,* and *virens.*

Cherry on Other Stone Fruits

In one nursery test myrobalan seedlings were budded with several sweet cherry varieties. A fair take of buds resulted and the scion varieties grew well. However, some died in midsummer, though others were growing well when the nursery was dug the following winter.

Two-year-old cleft grafts of sweet cherry were growing dwarfishly on a branch of a peach tree at the Davis Station at the time the orchard was pulled.

IX. Diseases of cherry rootstock species

Oak fungus

Mazzard root is semiresistant to the oak fungus root rot, *Armillaria mellea*, while mahaleb and Stockton Morello are quite susceptible. Since the disease travels slowly in mazzard, it is profitable to perform surgery upon roots of old trees and to keep the bases of the roots of affected trees exposed. In this way the disease will be retarded in its girdling development. The other two species are too susceptible to make this worthwhile.

Bacterial gummosis

Observations indicate that trees worked high on mahaleb seedlings are more free from cankers of bacterial gummosis, *Agrobacterium syringae*, than are those similarly top-worked upon mazzard seedlings. Barss (1918, 1925) reported that in Oregon mahaleb seedlings and sour cherries appear immune and that seedlings of mazzard show considerable resistance; also that susceptible varieties top-worked high upon resistant mazzard seedlings were less susceptible to the disease.

Lambert is more resistant to bacterial gummosis than other common varieties, whether on mazzard or mahaleb roots. Philp (1947) reported that "sweet cherry trees on Stockton Morello root seem less susceptible than those on ordinary mazzard." However, in San Joaquin County under unfavorable situations, they appear to be considerably more susceptible to bacterial gummosis than are similar trees on mazzard roots.

This has been observed on sandy soils, in which the Stockton Morello root does not do well. The disease was worse on Bing than on Royal Ann and Black Tartarian. Although the cankers were usually above the union, they often spread downward into the bark of the Stockton Morello. But unlike the cankers of crown rot, bacterial gummosis infections do not follow downward into the soil more than an inch or two in any of the rootstock species of stone fruits.

Gumming at the graft union and immediately above in top-worked trees has been observed to be more common with both Stockton Morello and mahaleb than with mazzard; but in only a few cases has this been due to bacterial gummosis infection. The gumming was usually caused by sunburn and perhaps sometimes by physiological or structural difficulties at the graft union. Possibly in some cases it was from gummy blisters of the necrotic rusty mottle or blister virus discussed on page 27.

Crown gall

The cherry stocks are not so susceptible to crown gall, *Agrobacterium tumefaciens*, as are the roots of some other stone fruits. Only a few seriously injured trees have been observed in California orchards. In the Davis Station nurseries, no differences have been detected among the cherry rootstock species in regard to this disease.

Though several nurserymen state they have not had much crown gall on any of them, one nurseryman reports more crown gall on mazzard than on mahaleb in his nurseries. One grower stated that in replanting his old orchard lands in which crown gall was prevalent mazzard roots were often severely infected whereas he had no difficulty in this regard with mahaleb roots.

Blackheart

Verticilliosis or Blackheart fungus (*Verticillium alboatrum*) is known to infect all three rootstock cherry trees in Europe, but there seem to be no observations as to whether it attacks trees on one rootstock species more freely than on another. It is a serious disease of apricots in California, but up to the present time plant pathologists have not identified it on cherry in this state.

Crown rot

As discussed on page 9, infection by crown rot fungi (*Phytophthora* sp.) is quite common in wet situations with trees on all three stocks, perhaps more often with mahaleb than with mazzard, and much more rarely with trees on Stockton Morello roots. Orchards have been observed where practically all the cherry trees in low wet areas died, except those on Stockton Morello roots.

Though apparently more common where the bud union is at or below the soil surface, crown rot has been seen with top-worked mahaleb and mazzard seedlings. The cankers usually begin at or near the soil surface, and progress more rapidly downward into the roots than up into the trunk.

Brown rot

The blossoms and fruits of cherries are subject to brown rot in wet seasons. Apparently owing to the crowded set of blossom clusters of the Burbank variety when on mahaleb and Stockton Morello, this disease was much more severe in one orchard on these species than in orchards on mazzard roots.

Virus diseases

Cherry trees are subject to several virus diseases, one or more of which may be carried in the seeds borne on affected trees. In this way they may appear in nursery seedlings. Ring spot and sour cherry yellows, both occurring in California, are known to be transmissible through seeds.

It is not known whether either the buckskin virus or the more recently discovered virus (or complex of viruses) associated particularly with the Stockton Morello can be transmitted by seeds, but all the above viruses are a serious menace to rootstocks. Many virus diseases are difficult to detect. They have become so common in both rootstocks and scion varieties that nurserymen and growers in the state should constantly be on their guard for them.

Necrotic rusty mottle

Plant pathologists are now studying a virus (or a combination of viruses) whose symptoms vary in the several varieties or in different conditions of growth. These symptoms may be gummy bark blisters, corky sunken or raised bark lesions, leaf spots, dieback of twigs or branches, or combinations of these. Named for its dominant symptom, the disease is called necrotic rusty mottle or blister virus. Pathologists fear that many Stockton Morello rootstocks from suckers in orchards are infected with these viruses, even though they appear healthy. Some sweet varieties seem little affected by them; but infected Bing trees on Stockton Morello clearly show the bark blisters.

Dr. Gilbert L. Stout (1949), plant pathologist of the California State Department of Agriculture, has described the disease and reported on experiments in its transmission by budding. He has made extensive surveys in most cherry districts of the state in an attempt to detect its presence. As mentioned on p. 24 Brooks and Hewitt (1949) have also reported on virus diseases in trees on Stockton Morello roots.

Buckskin disease

This disease first came to the attention of the Experiment Station 25 years ago in sections of Solano, Napa, and Sonoma counties. Rawlins and Horne (1931) found it could be transmitted by grafting and demonstrated it to be a virus. Study over a period of many years has failed to show how it spreads from tree to tree.

Like most viruses, it is perhaps carried by some insect species. It can be transferred to nursery or orchard trees by grafting wood or bud sticks taken from infected trees. It has some peculiar rootstock relationships that are not well understood. At least two strains of the Buckskin virus are known. The disease

in Napa Valley has symptoms differing in some detail from those in Green Valley, Solano County.

Because sweet cherries tend to resist or escape infection when on mahaleb roots in Green Valley, it was at first thought that the disease occurred only on trees on mazzard roots. However, Rawlins and Thomas (1941) report observations and experiments showing that, though mahaleb is highly resistant to the disease, certain sweet cherry varieties on this root are susceptible to artificial inoculation. Often they die within one to three years after symptoms appear, while those on mazzard roots usually linger many years longer. Longstem Bing seems to escape natural infection regardless of the rootstock on which it is growing.

On mazzard roots trees with this disease have small, pointed fruits that fail to mature but hang on the tree for a long time. Usually only a small branch or two is affected at first, but the disease gradually spreads until, after several years, it is evident throughout the tree.

In the autumn a reddish color appears along the veins at the base of the leaves (See fig. 20). The symptoms are different with trees on mahaleb roots. Infected trees on this stock have yellowish leaves, without the red discoloration, and the fruits appear nearly normal; but the trees soon die or become very weak.

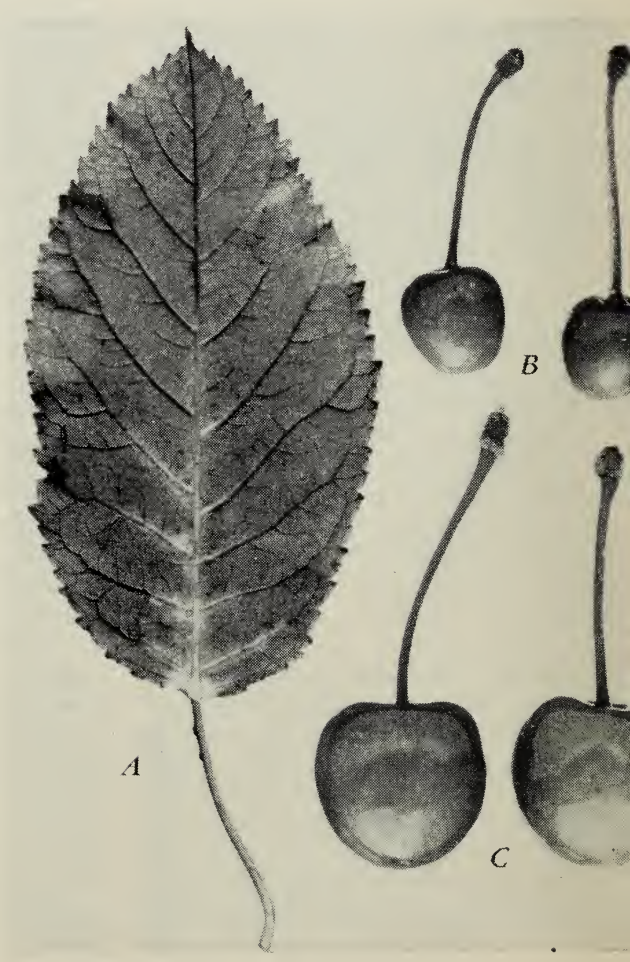

Fig. 20. Buckskin of sweet cherry on mazzard roots. A—leaf symptoms, showing light areas in the lower part of the leaf, are red in September and October. B—buckskin fruit of the Royal Ann variety. C—normal fruit of the same age.

In Solano County, varieties top-worked high on the scaffold branches of mahaleb seedlings tend to escape infection. An infected branch can usually be detected and cut out before the disease spreads to other branches. For about 15 years, as affected mazzard-rooted trees have been pulled, many orchardists have used as replants trees on mahaleb or mahaleb seedlings, for later top-working to sweet varieties. Though not entirely successful, this procedure has kept the growers of this district in business.

Buckskin has appeared in aggravated form on sweet cherry trees on Stockton Morello roots. But since trees on this root are not easily established in the unirrigated areas, where the disease mainly occurs, the relation between it and this stock has not been given much study. (Buckskin is known to affect peach seriously, causing a leaf-casting chlorosis, called X-disease in some areas.)

Apparently because the disease in Napa Valley is of a different strain from that in Green Valley, the use of mahaleb to deal with it is not promising there.

Leaf spot

Cherry leaf spot disease (*Coccomyces hiemalis*), though present in California orchards, has not defoliated nursery mazzard seedlings here as it does in certain eastern areas of the United States. Nursery budding of mazzard seedlings is therefore not interfered with by this disease.

X. Insect and animal pests of cherry rootstocks

Pacific peach tree borer

The larva of the peach tree borer (*Conopia opalescens*), commonly called peach root borer, occasionally attacks cherry roots in the nursery, but not so freely as it does the other stone fruits. It is native to California, and its original host plants were wild cherry and wild plum. In orchards it attacks the mahaleb root more freely than the mazzard.

California prionus

Larvae of this very large native beetle (*Prionus californicus*) occasionally attack roots of cherry. No observations have been made as to whether one rootstock species is preferred as host. Trees are sometimes killed by these large larvae, which girdle the bark and bore deeply into the wood and the roots

Root-knot nematode

Galls of the root-knot nematode (*Meloidogyne* sp.)* were reported by Day and Tufts (1944) to affect mahaleb root moderately, while the roots of mazzard and Stockton Morello were entirely free of them. Seedlings of English Morello and Montmorency were also free from infestation. There are no reports of serious damage by this pest to cherry roots in California orchards.

No orchards have been found upon mahaleb roots in heavily infested soils. But since, in some affected areas in the San Joaquin Valley, trees on mazzard are short-lived from other causes, mahaleb might well be tried. (As previously stated, mahaleb is particularly tolerant of hot sandy soils.)

Root lesion nematode

The root lesion or meadow nematode (*Pratylenchus vulnus*)** has done much injury to cherry roots, but its relation

* Nematologists have recently determined that more than one species of root-knot nematode affect the roots of fruit trees in California, all belonging to the genus *Meloidogyne*. (This replaces the former name *Heterodera marioni*.) It is impossible to state at present which species of *Meloidogyne* were involved in the cases reported by Day and Tufts (1944).

** Studies by Allen and Jensen (1951) of the University of California (Division of Entomology and Parasitology) indicate that nematologists have hitherto mistakenly identified the species with which we were working as *P. pratensis*.

to the various rootstocks has not been determined definitely. In 1941 Serr and Day (1949) found it associated with dieback of bearing cherry trees in Riverside County. It is apparently worse on Stockton Morello than on the others, and more severe on mazzard than on mahaleb. It was not certain whether other factors were retarding the vigor of the mazzard-rooted trees—for instance, delayed foliation in Southern California and too deep cultivation for that rootstock. However, a 5-year nursery test by Day and Serr (1951) in heavily infested soil showed no lesions on roots of mahaleb seedlings, while mazzard and morello roots were severely cankered by lesions.

Rodents

Mahaleb is more freely attacked by pocket gophers, meadow mice, and rabbits than are mazzard and Stockton Morello. Where jackrabbits are troublesome, growers plant large mahaleb seedlings and prune them high enough to place the tender branches out of their reach.

Pocket gophers are particularly injurious to mahaleb roots where basin irrigation is not feasible. In some of the top-worked orchards in Green Valley, losses from this source are almost as great as from buckskin disease. Many mahaleb-rooted trees with their large roots branching near the surface were not so severely damaged by pocket gophers as were trees with deeply placed roots. The gophers would often girdle, or partially girdle, one main root, instead of the whole trunk as they did with deeply planted trees.

Deer

Deer feed readily on the foliage of the sweet cherry varieties. In orchards next to the hills top-working must be as high as 4 or 5 feet. The tops of the scions will then have grown above the reach of deer by the time the grass dries up and the animals begin browsing in the orchards.

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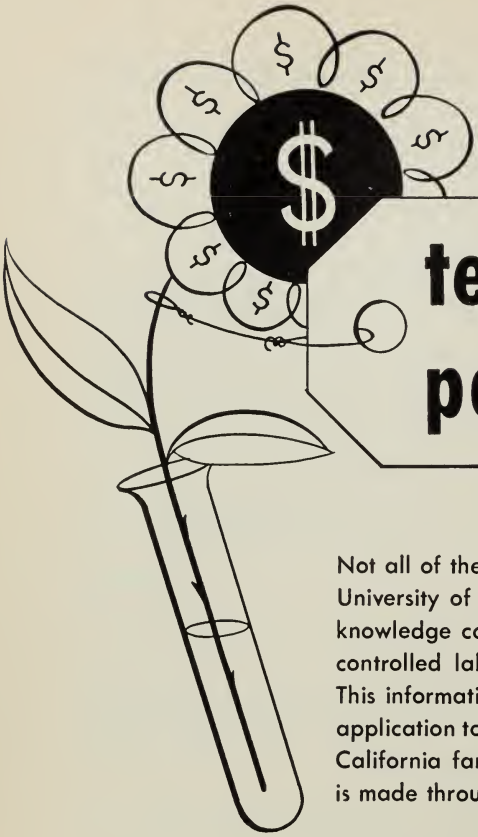

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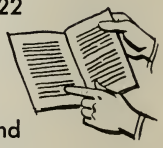

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