

# Blueberry Growing

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**C**ULTIVATED BLUEBERRIES constitute a new and valuable crop in New Jersey, North Carolina, Michigan, Washington, Oregon, Massachusetts, New York, and other States. The industry is based chiefly on the productive large-fruited varieties of the highbush blueberry obtained since breeding work was begun by the United States Department of Agriculture in 1909. However, some commercial plantings of the rabbiteye blueberry have been made in the Southeast. The available information on selecting and growing varieties of both these species in home gardens and commercial plantings and protecting them from diseases and insects is summarized in this bulletin.

In addition, the many wild species of blueberries gathered in large quantities for sale are discussed briefly.

Growers should all remember that blueberries flourish only on acid soil and that good drainage and ample moisture are essential for productive fields. Water should not stand on the soil at any time.

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# Blueberry Growing



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DEVELOPMENT OF THE BLUEBERRY INDUSTRY<sup>2</sup>

Blueberries, originally native North American wild fruits, are becoming an increasingly important cultivated crop in parts of the United States. They can be marketed fresh, canned, or frozen.

Prior to 1910 there were at least two cultivated plantings of highbush blueberries made with bushes selected from the wild. Subsequently the breeding and selection work of the late F. V. Coville laid the foundation for a new blueberry industry. The extent of the improvement made in the blueberry by Coville is indicated in figure 1, which shows the comparative size of the fruit of one of his largest fruited seedlings (fig. 1, *D*) and of Rubel, the best selection from the wild (fig. 1, *A*).



FIGURE 1.—Berries from different sources: *A*, Rubel the best highbush selection from the wild; *B*, wild highbush blueberry of eastern United States; *C*, wild lowbush blueberry of the Northern States; *D*, cross of two highbush varieties. Note the large size of the berries from the cross.

<sup>2</sup> The name "blueberry," as used in this bulletin designates the group of plants, commonly called "blueberries" and "huckleberries," that have many very small, soft seeds in contrast to the true huckleberries, which have 10 large, bony seeds.

The first commercial shipments of cultivated blueberries resulting from this work were made in 1916. In 1950 there were about 3,500 acres under cultivation in New Jersey, nearly 1,000 acres in North Carolina, about 2,500 in Michigan, and possibly 500 in all other States, chiefly in Washington, Oregon, Massachusetts, and New York. For 1950 the value of the crop from cultivated fields in New Jersey was \$2,000,000; in North Carolina \$200,000; and in Michigan \$1,200,000.

The first commercial planting of the rabbiteye blueberry, a wild blueberry of the South, was made by M. A. Sapp in western Florida about 1893 with bushes transplanted from the wild. Between 1920 and 1930 some 2,225 acres in Florida were set with plants transplanted from the wild or propagated from the early plantings and selections. Similar plantings were also made in Louisiana, Mississippi, Alabama, Georgia, South Carolina, and North Carolina. Few of these plantings were made with selected bushes, and since 1930 relatively few of them have been cultivated. The crop of the rabbiteye blueberry is nearly all from such plantings, and very little of it comes from the wild bushes. Although the blueberry crop from cultivated varieties had a value of more than \$3,500,000 in 1950, the total value of the industry in the United States is very much greater and is based largely on various species of wild blueberries in several widely separated areas: The blueberry barrens and uplands of New England, New York, Pennsylvania, West Virginia, Michigan, Wisconsin, and Minnesota; the swamplands along the Atlantic coast and in the Northeastern States; the upland sections of Alabama, Georgia, and other Southern States; the Cascade Mountains section of Oregon and Washington; the coastal section of northern California, Oregon, and Washington. Figure 2 shows the location of the areas in the United States from which native berries are most extensively harvested and marketed.

In the case of various other fruits, selection and breeding of superior varieties have enabled the grower to place on the market a product so much superior to that from the wild that relatively small quantities of such wild types are now marketed. With the blueberry, superior varieties of the highbush and of the rabbiteye are now being grown. The largest fruited varieties are being hybridized with drought-resistant varieties in order to obtain very large-fruited drought-resistant varieties that might also be used in erosion control. If produced at a sufficiently low cost, cultivated blueberries may replace much of the crop from the wild, now worth several million dollars annually. They can be grown in home gardens also, provided the soil is sufficiently acid.

## IMPORTANT SPECIES

Fruit from eight species of blueberries is harvested extensively in different parts of the United States and fruit from three others to a more limited extent. They are known as the lowbush (*Vaccinium lamarckii* Camp, formerly *V. angustifolium* Ait.), highbush (*V. australe* Small and *V. corymbosum* L.), dryland (*V. pallidum* Ait. and *V. alto-montanum* Ashe), evergreen (*V. ovatum* Pursh), mountain (*V. membranaceum* Dougl.), and rabbiteye (*V. ashei* Reade). In addition, commercial quantities of the Canada blueberry (*V. myrtilloides* Michx.) are harvested in Maine, usually where it occurs with the lowbush blueberry, and in the Adirondack Mountains of New

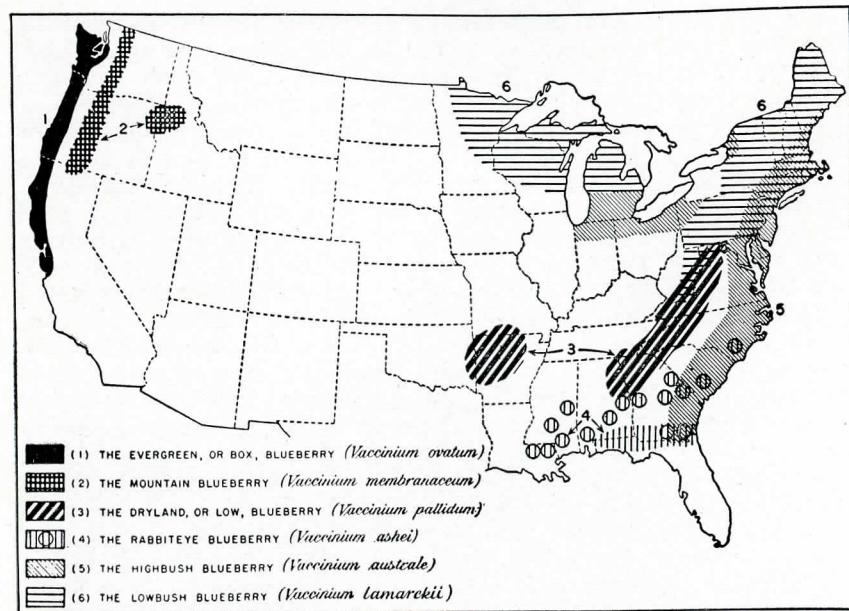


FIGURE 2.—Map of the United States, showing areas in which wild blueberries are extensively harvested.

York, where it is the chief kind at the higher elevations. In the mountains of western North Carolina at least two highbush suckering blueberries (*V. alto-montanum* Ashe, its hybrids, and *V. constablaei* Gray), related to the dryland one, are also harvested commercially. Still other species are sometimes harvested over extensive areas in various regions.

#### LOWBUSH BLUEBERRY

The lowbush blueberry, the most important commercial species, is native to northeastern United States and parts of Canada (fig. 2). In the United States fruit from this species is gathered in commercial quantities from Maine to Minnesota and southward in the Alleghenies to West Virginia. It is an upland species, usually 6 to 18 inches high, which stools into large colonies by means of underground shoots. (See illustration, p. 1.) No named varieties have been propagated for commercial planting. Selections have been made for breeding, for this species crosses readily with the highbush blueberry. Its fruit, which is usually light blue, ripens earlier than that of the highbush blueberry, but the flavor is similar. Although the fruit ripens during July and August, harvesting may extend into September in the most northern areas. The fruit is gathered for the canneries with rakes (figs. 3 and 4) similar to the cranberry scoop, but much smaller. For the fresh-fruit market the fruit is picked by hand as well as harvested with rakes. Even though only a part of the total wild crop is harvested, the annual value of the harvested fruit is probably more than \$5,000,000, the larger part being used by canneries and freezing plants. The Maine crop alone was valued at about \$2,000,000 in 1948.

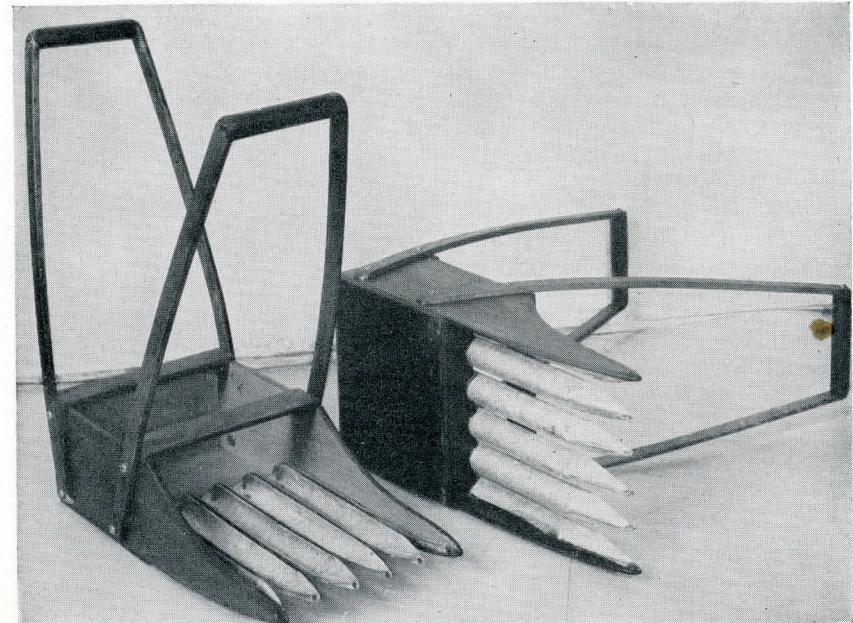


FIGURE 3.—Rake used for harvesting lowbush blueberries in Wisconsin.



FIGURE 4.—Harvesting lowbush blueberries for the canneries in eastern Maine. The rake is 10 to 12 inches wide and has 18 to 40 teeth.

After the forest has been cut or burned over, the lowbush blueberry comes in naturally in large areas in some of the Northern States. If burning is prevented, sooner or later the area grows up to brush and woodland again. Thus, areas that yield large quantities of berries for

a few years may produce none later, owing to the crowding and shading-out of the bushes. In eastern Maine and in some smaller areas elsewhere, however, the fields are reburned every second or third year in the spring while the ground is still wet, to kill back weeds and underbrush (chiefly sweetfern, hardwood sprouts, lambkill, or sheep laurel, alder, and hardhack) and to prune the blueberry plants. Either hay or straw with oil is used to help the burning.

As a further aid in control, weeds and bushes may be cut or pulled in the fall previous to burning or killed by brush-killing chemical sprays. Burning-over does not seriously injure the blueberry plants if properly done during the dormant season, but repeated burning lowers soil fertility. The Maine Agricultural Experiment Station reported that mowing sweetfern in July gave about 80 percent control



FIGURE 5.—Part of the blueberry barrens, which cover more than 100,000 acres in Washington County, Maine. Most of the blueberries are the lowbush.

of that weed and that 99 percent of the alder was eliminated by removal of the crowns. Dusting for control of the blueberry fruit fly (p. 46) is extensively practiced, and two applications have been found to be very successful. Early picking, before the berries are infested, is recommended. In Maine picking for the fresh-fruit market begins about July 20 and for the canneries about August 10. About 150,000 acres of native blueberries in Maine are given some care (fig. 5).

#### HIGHBUSH BLUEBERRY

The highbush blueberry is native from northern Florida to southern Maine and west to southern Michigan. It is gathered from the wild most extensively in eastern North Carolina and northward along the

Atlantic coast to Massachusetts, but in varying quantities throughout its range. The annual value of the crop from wild plants receiving no care is probably between \$1,000,000 and \$1,500,000. The value of the cultivated crop in 1950 was more than \$3,500,000.

The highbush blueberry is a native of swamps, of moist woods, and also of moist, open fields at high elevations. It grows to 10 or 15 feet in height and does not stand drought well. From this species have been selected the plants bearing fruit of large size, such as Rubel, Adams, Harding, Brooks, Sooy, Chatsworth, and Sam. Some of these selections when hybridized have produced the still larger fruited named varieties that are extensively propagated.

#### DRYLAND BLUEBERRY

The dryland blueberry, also commonly called "low huckleberry," is native from Georgia and Alabama to Maine and westward to Michigan and Oklahoma, but it is important chiefly in northern Alabama and Georgia and northward to Maryland and West Virginia. The plants grow in the dry, relatively poor soils of the ridges and hills and are very drought-resistant. The fruit is gathered most extensively in northeastern Alabama, northwestern Georgia, West Virginia, and western and northwestern Arkansas. The dryland blueberry grows from 1 to 3 feet in height and spreads in colonies much as does the lowbush blueberry. The berries have a light-blue color, and their flavor is good. They have a small, rather dry scar where the stem was attached. The dryland blueberry commonly ripens later than either the lowbush or the highbush blueberry and is sometimes called the late blueberry. In Georgia and Alabama, however, it ripens before the crop from cultivated fields in New Jersey; therefore, it brings good prices in markets. The annual value of the harvested crop, all from wild plants, may average \$300,000; in some years it is much more. The usual low form of this blueberry does not hybridize with the highbush. However, vigorous taller plants of this general type that bear larger berries than the usual low form and do cross with the highbush varieties have been found in Georgia and Alabama. Recent evidence indicates that this large-fruited dryland blueberry may be the more important commercially in those States.

#### EVERGREEN BLUEBERRY

The evergreen blueberry, commonly known as evergreen, or coast, "huckleberry," is native along the Pacific coast from central California to British Columbia. The fruit is gathered extensively in northern California, along the coast of Oregon and Washington, and in the Puget Sound district. Branches of this blueberry are important commercially for decorative purposes. They are shipped chiefly from December to March by the carload to eastern cities under the trade name "evergreen huckleberry." The branches for shipment are gathered in open woodland where there is partial shade. The plant is also an attractive ornamental shrub in flower and fruit as well as in leaf (figs. 6 and 7). It may reach a height of 20 feet in open woods.

No commercial plantings for fruit production are known. The annual value of the fruit crop may be \$150,000 to \$200,000 and that of branches an equal amount.

The berries ripen from August to November, but the chief shipments are made in September and October. The berries are usually small and shiny black and have a characteristic strong flavor not at all like that of other blueberries. This flavor makes them less desirable than

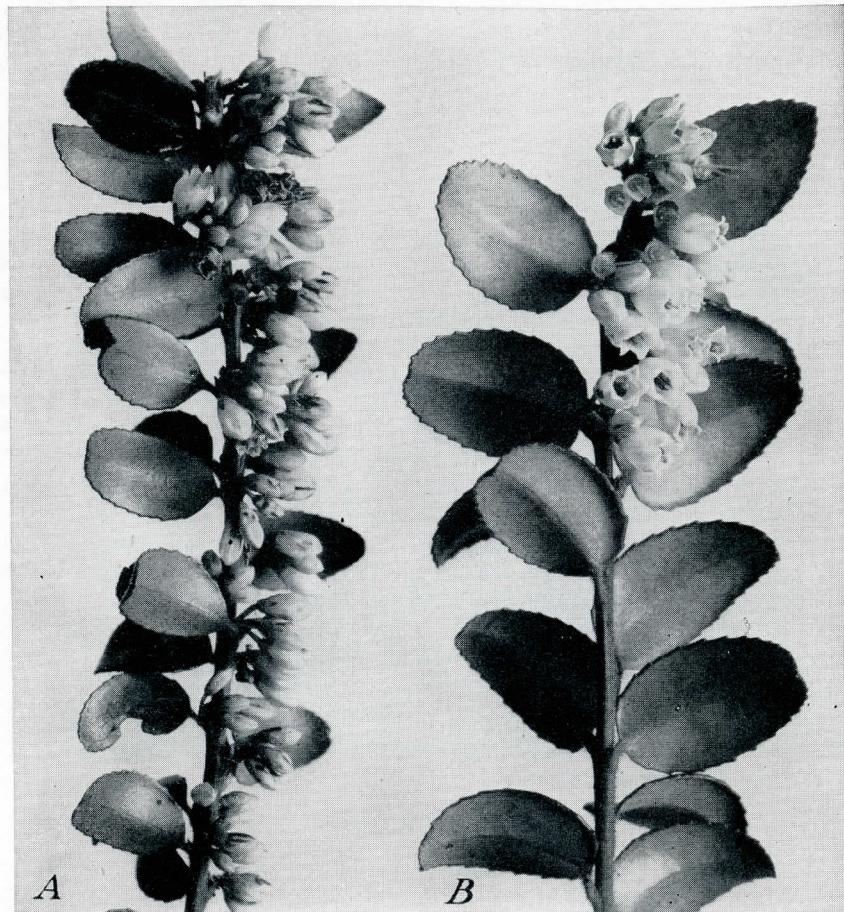


FIGURE 6.—Shoots of the evergreen blueberry, showing flower buds and flowers (A) at most nodes and (B) at upper nodes only.

other blueberries for eating fresh. They are extensively used, however, for pies and otherwise in cooking. A variation with slightly bluish fruit is not uncommon. A large part of the crop is stored frozen for use by pie makers.

The evergreen blueberry grows only in the mild climate near the Pacific coast and around Puget Sound; it has not been hardy in eastern United States where tested. Because of this lack of hardiness, selections of superior wild forms should be tested only in western

Washington and Oregon and in northwestern California. Cuttings, 6 to 8 inches long, with four to six of the upper leaves left on, taken during the winter, are readily rooted (fig. 8).

#### MOUNTAIN BLUEBERRY

The mountain blueberry, also called "broadleafed huckleberry," is a native of the high slopes of the Cascade Mountains of Oregon and Washington and eastward to Wisconsin. It is most abundant near Crater Lake, Mount Hood, Mount Adams, and Mount Rainier, where thousands of visitors pick the fruit each year. It is a very



FIGURE 7.—Branches, showing the fruiting habit of the evergreen blueberry of the Pacific coast.

drought-resistant plant, matures its fruit in the late summer even after 3 or 4 rainless months, and is important for forage. The plants grow 3 to 5 feet high and are abundant in burned-over areas. In the Cascade Mountains area at least, it is one of the best flavored and uniformly largest fruited of all wild blueberries. The annual value of the fruit crop may total \$200,000. The berries are somewhat pear-shaped, black or maroon in color, juicy, high-flavored, and rather tart but not too tart to be eaten fresh. Because its berries are borne singly (fig. 9) or in pairs rather than in clusters like those of the other blueberries, the individual bushes are not highly productive and are not likely to become important under cultivation. No cultivated plantings are known.

## RABBITEYE BLUEBERRY

The rabbiteye blueberry is native to river valleys and the edge of woods in southern Georgia, southern Alabama, and northern Florida. It is harvested from the wild to a very limited extent. It is chiefly important because it grows on locations with more upland conditions than the highbush and because it requires a very short, cold rest period



FIGURE 8.—Rooted cuttings of the evergreen blueberry, which is propagated relatively easily by means of cuttings having 4 to 6 leaves, taken during the winter.

in winter. Also, it is not so sensitive to soil acidity and is far more heat- and drought-resistant than the highbush. More than 3,500 acres, located mostly in northwestern Florida but also in North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Louisiana, have been planted to this species, the plants having been transplanted from the wild into commercial fields. No figures on the market value of the crop of this blueberry are available. A considerable part of the crop is frozen or canned.

Because much fruit shipped from the South has come from the unselected bushes, many of which produce small, gritty-fleshed berries, lacking in flavor, the rabbiteye has had a poor reputation in markets. The berries are mostly black and not so attractive as the blue-fruited species and varieties. However, some named rabbiteye varieties bear large, juicy, aromatic, blue fruit that compares favorably with that borne by selections of other species.

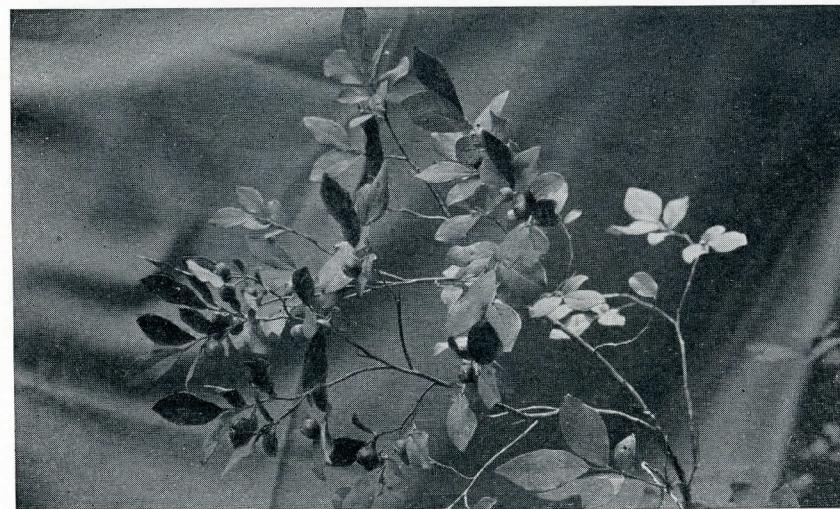


FIGURE 9.—A branch of the mountain blueberry, the fruits of which are gathered extensively in the Cascade Mountains of Oregon and Washington.

## BLUEBERRIES FOR THE HOME GARDEN

Blueberries can be produced in home gardens if the soil is naturally acid or is properly treated. They do not succeed in ordinary rich garden soils and soon die, but they do thrive in naturally moist acid soils such as those in which native blueberries and huckleberries, azaleas, laurel, and rhododendrons grow. For small plantings mulching with leaves, sawdust, hay, or straw to a depth of 5 or 6 inches helps to retain moisture, to keep down weeds, to control erosion, and to keep the ground cool. Blueberries should not be planted on soils limed in recent years unless actual tests have shown that they are still acid enough for blueberries. For the less acid soils, decaying oak leaves or acid peat mixed in the soil around the plants helps to make conditions suitable, but plants on such soils will always require extra care.

At least two varieties should be planted to provide for cross-pollination.

In the Southern States from eastern North Carolina to Florida and west to Arkansas and Louisiana, varieties of the rabbiteye blueberry may be grown in home gardens. Three plants each of Myers, Coastal, and Callaway might be selected.

From North Carolina to southern Maine and west to Michigan wherever the soils are sufficiently acid and moist the highbush varieties may be grown in home gardens. In New Jersey, New England, and Michigan, June may be selected as a good early variety and Stanley as a midseason variety. The recommended late varieties are: In New Jersey, Dixi, Atlantic, Pemberton, Berkeley, and Coville; in New England, Berkeley, Pemberton, and Coville; and in Michigan, Berkeley, Jersey, Burlington, and Coville. For North



FIGURE 10.—Mature rabbiteye blueberry bushes at Crestview, Fla., showing the many shoots and great height of some varieties of this species. The third and fourth bushes in the row have not grown so tall as the first bush.

Carolina gardens Wolcott is a good early variety; Scammell a late midseason; and Jersey a late. On the more upland soils, Adams is more productive than many varieties. It ripens with Cabot and June and has a long season.

#### RABBITEYE VARIETIES AND THEIR CULTURE

The rabbiteye blueberries are suggested for local market and home use in the Coastal Plain from eastern North Carolina to northern

Florida and to Louisiana and Arkansas. Limited test plantings for general market are suggested for the same area. In the Piedmont areas of the Southern States rabbiteye varieties often complete their rest period early in the winter and then start growth so that buds are killed by late winter cold.

The rabbiteye blueberries (figs. 10, 11, and 12) are generally set in midwinter 10 by 10 to 15 by 15 feet, depending on variety. For home plantings they may be set as close as 8 by 8 feet. Under good conditions they grow rapidly and bear commercial crops by the third year. They respond to cultivation or mulching and fertilization. In one planting in southern Georgia, the average annual yield of the Black Giant for the first 11 years of bearing was 9 quarts per plant; the eleventh year the yield was 30 quarts per plant. Pruning is not generally practiced, but because the fruiting habit of rabbiteye is very like that of the highbush blueberry some pruning of older bushes



FIGURE 11.—A planting of rabbiteye blueberry at Crestview, Fla. Plantings of 50 to 100 acres are not uncommon.

is considered desirable. The older stems and the smaller young shoots may need thinning to prevent the bushes from becoming too dense; pruning should be relatively light, however, because the rabbiteye blueberry is sufficiently vigorous to support and bring to large size heavy crops of fruit. Heavy pruning results in excessive watersprout growth.

Under the same growing conditions, the fruit of rabbiteye blueberry ripens later and over a longer season than that of the highbush and dryland blueberries. Picking in northern Florida usually begins near the end of May. Some varieties of rabbiteye blueberry ripen most of their fruit within a 30-day period, whereas other varieties not propagated now may mature fruit over a period of 3 months, the season extending into September in North Carolina. Selected varieties have firmer fruit with a much smaller scar where the berry is picked from the stem than do highbush varieties.

Characteristics of some rabbiteye varieties are given in table 1. The Black Giant, Clara, and Myers are three of the better selections from the wild that have been propagated, and Callaway and Coastal are two new varieties introduced in 1950. The Black Giant is fairly early and has large, black, soft fruit that ripens over a period of nearly 60 days. It produces very large bushes. Its branches are stout, and it needs to be kept low for ease of picking. Clara is midseason and



FIGURE 12.—Rabbiteye blueberry plant from a strong offshoot set in March of the year before the photograph was taken at Crestview, Fla., July 30.

has medium-size, dark-blue, and high-flavored fruit. The bush is tall, but it is somewhat lacking in vigor and needs heavier pruning than most varieties to produce large fruit. Myers is slightly earlier than Clara. The berries are light blue and of good quality. It is one of the best varieties, though it is not so large-fruited as Black Giant.

Callaway and Coastal are two new varieties resulting from breeding work. Both are crosses of Myers  $\times$  Black Giant. Both have larger fruit than have the older varieties, and Callaway has the best flavored fruit of any rabbiteye blueberry.

Other less-promising or less-known named varieties are Hagood, Ruby, Sapp Early (early), Ethel, and Walker. The Ruby has light-blue berries of large size, but the berries possess grit cells and are not so well-flavored as those of the previously mentioned varieties. The plant is not so tall as most others. Walker is rather early and has blue, good-quality fruit, but the bush is relatively small. Ethel is similar but has very light-blue fruit. Sapp Early is large-fruited and early and matures its fruit in a short period. It is very productive and has good-quality fruit. It seems to need only a very short winter rest period; its buds start early and may be killed by late frosts if planted north of the Coastal Plain area of Georgia and Alabama.

TABLE 1.—Rabbiteye blueberry varieties ranked approximately in order of merit with reference to certain characteristics

Rank	Season (early to midseason)	Size of berry (large to small)	Dessert quality (good to poor)
1	Coastal	Coastal	Callaway.
2	Callaway	Callaway	Ethel.
3	Walker	Ruby	Walker.
4	Ruby	Black Giant	Clara.
5	Ethel	Walker	Myers.
6	Hagood <sup>1</sup>	Ethel	Coastal.
7	Black Giant	Hagood	Black Giant.
8	Myers	Clara	Hagood.
9	Clara	Myers	Ruby.

Rank	Color (light blue to black)	Suckers (many to few) <sup>2</sup>	Bush size (large to small)
1	Ethel	Myers	Black Giant.
2	Callaway	Hagood	Hagood.
3	Walker	Ruby	Coastal.
4	Ruby	Black Giant	Myers.
5	Myers	Clara	Clara.
6	Coastal		Callaway.
7	Clara		Ruby.
8	Hagood		Walker.
9	Black Giant		Ethel.

<sup>1</sup> Long fruiting season.

<sup>2</sup> Amount of sucker growth unknown on other varieties.

Other promising varieties have been selected and are being propagated for general planting. As far as they have been observed, the named varieties, except Locke, have been so resistant to stem canker (a serious southern disease) that no infections have ever been found on them. Future plantings should consist entirely of the more desirable named varieties. Two rows alternating with two other rows of a different named variety should be planted because cross-pollination is necessary.

Propagation has been chiefly by offshoots, or suckers, which arise at distances of a few inches to 8 feet from the parent plant. These are usually grown in the nursery for a year before being set in their permanent location. Recently large-scale propagation by winter and summer cuttings, the same as for the highbush blueberry, has been suc-

cessful. Though hardwood cuttings of rabbiteye varieties do not root so easily as those of the highbush, an even larger percentage of the softwood cuttings root than of many highbush blueberries (p. 28).

The most serious insect pests of rabbiteye are fruitworms, stem borers, and mites. Stem canker, fruit spot, powdery mildew, phomopsis twig blight, and mummy berry are diseases of the rabbiteye.

## HIGHBUSH VARIETIES AND THEIR CULTURE

### SOIL AND CLIMATIC REQUIREMENTS

The highbush blueberry is found in the wild only where the soil is very acid and moist. Usually the best wild growth occurs where the acidity ranges from pH 4.3 to 4.8, and cultivated plantings have succeeded on such acid soils. Good growth may occur in soils with a pH value as low as 4; however, where the acidity is as low as pH 4, application of hydrated lime at the rate of about 1,000 pounds per acre should be tried. Where the acidity is as high as pH 5, finely ground sulfur<sup>3</sup> or ammonium sulfate may be used. If the soil is sandy or sandy containing some peat, ammonium sulfate should be used as it both acidifies the soil and furnishes nitrogen. If the soil is a loam, it may contain enough nitrogen and sulfur may be used to acidify it.

The best indication that blueberries may succeed on a soil is that they or some related plants, such as huckleberries, azaleas, or laurel, are found growing there naturally. Open porous soils, such as a sand-peat mixture with an admixture of loam, with the water table 14 to 30 inches below the surface, have been found best for blueberries.

The cultivated highbush blueberry is raised commercially from eastern North Carolina northward to southern New England and also in western New York, in southern Michigan, and in western Oregon and Washington. The plant is probably not hardy north of southern Maine and central Michigan, as it does not stand temperatures lower than about  $-20^{\circ}$  F. Instances have been reported of the tops being killed to the ground or to snow level at a temperature of  $-30^{\circ}$ . However, even in sections where the blueberry is not generally hardy, local conditions of air drainage or protection by deep snow may make blueberry growing possible. The southern limit for present-day highbush varieties is about 300 miles north of the Gulf of Mexico from Georgia to Louisiana. In Florida, southern Georgia, and southern Louisiana the cold period is so short that the bushes do not break their winter rest period and blossom normally. They probably need about the same amount of cold in winter as does the Elberta peach. The highbush varieties are not so satisfactory as the rabbiteye varieties in South Carolina, Georgia, Alabama, Mississippi, and Louisiana. The early varieties, Wolcott, Weymouth, June, and Cabot, begin to ripen during the latter part of May in Georgia and eastern North Carolina, the last of June in New Jersey, and mid-July in Massachusetts and Michigan.

The highbush blueberry is native to swamps and moist soils, and unless ample soil moisture is available the plants may die in periods of

low humidity. The hot, drying winds of summer in the Central States may prevent the successful culture of this blueberry in that area. Moreover, most of the prairie soils are not acid enough for the blueberry.

### VARIETIES AND THEIR CHARACTERISTICS

In 1906 the late F. V. Coville began experiments in the culture of the highbush blueberry. Selections were made in the wild, and breeding work was begun in 1909. Miss Elizabeth C. White, Whitesbog, N. J., made additional selections of wild plants and in cooperation with Coville established the first commercial plantings of hybrid blueberries. The breeding work has continued since 1909, and 22 selections have been named and propagated.

Formerly several selections from the wild (Rubel, Dunfee, Sooy, Harding, Sam, Grover, Adams, and Chatsworth) were grown commercially, but now only the Rubel of that group is considered of sufficient commercial value to be planted; many growers consider Atlantic, Pemberton, Jersey, Berkeley, Coville, Burlington, and Dixi better varieties than Rubel and of about the same season. Breeding has produced berries about three times the size of the best wild blueberry. All varieties other than Rubel now being planted commercially are the result of the breeding work of Dr. Coville. All the commercial varieties are of pure highbush parentage except Rancocas and June, which are highbush backcrosses (Rubel  $\times$  a selection from a lowbush-highbush cross), Weymouth, which is a second backcross to the highbush (June  $\times$  Cabot), and the Murphy and Wolcott, which are both a third backcross to the highbush. Table 2 lists the varieties and gives an estimate of the relative acreage of each.

Berries of any one variety are picked about once each week for 3 to 5 weeks. Table 3 gives the approximate percentage of the crop picked each week for 19 varieties if given a moderate pruning.

To keep a picking crew occupied from June 15 to August 9, a blueberry planting in Maryland might be planted to equal areas of four varieties that could be harvested successively (table 4).

Varieties differ in their relative ripening season from year to year and to some extent from section to section. Thus, following the warm winter of 1949-50 many varieties in North Carolina ripened much later than usual. The heavy pruning commonly practiced in North Carolina also causes the crop of any given variety to ripen earlier and in a shorter period than does the lighter pruning used in Michigan.

### Varieties for Different Seasons

Cultivated plantings include about 18 varieties. Information on the merits of some of these is limited, but the discussion in this section and the information summarized in tables 3 and 5 may give an idea of their relative qualities. Climate and weather conditions affect the dessert quality and other characteristics of the fruit as well as of the plants. In general the berries are more highly flavored toward the northern limit of the blueberry areas, where the days are long and the nights cool when the berries ripen. When days are sunny and nights cool in more southern regions the flavor is much better than when the days are hot and cloudy and the nights warm. The varieties mature their berries over periods of 2 to 6 weeks (fig. 13). They are grouped as early, midseason, and late varieties.

<sup>3</sup> As the result of studies in New York, it is recommended that to acidify sandy soils  $\frac{3}{4}$  pound of sulfur per 100 square feet be applied for each full point that the soil registers above pH 4.5 and that to acidify medium loams  $1\frac{1}{2}$  to 2 $\frac{1}{2}$  pounds be applied for each full point above pH 4.5.

TABLE 2.—Percentage of estimated 1950 acreage planted to each of 22 varieties originated by F. V. Coville, listed in order of their dates of naming or introduction <sup>1</sup>

Name	Parentage	Year cross made	Year named or introduced	Estimated acreage (1950) <i>Percent</i>	Characteristics responsible for introduction
Pioneer	Brooks × Sooy	1912	1920	2	Midseason; commercial.
Cabot	Brooks × Chatsworth	1913	1920	4	Early; commercial.
Katharine	Brooks × Sooy	1913	1920	0	High-flavored; noncommercial.
Greenfield	Brooks × Russell	1913	1926	0	Earliest; noncommercial.
Rancocas	(Brooks × Russell) × Rubel	1915	1926	9	Productive; commercial.
Jersey	Rubel × Grover	1916	1928	30	Late; commercial.
Concord	Brooks × Rubel	1916	1928	6	Productive; commercial.
Stanley	Katharine × Rubel	1921	1930	7	High-flavored; commercial.
June	(Brooks × Russell) × Rubel	1919	1930	2	Very early; commercial.
Scammell	(Brooks × Chatsworth) × Rubel	1915	1931	1	Productive; commercial.
Redskin	Brooks × Russell (F <sub>2</sub> )	1913	1932	0	Red-colored; noncommercial.
Catawba	do	1913	1932	0	Catawba-grape color; noncommercial.
Wareham	Rubel × Harding	1915	1936	0	Very late; commercial.
Weymouth	June × Cabot	1928	1936	8	Very early; commercial.
Dixi	(Jersey × Pioneer) × Stanley	1930	1936	1	Large; commercial.
Atlantic	Jersey × Pioneer	1925	1939	1	Large; late; commercial.
Burlington	Rubel × Pioneer	1916	1939	2	Very late; commercial.
Pemberton	Katharine × Rubel	1921	1939	3	Very vigorous; large; late; commercial.
Berkeley	Stanley × (Jersey × Pioneer)	1932	1949	0	New; very large; light blue; commercial.
Coville	(Jersey × Pioneer) × Stanley	1930	1949	0	New; very large; latest; commercial.
Wolcott	Weymouth × (Stanley × Crabbe 4)	1934	1950	0	Very early, for North Carolina; commercial.
Murphy	do	1934	1950	0	Do.

<sup>1</sup> About 18 percent of the estimated acreage was planted with Rubel, a variety selected from the wild by Miss E. C. White, and 6 percent with seedlings and other varieties.

TABLE 3.—Percentage of the crop picked each week during the ripening season of 19 blueberry varieties

Variety	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week	Eighth week	Ninth week
	<i>Percent</i>								
Wolcott	60	30	10						
Weymouth	50	30	20						
Murphy		50	30	20					
June		40	30	20	10				
Cabot		30	30	20	10	10			
Rancocas			40	30	20	10			
Stanley				50	30	20			
Concord				50	30	20			
Pioneer				40	30	30			
Scammell				30	30	30	10		
Atlantic				30	30	30	10		
Pemberton				30	30	30	10		
Berkeley				20	40	30	10		
Rubel				20	40	30	10		
Jersey					50	40	10		
Dixi					40	40	20		
Wareham					20	40	30	10	
Burlington						30	30	30	10
Coville									10



FIGURE 13.—Cluster of flowers and buds at the end of a highbush blueberry branch. The flowers in any one cluster open over a period of several days, and the berries mature over a still longer period.

TABLE 4.—Usual harvesting period in Maryland for 4 varieties of blueberries, and percentage of crop that could be picked during each period

Variety	Crop to be picked during—			
	June 15 to 28	June 29 to July 12	July 13 to 26	July 27 to Aug. 9
Weymouth.....	Percent 90	Percent 10		
Stanley.....	20	60	20	
Berkeley.....		30	60	10
Coville.....			30	60

TABLE 5.—Highbush blueberry varieties ranked approximately in order of merit for certain growth, ripening, and other characteristics

Rank	Season (early to late)	Size of berry (large to small)	Dessert quality (good to poor)	Color (light to dark blue)	Shipping quality (good to poor)	Cold resistance (hardy to tender)	Bush shape (erect to spreading)
1	Wolcott.....	Berkeley.....	Wareham.....	Berkeley.....	Jersey.....	Jersey.....	Rubel.....
2	Weymouth.....	Coville.....	Dixi.....	Stanley.....	Burlington.....	Rubel.....	Rancocas.....
3	June.....	Dixi.....	Stanley.....	Jersey.....	Berkeley.....	Berkeley.....	June.....
4	Murphy.....	Atlantic.....	Pioneer.....	Atlantic.....	Rancocas.....	Burlington.....	Scammell.....
5	Cabot.....	Pemberton.....	Coville.....	Concord.....	Atlantic.....	Wareham.....	Pemberton.....
6	Rancocas.....	Wolcott.....	Atlantic.....	Burlington.....	Rubel.....	Weymouth <sup>1</sup> .....	Stanley.....
7	Stanley.....	Murphy.....	Concord.....	Rubel.....	Coville.....	Coville.....	Wolcott.....
8	Concord.....	Weymouth.....	Pemberton.....	Cabot.....	Wareham.....	Rancocas.....	Coville.....
9	Pioneer.....	Jersey.....	Berkeley.....	Coville.....	Wareham.....	Stanley.....	Jersey.....
10	Scammell <sup>2</sup> .....	Concord.....	Scammell.....	Rancocas.....	Wolcott.....	June.....	Berkeley.....
11	Berkeley.....	Scammell.....	Burlington.....	Dixi.....	Murphy.....	Dixi <sup>1</sup> .....	Concord.....
12	Atlantic.....	Stanley.....	Wolcott.....	Pemberton.....	Pioneer.....	June.....	Wareham.....
13	Pemberton.....	Wareham.....	Jersey.....	Wareham.....	June.....	Atlantic <sup>1</sup> .....	Burlington.....
14	Rubel.....	Burlington.....	Rancocas.....	Wolcott.....	Stanley.....	Pemberton <sup>1</sup> .....	Dixi.....
15	Jersey.....	Pioneer.....	Murphy.....	Jersey.....	Dixi.....	Cabot.....	Atlantic.....
16	Dixi.....	June.....	June.....	Pioneer.....	Weymouth.....	Pioneer.....	Weymouth.....
17	Wareham.....	Rancocas.....	Rubel.....	Scammell.....	Pemberton.....	Murphy <sup>1</sup> .....	Murphy.....
18	Burlington.....	Rubel.....	Cabot.....	Cabot.....	Cabot.....	Murphy <sup>1</sup> .....	Murphy.....
19	Coville.....	Cabot.....	Weymouth.....	Weymouth.....	Concord.....	Wolcott <sup>1</sup> .....	Cabot.....

<sup>1</sup> Dixi, Weymouth, Murphy, and Wolcott are too new for one to estimate their cold resistance accurately; and little is yet known of the cold resistance of Atlantic and Pemberton.

<sup>2</sup> Scammell may ripen as late as Jersey if not pruned heavily.

*Early Varieties*

The Weymouth, June, and Cabot varieties have been planted for early fruit. Wolcott and Murphy are two new very early varieties for North Carolina planting. Cabot (fig. 14) matures over a long season, even requiring seven pickings some years. Although the berries may be large at the first picking, they are usually small, are poor in dessert quality except north of New Jersey, and crack badly in wet weather. The bush is very subject to stem canker, stunt, and mite; therefore, this variety is being discarded in North Carolina and



FIGURE 14.—Cabot, about 3 years old, with a good commercial crop of fruit and fine new growth. Ordinarily, unless large clusters of Cabot such as those shown are pruned back, the berries are not very large and insufficient new wood is produced for a full crop the following year.

to some extent in other States. June is earlier than Cabot and matures all its fruit in a short time. Though the berries are dark and not high in flavor, June is liked in New Jersey and North Carolina. Weymouth is usually earlier than June, although it blossoms later in some locations. Its berries lack dessert quality and are dark, but Weymouth is extensively planted in North Carolina because of the earliness and size of the fruit and the productivity of the bush.

Wolcott and Murphy should replace other early varieties in North Carolina, for they are highly resistant to stem canker. Tests so far indicate that they are not satisfactory in Maryland or New Jersey.

*Midseason Varieties*

Rancocas, Stanley, Concord, Pioneer, and Scammell are considered midseason varieties. Stanley and Pioneer are high-flavored. Rancocas is considered one of the most dependable varieties in New Jersey and North Carolina; it is very resistant to stunt and sufficiently resistant to stem canker to be grown commercially, but its berries crack badly in wet weather and are expensive to pick. In Michigan it is subject to leaf drop and is not in favor. Stanley is favored because the bush is inexpensive to prune; but the berries often become very small at the end of the season. It is too subject to stem canker to be a dependable commercial variety in North Carolina. Concord matures all its fruits quickly but holds them on the bush a long time. The fruit tears in picking and does not keep well. Pioneer is unproductive in New Jersey and North Carolina but is fairly productive in Michigan and New England. It is very subject to stunt, stem canker, and mite in North Carolina. It is being rapidly discarded except in Michigan and New England. Scammell has been productive and resistant to stem canker in North Carolina, but it is very subject to stunt. Though the bushes are productive and the fruit large in New Jersey, the fruit is dark. If the clusters are not headed back, the fruit ripens with the late varieties.

*Late Varieties*

Atlantic, Pemberton, Berkeley, Rubel, Jersey, Dixi, Wareham, Burlington, and Coville are late varieties. The season of any of these may be extended about 2 weeks by light pruning and leaving a heavy crop on the bushes. Berkeley, Coville, Dixi, Atlantic, Pemberton (fig. 15, A), and Jersey bear the largest berries. Pemberton is the most vigorous, although all varieties of this group are vigorous. Dixi has high flavor but a bad scar and cracks badly. Atlantic is generally preferred to Dixi for commercial planting and cracks less than most others. Pemberton berries crack in wet weather somewhat and tear in picking more than those of most other varieties (fig. 16, B and C). Decay is much more likely to start at a large scar or where the skin is torn than at a small scar; hence, Burlington is considered a better shipping variety than is Pemberton. Its berries, however, are twice the size of those of Rubel, and the bush is much more vigorous. Jersey has very open clusters and a vigorous bush that is easy to prune. It is the leading variety in all sections. Wareham is hardy and productive, and its berries are high in dessert quality in Massachusetts, but they are one of the worst to crack and are dark. Burlington berries have fine scars (fig. 16, A), a good blue color, fairly good flavor, and do not crack, but they are of only average size. Its bush is vigorous and easy to prune. Berkeley is the lightest blue, and Coville is the latest to mature. These two are among the most promising commercial varieties.

*Varieties for Different Sections*

In New Jersey, Weymouth or June for early season, Rancocas or Stanley for midseason, and Berkeley, Dixi, Atlantic, Pemberton,

Jersey, or Coville for late season are desirable. In North Carolina, Wolcott or Murphy for early season and Rancocas for midseason are suggested. Jersey is raised for the late season, although later varieties are considered less desirable than early ones. In Michigan and New England, Jersey is the standard sort, but Berkeley, Atlantic, Burlington and Coville are promising late varieties. However, in Michigan, Weymouth, Stanley, and Jersey are good for early, mid-season, and late seasons, respectively. In New England, Weymouth

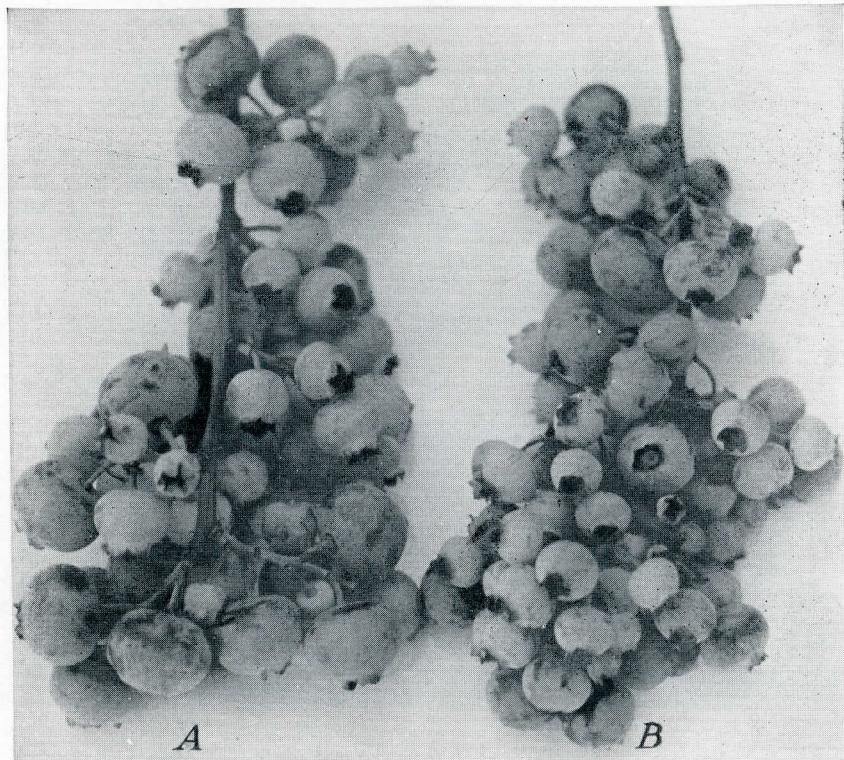


FIGURE 15.—Clusters of blueberries: A, Pemberton; B, Rubel. These two varieties ripen at about the same season. Each cluster is made up of smaller clusters.

(early), Stanley (midseason), and Jersey (late) are standard varieties. In western Oregon and Washington, Pioneer, Stanley, and Jersey are known to succeed.

#### Varietal Descriptions

**Adams.**—Selection from wild. Bush vigorous, tall, open spreading, productive; berry small, dark blue, of fair dessert but poor keeping quality; scar poor; ripening about with Cabot, with a long season; best for upland soils; grown to a slight extent in Michigan. Fruit too dark, too small, and too tender for a commercial variety.

**Atlantic.**—Jersey  $\times$  Pioneer. Bush very vigorous, open spreading, productive; leaf large; fruit cluster loose; berry very large, five-sided, oblate, of good blue

color, firm, with slight aroma, above medium in dessert quality; scar one of best, resistant to cracking; season late, ripening slightly earlier than Jersey. A late variety. Promising for large size, fine color, and good fruit scar and for productiveness.

**Berkeley.**—Stanley  $\times$  (Jersey  $\times$  Pioneer). Bush vigorous, open spreading, productive; leaf large; fruit cluster loose; berry largest, oblate, light blue, firm, with slight aroma, medium in dessert quality; scar excellent; resistant to cracking; season late, but earlier than Jersey. Promising for its beauty of color, large size, firmness, and productiveness.

**Burlington.**—Rubel  $\times$  Pioneer. Bush vigorous, upright spreading; leaf large; fruit cluster medium tight; berry medium size, round-oblate, of good blue color, firm, with slight aroma, medium in dessert quality; scar one of best; resistant to cracking; season late, about with Wareham, lasting about a week after Jersey and Rubel. Promising for its lateness and its fine scar; superior to that of most other highbush varieties.

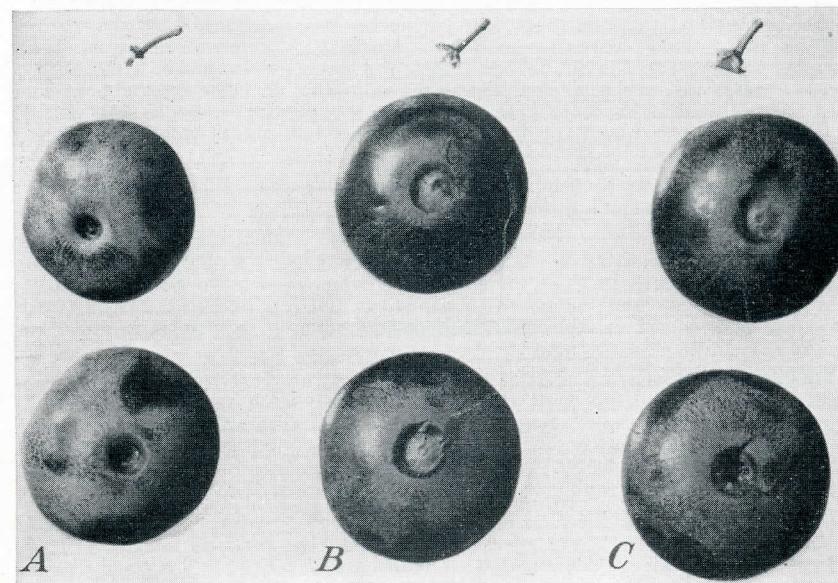


FIGURE 16.—A, Berries of Burlington, showing small clean scars where the berries separated from the stems; B and C, berries of Pemberton, showing tearing of the skin and flesh and large scars.

**Cabot.**—Brooks  $\times$  Chatsworth. Bush below average in vigor, low spreading; leaf medium size; fruit cluster long, tight; berry small to medium size, oblate, of good blue color, not very firm, with slight aroma, of poor texture, usually below medium in dessert quality except in Michigan and the Northeast; scar fair; season early and long, first ripening usually just after Weymouth and June and last pickings with Jersey and Rubel. Being discarded in all sections—in North Carolina because it is very susceptible to stunt, stem canker, and mite injury and flowers early, exposing it to injury by late spring frosts, and in the North because of small size, long season, and bad cracking.

**Concord.**—Brooks  $\times$  Rubel. Bush average in vigor, upright spreading, productive; leaf medium size; fruit cluster tight (see cover illustration); berry above medium size, oblate, of good blue color, firm, with very slight aroma, above medium in dessert quality; scar poor; midseason to late, suitable for leaving on bushes longer than most other varieties; does not drop; usually picked after the Stanley. Though productive and large, not promising because of having bad scar and being expensive to prune.

**Coville.**—(Jersey × Pioneer) × Stanley. Bush vigorous, open spreading, productive; leaf large; fruit cluster loose; berry very large, round-oblato, of good blue color, firm, aromatic, of good dessert quality but tart till ripe; scar good; resistant to cracking; season latest of all, 10 to 14 days after Jersey; does not drop. Promising for its very late season, large size, and productiveness.

**Dixi.**—(Jersey × Pioneer) × Stanley. Bush vigorous, open spreading, productive; leaf large; fruit cluster medium loose; berry very large, round-oblato, of fair blue color, firm, aromatic, of high dessert quality; scar large; season late, slightly after Jersey. Liked for its large size, high dessert quality, and productiveness but has a poorer scar than Atlantic and Jersey. Cracks badly in wet weather.

**Jersey.**—Rubel × Grover. Bush above average in vigor, erect, productive; leaf large; fruit cluster long and very loose; berry large, round-oblato, of good blue color, firm, lacking aroma, of below to about medium in dessert quality; scar good; season late, with Rubel. Liked for its vigorous fine, hardy bush, resistant to stem canker in North Carolina, open fruit cluster, and large, late-ripening berry.

**June.**—(Brooks × Russell) × Rubel. Bush below average in vigor, erect; leaves medium size, subject to June spot and summer dropping; fruit cluster loose; berry medium size, round-oblato, dark blue, firm, with slight aroma, medium to low dessert quality; scar medium; season very early, usually picked in three pickings. Liked for its early ripening, but plants weakened by leaf drop following spot.

**Katharine.**—Brooks × Sooy. Not commercial because of bad tearing of skin and flesh at the stem end but high-flavored.

**Murphy.**—Weymouth × (Stanley × Crabbe 4). Bush vigorous, spreading, productive; leaf large; fruit cluster loose; berry large, round-oblato, dark blue, similar to Weymouth in color, firm, slightly aromatic, of fair dessert quality; scar fair; season early, about with June. Promising in North Carolina for its early season and canker resistance; not promising in Maryland and New Jersey.

**Pemberton.**—Katharine × Rubel. Bush one of the most vigorous, erect, productive; leaf very large; fruit cluster very loose; berry very large, round to round-oblato, darker than Jersey and Atlantic, firm, with slight aroma, medium to above in dessert quality; scar poor; season late, slightly before Jersey and Rubel. Liked because of its vigorous bush and large size of berry; however, it is dark, difficult to pick, and cracks somewhat in wet weather.

**Pioneer.**—Brooks × Sooy. Bush vigorous, open spreading; leaf large; fruit cluster long and rather tight; berry medium size but large if heavily pruned, oblato, darker than Cabot, firm, with characteristic aroma, of good dessert quality; scar medium size; season variable, midseason to nearly as late as Rubel. Being discarded because of its uncertain production and in North Carolina also because of its being very subject to stunt, stem canker, and mite. Not so hardy as most varieties.

**Rancocas.**—(Brooks × Russell) × Rubel. Bush of medium vigor, erect, productive; leaf small, serrate; fruit cluster very tight; berry medium size, oblato, of fair blue color, firm, crisp, with very slight aroma, medium in dessert quality; scar medium size; early midseason, just after Wolcott, Murphy, Weymouth, June, and Cabot. Leaf subject to June spot and drop in summer in Michigan, and berry cracks badly after rain, but liked, except in Michigan, for its dependable productiveness and in North Carolina for its resistance to stem canker and stunt. Expensive to prune and pick.

**Rubel.**—Selection from wild. Bush erect, vigorous, productive; leaf medium size; fruit cluster very loose; berry medium size, oblato, of good blue color, firm, with slight aroma, of fair dessert quality; scar good; season late, with Jersey. Liked as a late variety for its hardiness and productiveness and in North Carolina for its resistance to stem canker, but in most new plantings Berkeley, Coville, Atlantic, Jersey, Pemberton, and Burlington are substituted as larger fruiting late varieties.

**Scammell.**—(Brooks × Chatsworth) × Rubel. Bush erect, vigorous, productive; leaf very small; fruit cluster long and tight; berry large if properly pruned,

oblato, dark blue, firm, with very slight aroma, medium in dessert quality; scar medium; season late midseason (after Stanley), unless clusters are pruned back a large part of berries ripen with Jersey. Liked in North Carolina for its productiveness and resistance to stem canker, but very subject to stunt and dark in color; not grown much elsewhere.

**Stanley.**—Katherine × Rubel. Bush erect, vigorous, but with few main branches; leaf very large; fruit cluster medium, loose; berry medium size, but last berries to ripen often very small, oblato, of good blue color, firm, very aromatic, of high dessert quality; scar medium size to above; midseason, ripening just after Rancocas. Though very aromatic the berries usually are not very large; liked where berries are of good size.

**Wareham.**—Rubel × Harding. Bush upright spreading, vigorous; leaf small, serrate; fruit cluster medium loose; berry medium size, round oblato, dark blue, firm, with characteristic aroma, of high dessert quality; scar small; late, lasting about a week later than Jersey and Rubel. Being discarded because of dark color and very bad cracking.

**Weymouth.**—June × Cabot. Bush erect, open spreading, of average vigor; leaf of above average size; fruit cluster medium loose; berry of above medium size, round oblato, dark blue, lacking aroma, usually of poor dessert quality; scar medium; very early, ripening all berries quickly. Planted extensively for early season, but dark, not of good quality, and subject to stem canker, stunt, and mite injury.

**Wolcott.**—Weymouth × (Stanley × Crabbe 4). Bush very vigorous, upright, productive; leaf large; fruit cluster loose; berry large, round, dark blue, similar to Weymouth in color, firmer than Weymouth, aromatic, medium in dessert quality; scar small, very good; season early and short, with Weymouth. Promising in North Carolina for its early season and canker resistance; not promising in Maryland and New Jersey.

#### NEED FOR CROSS-POLLINATION

Results of experiments indicate that it is essential at least under some conditions to grow two varieties of blueberries near each other for cross-pollination. The early experiments of Coville led him to state that "When blueberry flowers are pollinated with pollen from their own bush the berries are fewer, smaller, and later in maturing than when pollen comes from another bush [from a bush of another variety]." Experiments in North Carolina, New Jersey, and Massachusetts have, in general, confirmed Coville's results. However, growers in Michigan have set solid blocks to a single variety, and the heavy crops of large-size berries of Rubel and Jersey grown in solid blocks indicate that so far the practice has been satisfactory there. It is suggested that growers set two rows of one variety and alternate with two rows of another. All varieties seem to overlap enough in time of flowering to be effective pollinizers for any other variety.

#### GROWING AND CARE OF SEEDLINGS AND NATIVE PLANTS

Because the cultivation of the blueberry is a relatively new industry and most cultivated varieties are the result of breeding and have been introduced recently, many practices are being tested that would not be followed in an older industry. Several large fields of seedlings are still bearing fruit in New Jersey, Michigan, and Washington. Though they may produce good crops, the berries are variable in season, size, color, and flavor and are less desirable for the general market than are berries of cultivated varieties.

Some fields of bushes selected from the wild are also still being picked, but the fruit is much smaller and even less desirable than that

of seedlings of varieties. Many areas of native bushes are being given some attention; the competing trees and bushes are being removed, the blueberries fertilized, and the bushes pruned. Where the stand of blueberries has been good this care has sometimes been profitable. Such berries, however, have to compete with fruit from cultivated plantings of selected varieties.

#### PROPAGATION

With careful attention the blueberry can be propagated extensively by either hardwood or softwood cuttings. The hardwood cuttings, 4 to 5 inches long, are made from dormant shoots of the previous season's growth, the lower cut being made just below a bud and the upper just above one (fig. 17, *A*). Wood with fruit buds should be cut off and discarded, as but few cuttings with fruit buds root, or make good plants. The cuttings are rooted either in ground beds with lath shade about 7½ feet above the ground or in covered frames.

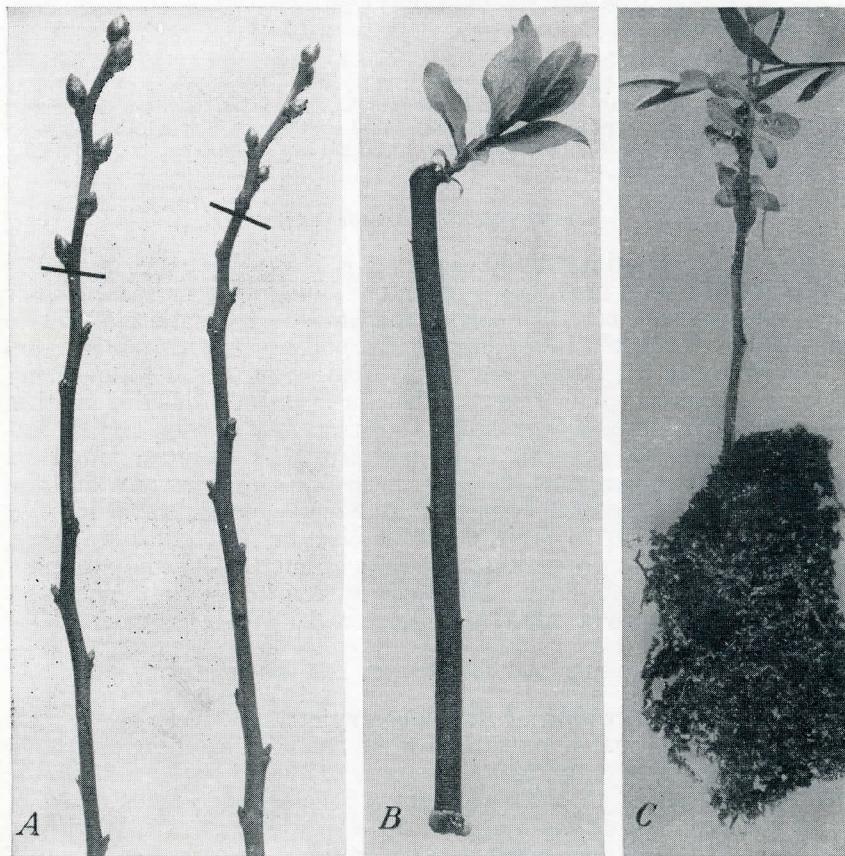


FIGURE 17.—*A*, Hardwood cuttings with fruit buds at tip; these should be cut off as indicated. *B*, Cutting with a shoot at the upper end and a good callus but no roots at the base. Roots should appear within a few days. *C*, Well-rooted cutting.

Ground beds are those made directly on the ground; they are usually filled with a mixture of half peat and half sand to a depth of about 6 inches. The most commonly used covered frames are 6 feet by 27 inches by 16 to 40 inches deep and contain trays 4 inches deep with the bottom made of 1/8- to 1/4-inch-mesh hardware cloth or fly screen. The trays rest on cleats 8 to 10 inches below the top of the frame. The trays are filled with peat or peat and sand, and the cuttings are placed about 1 inch apart in rows 2 inches apart and in a slanting position. An advantage of the tray is that it can be removed to a coldframe or to the nursery row, while cuttings in the ground bed require transplanting. In Michigan each frame is covered with a sash and then with coarse burlap, while in New Jersey either slat or lath covers are used for shade. Recently, experiments have shown that with bottom heat at 70° F. more and better rooting of hardwood cuttings is obtained.

Cuttings are made while the plants are dormant. They may be stored in a cool moist place until they can be placed in the propagating beds early in the spring. Usually they have rooted by June (fig. 17, *C*), but are left in the ground beds or, if propagated in covered frames, are placed in coldframes until the following spring.

Softwood cuttings are made when secondary growth first appears on the new shoots. They are made about 4 inches long, and only the two upper leaves are left on the cutting. The upper half of each of the two leaves is usually cut off to reduce transpiration. In Michigan softwood cuttings are handled in frames as are the hardwood cuttings; in New Jersey they are propagated under glass. Softwood cuttings are little used commercially.

Both hardwood and softwood cuttings are usually grown for a year in the nursery row before being planted in the fields. The nursery rows are usually 18 inches apart and the plants 6 to 10 inches apart in the row. After a year in the nursery row they are called 2-year plants. Well-grown 2-year plants are considered most desirable for field planting.

Murphy, Wolcott, Rancocas, Rubel, Pemberton Berkeley, and Coville are relatively easy to root from cuttings; Jersey, Concord, and Scammell are somewhat less so; and June, Atlantic, and Stanley are more difficult.

#### PLANTING AND CULTIVATION

The plants are usually set 4 or 5 by 8 feet, 4 or 5 by 10, or 6 by 8 as early in the spring as the soil becomes suitable for working. Setting them 5 by 8 feet (1,089 plants per acre) or 6 by 8 (908 plants per acre) is suggested for new plantings. Setting 4 by 10 feet (1,089 plants per acre) or 5 by 10 (871 plants per acre) is suggested for plantings for standard tractor cultivation. In New Jersey some early fall planting is done; in eastern North Carolina planting is done in the late fall or winter. The blueberry is shallow-rooted; therefore, cultivation should be shallow. Clean cultivation has been the usual practice, but because of danger of erosion and of soil impoverishment it is not advisable as a permanent practice. In Michigan a spring oat cover crop sown just after the harvest is recommended. Ground covers of lespedeza and annual bluegrass and mulches are being tested in New Jersey.

### MAINTAINING SOIL FERTILITY

The essential requirements for successful blueberry culture are that the plants be vigorous and that they produce good crops each year. On fertile soils very little fertilizer may be required, while on poor soils larger amounts may be necessary to maintain satisfactory growth. Stable manure should not be used except as careful trials have shown it safe to use. It has sometimes been very injurious, but light applications to some of the more acid soils have been beneficial. In Michigan the application of superphosphate alone up to 670 pounds per acre has given good results, but about 500 pounds of a complete fertilizer has generally been somewhat better. In localities where blueberries are now planted in New Jersey and North Carolina, nitrogen has seemed most often the limiting element. For locations where satisfactory practices are still unknown, it is suggested that one application, 400 to 600 pounds per acre, of a complete fertilizer (about 5-10-5) be made in the spring at the time the buds are starting. This should be followed about 6 weeks later, if the soil is not very acid (pH 4.8 or above), by an application of 110 pounds of ammonium sulfate per acre; or, if the soil is very acid (below pH 4.0), by an equivalent amount of nitrogen in the form of nitrate of soda (150 pounds per acre), followed by one or possibly two similar applications at intervals of 6 weeks. The more fertile fields should not have the later fertilizer applications. The fertilizer should be broadcast to within 6 to 12 inches of the plant and out as far as the roots extend.

If the foliage shows chlorosis, or yellowing, ammonium sulfate should always be used as a source of nitrogen instead of nitrate of soda; and the plants should turn green within a few weeks. For blueberries on loam, sulfur may be used in place of sulfate of ammonia (p. 16).

### GOOD DRAINAGE ESSENTIAL

Although the highbush and rabbiteye blueberries are both natives of swamp and moist lands, cultivated fields should be well drained. The blueberry is considered a shallow-rooted plant because it survives in swamps and is not often found on high, dry sites. Vigorous productive bushes, however, can grow only where there is an extensive soil volume not saturated with water during the growing season and only for short times during the dormant season. Under such favorable conditions an extensive root system develops that can support a large bush and crop. If, because of heavy rains or poor drainage, the water table is raised for several days, the root system may be weakened or the plants killed; sometimes the lower part of the root system is killed so that when a drought follows such injury the whole plant may die. Precautions to obtain proper drainage should be taken, because the low-lying soils usually selected for blueberries often have depressions or pockets from which the water does not drain out and the blueberry plants are drowned.

### IRRIGATION OFTEN PROFITABLE

Most areas where blueberries are grown are subject to droughts severe enough to injure both the plants and the crops. More and

more blueberry growers are providing for irrigation. Many blueberry growers use an overhead sprinkler system, which can be used for frost protection also. Under ideal conditions of drainage and irrigation, excess water can be quickly removed during or after storms. In times of drought, 1 to 2 acre-inches of water should be applied about 10 days apart during the picking season and as needed later in the season during the heat of summer.

Mulching with sawdust or other materials helps to conserve moisture.

### MULCHING

Mulching with leaves, sawdust, hay, or straw, as suggested for home garden plots of blueberries (p. 11), has been followed commercially on small areas in New England, New Jersey, Ohio, North Carolina, and northern Georgia with success. Mulching materials applied to a depth of several inches keep down weeds, keep the soil cooler in summer, help to retain soil moisture, and help to control erosion. The plant rows may be covered for 2 to 2½ feet on each side, or the entire area may be mulched. Leguminous hay mulches (clover, soybean, etc.) have sometimes been injurious and should not be used unless thorough trial has shown no injury over a period of a year or more. When leaves, sawdust, hay, or straw are used, additional nitrogen must be applied to obtain good growth. Instead of using the 110 pounds of ammonium sulfate per acre required where mulches are not applied, two applications, each of 300 pounds per acre, should be used on mulched areas, 6 weeks apart. For small plantings one-third to one-half pound of fertilizer per bush should be scattered over the surface at each application, not closer than 6 to 8 inches to the base of the plant.

### PRUNING

The blueberry produces fruit on wood of the previous season's growth. The largest fruit is borne on the most vigorous wood. Most varieties tend to overbear, and unless part of the buds of such varieties are pruned off the berries are relatively small and there is too little vigorous new growth for the next year's crop. The erect-growing varieties, such as Rubel, Rancocas, Scammell, June, and Concord, need to be thinned at the center, whereas Cabot and Pioneer are especially spreading and are likely to need pruning of the lower drooping branches.

Heavy pruning (thinning the small branches, heading back clusters, and cutting out some old stems) reduces the crop greatly and hastens ripening. It should rarely be practiced. Light pruning (thinning out some of the small branches and an occasional stem), though it reduces the crop for a particular year, increases the size and earliness of the berries and tends to produce more vigorous new growth for the next year's crop than does no pruning. The heavier the pruning the larger the berry size, the earlier the ripening, and the smaller the total crop for that year. Under some conditions where the crop is heavy and no pruning is done, few of the berries mature.

Tests in Michigan of different methods of pruning (table 6) illustrate the effect of pruning for 2 years, on yield per plant and size of berries. With Rubel, very heavy pruning as compared with light

pruning reduced the crop more than 75 percent the first year and more than 50 percent the second year. On the other hand, it increased the size of the berries by about 25 percent the first year and by about 30 percent the second year. Similar decreases in yield and increases in size following very heavy pruning occurred with the Pioneer variety.

TABLE 6.—Yield per plant and size of berries from full-grown bushes of the Rubel and Pioneer blueberries under different types of pruning at South Haven, Mich., for 2 successive seasons

[1 pound=1.14 pints]

Type of pruning	Berries per plant				Berries per half-pint cup			
	Rubel		Pioneer		Rubel		Pioneer	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
None	23.4	20.1	25.3	26.9	222	181	190	132
Light	17.3	19.9	18.4	18.8	189	204	173	136
Medium	16.3	14.3	17.4	11.0	174	192	151	130
Heavy	7.6	8.1			164	169		
Very heavy	3.9	9.1	5.8	10.8	145	145	85	99

Pruning also had an important effect on the time of ripening. In the first season, 93 percent of the crop from heavily pruned Rubel bushes was harvested at the first picking; whereas with light and medium pruning only 63 and 65 percent of the crop, respectively, was harvested at that picking. With the Pioneer, 92 percent of the crop on heavily pruned bushes was harvested at the first three pickings (within 2 weeks), but on lightly pruned bushes only 54 percent ripened in the same period and the other 46 percent ripened over a 4- to 5-week period. Thus, it is possible to shift the ripening period by the amount of pruning done. In North Carolina and other Southern States relatively heavy pruning even at a sacrifice of yield may be practiced to obtain an early-maturing crop, and in the Northern States the practice of light pruning may spread the ripening season over several weeks.

Relatively less pruning is necessary on very vigorous plants. If plants are heavily fertilized and the soil-moisture supply is adequate at all times, they make much stronger growth and can produce a much heavier crop of large berries than if fertility is lacking and the soil-moisture supply is insufficient at times.

Usually very little pruning is necessary until the end of the third season, when regular annual pruning should ordinarily begin. The general practice is as follows: (1) The low spreading branches next to the ground should be cut out, leaving only the more erect branches or shoots; (2) if the center of the bush is dense, the weak and the older branches at the center should be cut out; (3) most of the small slender

branches should be removed, leaving the strong branches and shoots (fig. 18). Often, many of these small branches are thickly set with fruit buds, and sometimes few of these slender branches have fruit buds. These weaker branches cause the bush to become too dense, thus making picking difficult and leaving inadequate space for strong new shoots. Rubel, Concord, and Rancocas bushes require much thinning out of the small branches and are, therefore, expensive to prune. Finally, in order to increase the size of the berries the fruiting shoots of some varieties should be cut back, the amount depending on the number of fruit buds on such shoots. June, Weymouth, Rancocas, Concord, Stanley, Jersey, and Rubel require very little cutting back; Cabot, Scammell, and Pioneer require cutting back to about three to five fruit buds per shoot. The amount of cutting back neces-



FIGURE 18.—Four-year-old blueberry bush of the June variety: A, Before pruning; B, after pruning. Pruning reduced the fruit buds by about 75 percent. In very fertile soils a large number of fruit buds might be left for a heavier crop.

sary varies from year to year, depending on growing conditions. Cutting back is usually done after danger of cold injury is past. General pruning may be done at any time from leaf fall in the autumn to the beginning of growth in the spring.

#### HARVESTING AND MARKETING

The first berries from the early varieties are picked about May 20 in North Carolina, June 20 in New Jersey, and July 10 in southern Michigan. From three to seven pickings are made at 5- to 7-day intervals. In any one locality the season usually lasts 6 to 7 weeks. To provide the best possible supply to markets, the North Carolina growers are mainly interested in early to midseason varieties, the New Jersey growers in midseason and late ones, and the Michigan growers in late sorts. In 8 hours a picker can harvest 60 to 80 pints, or even more where the crop is heavy. Pint baskets are used mostly as containers,

but these have to be made tighter than for larger fruits such as strawberries. Most of the crop in the three States mentioned is marketed cooperatively. The berries are sold according to size grades, the larger berries usually bringing a higher price than the smaller ones. Early and late in the season small berries sometimes bring higher returns than larger berries in midseason.

#### YIELDS

Yields vary greatly. In Michigan on good soil the yields from the second to the sixth year usually increase from 50 to 6,000 pints per acre. Larger yields are possible; as many as 9,600 pints per acre have been obtained from good fields. Full production is reached in 6 to 10 years, but it may be reached earlier with good culture. Individual bushes should produce a little fruit after being planted 1 year. When mature, they usually bear 6 to 8 pints per plant, and with medium pruning they may even produce 12 to 20 pints per plant (table 6).

#### USES

Although most of the crop from cultivated fields is marketed in the fresh state, large quantities of the highbush blueberry are canned or frozen. Because the canned berries are used largely for pies they are packed mostly in water and to a lesser extent in a sugar sirup. The frozen berries also are used mostly for pies and should be frozen with added sirup. Recently quantities have also been frozen in small containers for table use. Both before and after freezing, Pioneer and Concord are better in flavor than Rubel and Rancocas. Atlantic and Coville are two of the best for freezing. The frozen product is nearly equal to fresh fruit in appearance and quality. The frozen pack in 50-percent sirup is considered preferable to that in either 40- or 60-percent sirup and is much superior to packs that contain neither sirup nor sugar. Frozen berries are also superior to canned ones. Blueberry juice has been produced commercially to a limited extent.

### BLUEBERRY DISEASES

Diseases cause more or less damage in all blueberry-growing sections.

In the South the loss from diseases is more serious than elsewhere. There stunt, a virus disease, is considered of first importance, as it affects most varieties and all bushes infected soon become unproductive. Stem canker is a close second in importance. Although most varieties are susceptible to stem canker, bushes remain productive for a few years after infection. Foliage diseases cause more damage than elsewhere.

In New Jersey, stunt is the most important disease, followed by mummy berry and powdery mildew. Stem canker is a minor problem. Foliage diseases other than mildew usually do not cause any damage.

In New England, mummy berry is severe in some years, powdery mildew is usually present, and witches'-broom and leaf rust do some damage annually.

The most important disease in Michigan is mummy berry, which causes considerable loss some years, especially in fields on muck

soil. Stunt is increasing in a few fields. Foliage diseases, except mildew, are lacking.

In the Pacific Northwest, a tip and blossom blight, caused by *Botrytis* sp., does considerable damage. This disease is favored by the cool and foggy weather that prevails during the early growing season in this area.

#### STUNT

Stunt, a virus disease, at present is known to occur in damaging amounts in fields of the highbush blueberries in New Jersey and North Carolina and to a lesser extent in Massachusetts, Michigan, and New York.

Stunt causes extensive dwarfing of bushes, compact bushy growth due to an abnormal number of short twigs, small, sometimes broad



FIGURE 19.—Blueberry stunt. A healthy shoot (upper left) and one infected with stunt (lower right). Note small berries on infected shoot and bunching appearance caused by small leaves, broad in comparison to length, at close intervals on abnormal number of short side shoots. (Photograph, courtesy Michigan Agricultural Experiment Station.)

leaves that are yellowish at tips during the spring and turn to red in early fall, and small berries that adhere tightly to the stems even when ripe (fig. 19).

When bushes are infected while young they never develop to normal size but remain about the size they were when infected. Bushes of all ages may become infected. The first-year symptoms in an old bush may show on one branch only. The new growth on this branch will be short, with short stubby side twigs, the leaves small and yellow along the margins and tip, and the berries small. The following year the disease will usually show throughout the infected bushes,

which will remain at about that height. Sometimes during the first season after infection signs of stunt show only on the young basal shoots. If all old stems or canes of an infected plant are cut off at the ground level, an abnormal number of basal shoots develop but none will attain a height of more than 2 feet.

All standard varieties of blueberries are susceptible to infection with stunt, but a wide range in tolerance is exhibited by varieties. Rancocas seldom shows symptoms of the disease under field conditions, and it is considered highly resistant. It is about the only variety that can be successfully grown in a field of mixed varieties exposed to infection. June, however, is highly tolerant and will survive and yield fairly well for several years after infection. Other varieties that may have slight tolerance are Dixi, Harding, Rubel, Stanley, Jersey, and Pemberton. Cabot, Concord, Pioneer, Burlington, and Scammell are among the most sensitive varieties.

Stunt is perhaps the most damaging disease of cultivated blueberries, as the virus is infectious and spreads rapidly after it becomes established in a planting. Records taken in North Carolina indicate that the disease may make a field unprofitable 5 or 6 years after it is introduced.

#### Control

There is no known cure for the disease after the infective agent is transmitted to a bush. Frequent inspection of fields and prompt removal of all bushes showing even the slightest symptoms are recommended as control measures. Infected bushes should be grubbed out so that no suckers will develop from the crown or roots, for suckers may transmit the disease as readily as any other part of the plant. When an infected bush is removed, the vacant space may be replanted immediately if the vector is controlled. To be successful roguing should be started as soon as any bushes show symptoms and should be followed with two inspections each season. Low spring temperatures, drought, and iron and magnesium deficiency also cause various abnormal leaf coloring that may confuse the inspector; but the other typical stunt symptoms—small leaves, short, stubby side shoots, and small berries—will be absent. It is often advisable when making inspection for stunt to be sure that there is more than one typical stunt symptom before condemning a bush. Bushes having symptoms suggestive of stunt should be marked in some manner and the final decision should be made at the next inspection period. If more than 4 or 5 percent of the bushes show symptoms, it is doubtful if roguing will prove effective.

As the disease is spread under field conditions by leafhoppers, it is essential to control these insects. For control of leafhoppers see section on "Sharp-nosed leafhopper," page 48.

There are no indications that the infective agent of stunt can be transmitted from a diseased bush to a healthy one by tools used in pruning or in cultivating. It can, however, be transmitted in buds, grafts, or cuttings taken from infected bushes.

#### MUMMY BERRY

Mummy berry, caused by the fungus *Monilinia vaccinii-corymbosi* (Reade) Honey, has been a serious disease on the highbush blueberry

in some years in New Jersey and other northern blueberry sections and on the rabbiteye blueberry as far south as southern Mississippi. It is erratic in its occurrence. It may almost disappear for a few years and then quickly build up to epidemic proportions when spring weather conditions are favorable for spore production and infection.

The fungus causes blighting of the new shoot tips and blossoms and destruction of the berries. Wilting and killing of the shoot tips and blossoms are first noticed in moist weather in early spring (late March

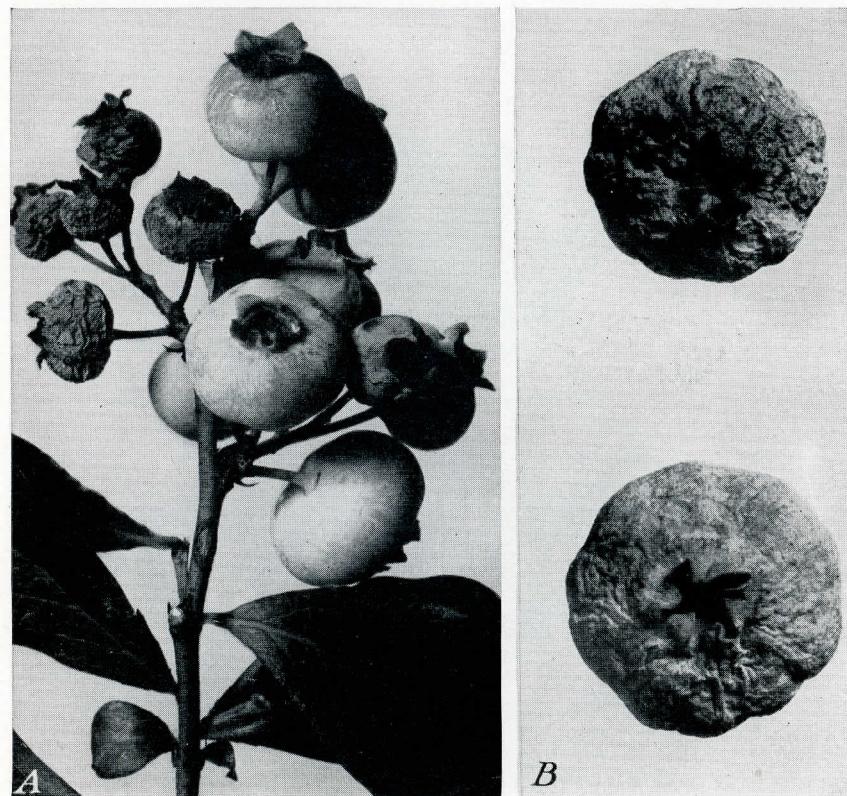


FIGURE 20.—A, Cluster of highbush blueberries, of which five are affected by mummy berry; B, affected berries, which commonly drop before ripening.

through April in New Jersey), and the visible effect is not unlike frost injury. Spores are produced on the wilted tips and blighted blossoms. The spores later infect the very young fruits. The infected fruits develop to almost full size before their growth is stopped. When normal berries are still green, the infected ones, commonly called mummy berries, turn cream or tan and shatter easily (fig. 20).

Within these fallen mummy berries are formed hard fungus structures (sclerotia), frequently the size and shape of normal berries, black on the outside and whitish within. These bodies may remain dormant on or near the soil surface for several years; but ordinarily, if weather conditions the following spring are favorable, each may

produce one to several small, stalked, toadstoollike structures (apothecia) (fig. 21). Inside these are formed numerous spores capable of starting the disease anew on the young shoots and blossoms.

A large number of berries may become infected and fall to the ground, but the most serious damage is the killing of blossoms, fruit clusters, and young shoots. The berries of some varieties, particularly Jersey and Rubel, are very susceptible to infection. Blighting of shoot tips of the Adams variety and of blossom clusters of the Cabot is sometimes serious.

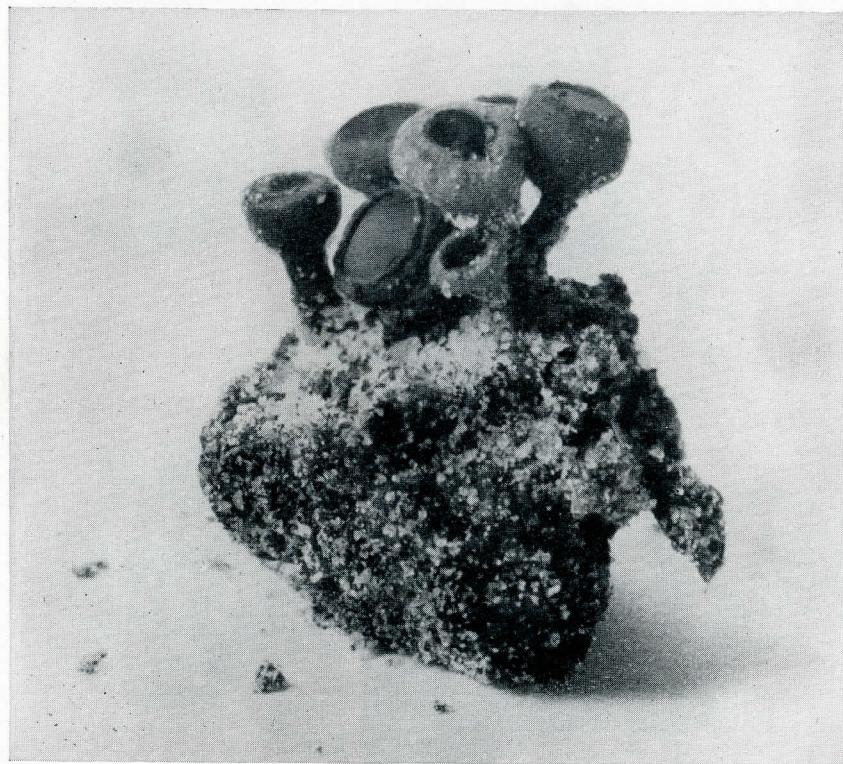


FIGURE 21.—Mummy berry fungus. These apothecia, or spore-forming structures, developed from an old mummy (covered with adhering soil particles) that dropped to the ground during the previous year. Spores from these apothecia infect very young tip leaves. (Greatly enlarged.)

#### Control

Spraying has been only partially effective against mummy berry. In small plantings the practice of removing all wilted shoots daily before spores are produced has given fair control.

The control measures most common in commercial fields in New Jersey and Michigan consist of hoeing or raking the soil surface under and between the bushes in the rows and cultivating between the rows. The object of raking and tillage is to disturb or cover the old mummy berries lying on the soil surface or immediately below during a critical period before the mummies form their spore-

producing structures (fig. 21). If the mummies are disturbed or covered with soil, they remain dormant. Raking and cultivating should be done as early as weather and soil conditions will permit, and if practical the cultivation should be repeated after each hard rain that packs the soil until after blossoming. In some years weather conditions will not be favorable for cultivation early enough to be effective, especially where plantings have been made on muck or peat soils.

#### PHOMOPSIS TWIG BLIGHT

On both highbush and rabbiteye blueberries a distinct blight of twigs, of the tips of shoots, and sometimes of entire shoots is caused by *Phomopsis vaccinii* Shear, a fungus that is also parasitic on the cranberry. No cultivated variety of the highbush blueberry is known to be resistant. The disease occurs in New Jersey, Massachusetts, and North Carolina, and possibly in other sections. It is usually not serious but has done considerable damage in areas where water stands for any length of time during the growing season and has become rather severe after abnormally heavy rains, which have resulted in the flooding of fields.

The fungus enters the tip of a fast-growing shoot and progresses toward the base. Its advance is rapid in succulent tissues; the tip wilts and turns dark brown or black within a few days and a sharp line of demarcation separates it from the healthy, light-green bark below. However, some of the leaves may drop from the apparently healthy part of the shoot. If the shoot is split, a slightly discolored zone of underlying tissue may be found extending downward several inches beyond the darkened bark area, and even below this zone the pith shows a brownish color and is divided transversely into sections. When the fungus reaches the base of a succulent shoot it enters the older wood, in which it progresses much more slowly. As soon as the older wood is girdled, the parts above the girdle die.

The fungus lives over winter in blighted wood and produces numerous spores in the spring. Because these spores require moist conditions for germination, a prolonged period of dry weather in the spring may greatly reduce the number of new infections.

#### Control

Dormant pruning should include the removal of all blighted or discolored wood. Branches apparently winterkilled should be regarded with suspicion. Carefully collect and burn prunings before growth starts. When blighted tips are discovered during the summer, remove the new infections before the fungus reaches the old wood, by cutting the shoot back to a point where the pith appears normal. After a badly infected field has been pruned, a delayed dormant application of lime-sulfur (1 part of commercial lime-sulfur solution to 9 parts of water), followed 2 or 3 weeks later by a spray of 4-4-50 bordeaux mixture, helps to prevent new infections.

#### STEM CANKER

Stem canker, caused by *Phylospora corticis* Demaree & Wilcox, is of considerable economic importance in the South, but it is only of slight importance in New Jersey. The disease initially becomes es-

established in new shoots. It is inconspicuous at first but gradually spreads year after year, finally forming large, more or less swollen, cankers with deep cracks or forming a grayish area, only slightly swollen, with uneven dark surface (fig. 22). The disease is spread by spores that develop in tiny black receptacles on the surface of the cankers.

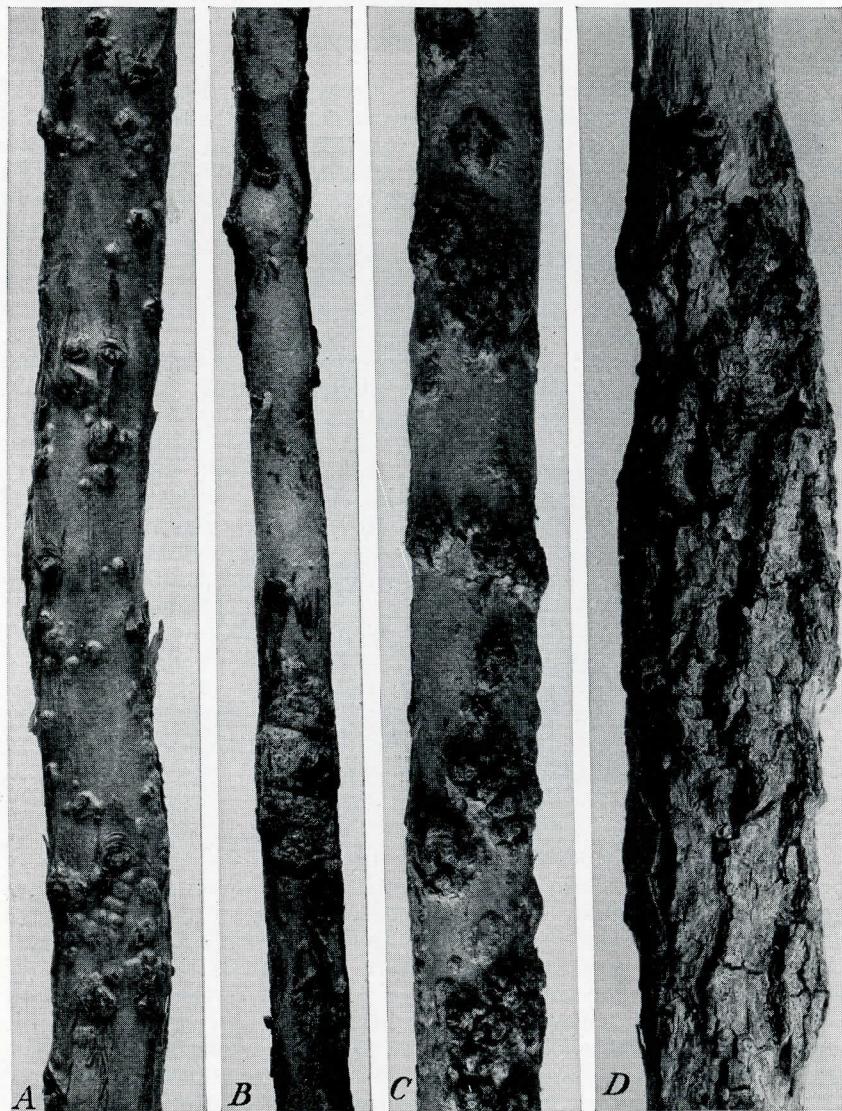


FIGURE 22.—Stem canker. A, Infections as they appear at the beginning of the second season. Note cracking of some swellings. One and one-half times natural size. B, Canker around point of infection, at end of second season. One and one-fourth times natural size. C, Blisterlike swellings, such as are shown in A, during the third season. About natural size. D, Old and deeply cracked canker that has girdled the stem. Parts above such cankers usually die. About one and one-half times natural size.

The injury is caused by girdling of the branches and stems by the fungus in the infected bark; this results in the weakening or death of the stems about the cankered areas and a material reduction in the fruiting capacity of the bushes. This damage is sufficiently great in some otherwise desirable varieties to make them unprofitable to grow.

Varieties of cultivated blueberries exhibit a wide range in resistance to the stem canker fungus. A few are highly resistant, some moderately so, and several are so susceptible they should not be planted in the South. Among the highly resistant commercial varieties are Wolcott, Murphy, and Scammell, and Adams, a noncommercial one. The varieties Atlantic, Jersey, Rubel, Wareham, and Rancocas are moderately resistant but can be grown successfully in sections where the disease is present. The varieties that should not be planted in the southern sections on account of their extreme susceptibility to canker are Dixi, Katharine, June, Pemberton, Burlington, Concord, Pioneer, Stanley, Weymouth, and Cabot. So far as is known, all named varieties of the rabbiteye species are highly resistant.

#### Control

Attempts to control the disease by spraying, pruning out the cankered branches, or even removing the entire bush when badly infected have not so far proved to be of much value. It has been observed that when a badly diseased bush is removed and the space is reset with a new plant of the same variety, or one equally susceptible, the new plant soon becomes infected and shows evidence of injury and lack of productivity in about 3 or 4 years, or soon after its normal age for profitable fruit production. Therefore, the only practice known to reduce the loss occasioned by the canker disease in fields where it is serious is to remove all plants of very susceptible varieties and reset with resistant ones. This may not eradicate the disease; however, up to the present time, injury to the resistant varieties has not been sufficient to cause any apparent reduction of the crop.

In the South, blueberry growers who contemplate enlarging their plantings or who plan to start a new field should select only those varieties known to be resistant to the disease; at least they should limit the use of the most susceptible varieties. It is further recommended that they obtain plants or propagating wood from a region or field where it is known that stem canker is not present. The use of disease-free plants does not, however, give complete assurance that the disease will not appear later, since wild blueberry bushes in nearby swamps or forests may have the disease and it can be spread from these to the new planting.

#### POWDERY MILDEW

Powdery mildew, caused by the fungus *Microsphaera alni* DC. ex. Wint., is the most widespread disease of cultivated blueberries. It is found at some time every summer in about all fields from Maine to Florida and west to Louisiana. Evidence of the disease is very conspicuous on some varieties, owing to the abundant white growth of fungus threads and spores on the upper surface of leaves. On some varieties the disease shows as superficial reddish areas on the lower leaf surface and faintly yellow spots above.

Varieties show wide differences in resistance to mildew. Cabot and Pioneer are more susceptible than others. Jersey, Stanley, and Rubel are moderately resistant, and Rancocas, Harding, Dixi, June, and Weymouth are highly resistant.

The disease does considerable damage in some years, but since the greatest amount of infection occurs after harvest most growers are not alarmed and control measures are generally not practiced. The spray program recommended below for double spot will kill the causative fungus.

#### DOUBLE SPOT

The term "double spot" is commonly applied to a blueberry leaf disease caused by the fungus *Dothichiza caroliniana* Demaree & Wilcox. The disease has been observed only in North Carolina where, in years when rains are frequent in May and June, it becomes serious, resulting in considerable defoliation in late summer and fall. The fungus is not known to attack any part of a blueberry plant except the foliage.

A few spots may appear on the leaves during the latter half of May, the number gradually increasing in June, July, and August. At first the spots are small, ranging from  $\frac{1}{16}$  inch to  $\frac{3}{8}$  inch in diameter, and circular, with a light-brown center surrounded by a dark-brown ring. Apparently the leaf tissues build up a protective layer around the small spots and the fungus is originally confined to a small area. After midsummer, the fungus breaks through the protective zone and invades a much larger area causing spots,  $\frac{1}{4}$  inch to  $\frac{1}{2}$  inch in diameter of cinnamon-brown color, that surround the central, or original, small spot. This characteristic suggested the name "double spot" now in common usage (fig. 23).

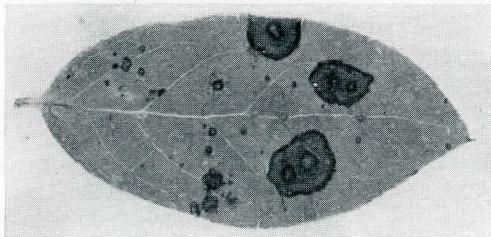


FIGURE 23.—Double spot, a serious leaf disease of the cultivated highbush blueberry in the South.

Apparently all varieties of the highbush blueberries are susceptible to this disease. There is, however, some difference in the degree of susceptibility. Cabot, Dixi, Pioneer, and Rancocas are most susceptible; Adams, Concord, Jersey, and Weymouth are moderately resistant; and June is resistant.

#### Control

Spraying with 4-4-50 bordeaux mixture has given very satisfactory control in commercial fields. Where the disease is serious, three applications are recommended: the first soon after blossoming period, the second immediately after harvest, and a third about 30 days after the second application.

#### WITCHES'-BROOM

Witches'-broom is caused by the rust fungus *Pucciniastrum goepertianum* (Kuhn) Kleb. and may bring about extensive damage to blueberry bushes when growing near trees of the true fir. This rust fungus also causes a disease of the fir. Spores are produced on the leaves of the fir; these may be carried several hundred yards by wind to blueberry plants where they cause the witches'-broom disease of blueberries. Spores from the blueberry bush will infect only the true fir and will not spread the disease to other blueberry bushes.

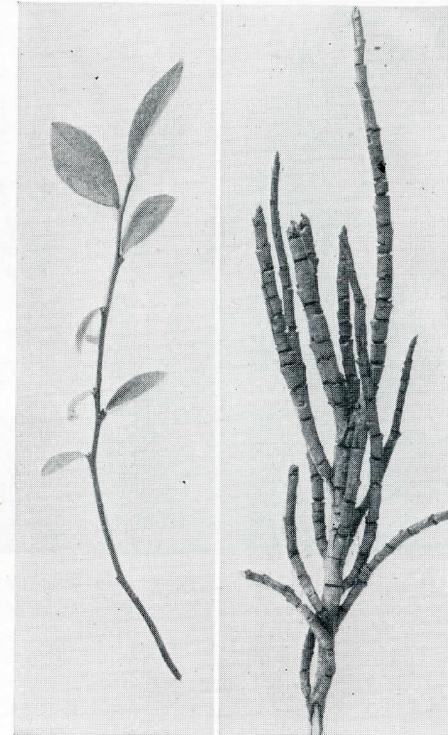


FIGURE 24.—Witches'-broom. A normal blueberry shoot (left) compared with one (right) infected with the witches'-broom fungus. (Photograph, courtesy Maine Agricultural Experiment Station.)

When an infection takes place in a blueberry shoot, it results in the production of several short, stiff, swollen twigs (fig. 24) crowded on a small area near the point of infection. Several witches'-brooms on a bush may make it worthless for fruit production (fig. 25).

Witches'-broom is serious in cultivated blueberries, principally in New England and especially on those planted near wooded areas of fir. Witches'-broom does not occur on the cultivated highbush blueberry in the Pacific Northwest, but it is found abundantly in that area on the native evergreen blueberry, which is occasionally cultivated.

Blueberries should not be planted near wooded areas composed wholly or partly of fir trees. There is no known remedy, but it is



FIGURE 25.—Several large witches'-brooms on an old blueberry bush. (Photograph, courtesy Maine Agricultural Experiment Station.)

considered helpful if the young witches'-brooms are removed well below the affected stem tissues as soon as they appear. Susceptible varieties include Adams, Cabot, Pioneer, and Rubel. The varieties Katherine and Rancocas seem to be resistant.

#### LEAF RUST

Leaf rust is caused by the rust fungus *Pucciniastrum myrtilli* (Schum.) Arth., and, like the fungus responsible for witches'-broom, has an alternate host—hemlock.

Ordinarily spores from the hemlock are carried by wind at least  $\frac{1}{4}$  mile to blueberry plants, and in such areas the rust occurs about every year. Strangely, in some years the disease occurs in an epidemic form 100 miles or more from hemlock forests. In such cases it is thought that spores from hemlock forests are lifted by upward air currents to high altitudes and then carried long distances before dropping. Severe infections have been observed in New Jersey, Maryland, North Carolina, Alabama, and Florida. Sometimes considerable defoliation occurs, usually in September. In the Pacific

Northwest the cultivated highbush blueberry does not become infected, even when planted immediately adjacent to the western hemlock. In that region, however, various native blueberry species are severely infected with leaf rust. The rabbiteye blueberry, which has been planted experimentally in the Northwest, also becomes infected.

The disease shows on blueberry leaves as circular to irregular dark-brown spots  $\frac{1}{8}$  inch or less in diameter on the upper surface and lighter brown spots with yellowish pustules on the lower surface. The spots may be numerous, killing most of the leaf area. The rust spores forming on blueberry during the summer are capable of infecting other blueberry leaves; consequently, scattered infections in spring may increase rapidly during the summer and cause much damage by autumn. There is no known control for leaf rust. The highbush varieties Adams, Concord, Jersey, and Rubel are susceptible, and Cabot, Dixi, June, Rancocas, and Weymouth are highly resistant. Of the rabbiteye varieties Black Giant, Myers, and Owens are highly resistant.

#### BOTRYTIS TIP BLIGHT<sup>4</sup>

Tip blight, caused by a species of *Botrytis*, is the most important blueberry disease in the Pacific Northwest. Infection apparently takes place in the growing blueberry tips and the fungus spreads rapidly down the cane, killing the tissue as it advances. The entire succulent growth of a single year may be killed. The dead cane appears brown to black. After weathering, this discoloration often turns grayish. Tip blight is most severe on young rapidly growing plants. In addition to tip blight *Botrytis* also produces a leaf spot, a blossom blast, and a fruit rot. Recently *Botrytis* fruit rot was shown to be important in berries grown in New Jersey when they were held in cold storage from 10 to 19 days.

In Washington, *Botrytis* attacks many wild blueberry species in addition to the cultivated highbush blueberry. All varieties of the cultivated blueberry are susceptible, but some are more so than others. Atlantic seems to be the most severely infected variety. No data are available on the relative susceptibility of the different named blueberry varieties. Some wild blueberry species are apparently resistant.

#### Control

This disease has not been controlled by spraying. Tip blight appears to be more severe on heavily fertilized plants that make very rapid and succulent growth. Rapid forcing of blueberry plants, especially during the latter part of the growing season, should be avoided.

#### FOLIAGE DISEASES OF MINOR IMPORTANCE

Although double spot, leaf rust, mummy berry, and powdery mildew are the most important leaf diseases of blueberry, a few more cause some damage to foliage. Common names have not been assigned to these minor troubles. One found mostly in southern plantings, caused by the fungus *Gloeocercospora inconspicua* Demaree &

<sup>4</sup>Prepared by A. C. Goheen, agent, Division of Fruit and Nut Crops and Diseases.

Wilcox, does some damage in North Carolina. It shows as very dark brown or almost black spots,  $\frac{1}{4}$  inch in diameter, with indefinite outline on both surfaces of the leaves. Spots may be numerous, resulting in defoliation. The disease is often associated with and mistaken for double spot. The disease has also been seen in Maryland.

A disease, caused by the fungus *Phyllostictina vaccinii* Demaree & Wilcox, has been found on the highbush blueberry in Maryland and in North Carolina and on the rabbiteye species in Mississippi, Georgia, North Carolina, and Maryland. The disease shows on leaves as small, circular spots, grayish in the center and surrounded by a brown ring. Affected bushes are sometimes partially defoliated near the end of summer. The same disease also attacks berries of Black Giant, a rabbiteye variety. On the fruit the disease appears during the pre-ripening period as a hard, dry rot, localized in spots about  $\frac{1}{4}$  inch in diameter that are grayish and sunken and with numerous black pimplelike structures in the center. The spots are conspicuous on the black background of ripe berries. The affected ones must be sorted out before marketing.

### BLUEBERRY INSECTS

The number of insects attacking blueberries is extensive. Only the more important ones attacking cultivated blueberries are discussed.

**Many of the chemicals used for insect control are poisonous to man, or irritating to the human respiratory tract. Persons unskilled in handling these substances should obtain the advice or supervision of experts before attempting to use them. Poisonous materials should be stored and handled with care. They should be kept in tightly closed, plainly labeled containers, in places where they cannot contaminate food or be mistaken for flour or other food material or for medicines and where they will not be accessible to children, pets, or livestock. Adequate measures should be taken for the protection of operators who apply these materials. Proper precautions should be taken that sprays poisonous to consumers are not applied late in the season so that they will remain on the fruit when marketed.**

#### BLUEBERRY MAGGOT

One of the most serious pests of blueberries is the blueberry maggot, or blueberry fruit fly (*Rhagoletis pomonella* (Walsh)). This insect is present on wild blueberries as well as in cultivated fields from New Jersey northward. It feeds on the berries, and the presence of a few infested berries may cause an entire shipment to be condemned as unmarketable. The adult (fig. 26) is somewhat similar to the house fly in shape and about  $\frac{3}{16}$  of an inch long. It has a brown face and shining black body, with white on the sides and rear of the thorax and a white band at the rear of each abdominal segment. The wings are translucent with characteristic black bands. In New Jersey the flies usually emerge between early June and early July. Farther north the flies emerge somewhat later. About 7 to 10 days after emerging the flies lay eggs in ripe or ripening fruit. The eggs hatch in 2 to 5 days, and the larvae mature in about 20 days, at which time

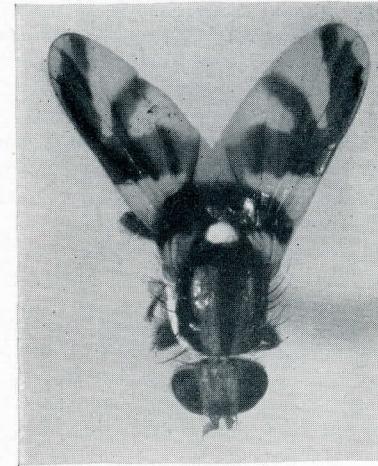


FIGURE 26.—An adult blueberry fruit fly.

they leave the fruit and enter the ground, pupate, and remain dormant until they emerge as flies the next or some following season.

#### Control

Before they lay eggs, the adult flies can be killed by three or four dustings with a 2 percent rotenone dust or with an activated rotenone dust, 15 pounds to the acre. The first application should be made 7 to 10 days after the flies first appear in numbers and repeated at 10-day intervals. In Maine two applications of a 50 percent calcium arsenate, 10 percent monohydrated copper sulfate, and 40 percent hydrated lime dust are recommended at the rate of 6 pounds per acre per application.

#### CRANBERRY FRUITWORM, CHERRY FRUITWORM, AND PLUM CURCULIO

In New Jersey and North Carolina the green fruit of cultivated blueberries is often seriously attacked by the larvae of the cranberry fruitworm (*Mineola vaccinii* (Riley)), the cherry fruitworm (*Grapholitha packardii* (Zeller)), and the plum curculio (*Conotrachelus nenuphar* (Hbst.)). Cranberry fruitworm moths emerge and start to lay eggs in newly set fruit soon after the first blossoms drop. Cherry fruitworm moths appear late in the blooming season and do not lay eggs in large numbers until the bloom is nearly all off. Plum curculio adults appear in the field early in the blooming period. The adults feed and lay eggs during the period when there are large numbers of small green berries on the bushes. As the larvae of the two fruitworms feed in several berries in the cluster before maturing, only a few worms may destroy a large number of berries. Plum curculio grubs feed in one berry only, but they may be so numerous that they destroy as many berries as the fruitworms do.

All three pests are often present in the same field. The larva of the cranberry fruitworm in blueberries is greenish on the underneath and sides and brownish red on the back and is about  $\frac{1}{2}$  inch long

when full grown. The larva of the cherry fruitworm is a uniform reddish-orange color and is about  $\frac{5}{16}$  to  $\frac{3}{8}$  of an inch long when mature. The plum curculio larva is a white, legless grub with light-brown head and is about  $\frac{5}{16}$  of an inch long when full grown. The crop loss caused by these pests is often serious. Moreover, these larvae are present in the fruit of early pickings and so are included in the pack, where they ruin its appearance by crawling around under the cellophane cover or they may be crawling around in the refrigerator after the berries are purchased.

#### Control

Two applications of methoxychlor spray or dust will control all of these insects if the first application is made when the largest berries of early varieties are about  $\frac{1}{4}$  inch in diameter and the second in 7 to 10 days. Apply 3 pounds of 50 percent wettable methoxychlor per 100 gallons of water at the rate of 200 gallons per acre, or dust with 5 percent methoxychlor at the rate of 25 pounds per acre.

#### SHARP-NOSED LEAFHOPPER

Proof that the sharp-nosed leafhopper (*Scaphytopius magdalensis* (Prov.)) is the vector of blueberry stunt disease has placed this insect among the most important of the pests of the cultivated blueberry. Since it spreads the stunt virus from plant to plant, adequate control of this insect is essential if the spread of stunt disease is to be arrested. This leafhopper has two generations a year; the adults of the first generation appear about the close of the blooming period and persist in the field until late July and early August in diminishing number. These adults lay the eggs which produce the second-generation adults that appear in late August and which are present until leaves drop in late fall. Eggs are laid within the leaf tissues. The adults of the insect are cinnamon brown to dark grayish brown and measure about  $\frac{1}{8}$  of an inch in length. The common name "sharp-nosed leafhopper" refers to its acutely angled facial profile.

#### Control

The methoxychlor sprays or dusts recommended for fruitworm and curculio control destroy the first generation of sharp-nosed leafhoppers before they become adults. The second generation can be controlled with two applications of DDT spray or dust. The first summer application should be made about mid-August in New Jersey, or as soon as harvesting is completed, and the second application 3 or 4 weeks later. Use 2 pounds of 50 percent wettable DDT per 100 gallons of water in a spray at the rate of 200 gallons per acre, or dust with 5 percent DDT dust at the rate of 25 pounds per acre. Stunt-diseased plants should be removed promptly as soon as symptoms are noticed, whether or not a leafhopper-control program is followed.

#### CRANBERRY WEEVIL

The cranberry weevil (*Anthonomus musculus* Say) is distributed throughout the United States east of the Rockies where its food plants, which include cranberries, blueberries, and huckleberries, are found.

When uncontrolled, this weevil may reduce the blueberry crop 50 percent or more in New Jersey. The adult is about  $\frac{1}{8}$  of an inch long and has a slightly curved snout about one-third as long as the rest of the body. The wing covers have rows of little pits running lengthwise, and scattered over the body are pits and small white scales that form transverse patches on the wing covers. The general color is dark reddish brown with the legs and abdomen lighter brown.

There is one generation a year. The weevils pass the winter hiding under trash in or around the field, resuming activity as weather warms in the spring. The damage they do is of two kinds. When the early leaf and fruit buds start to swell, the weevils bore into some of them and consume most of the contents. Most leaf buds so injured do not open at all, and the few that do open form only a small rosette of malformed leaves. As soon as the blossoms show white, egg laying begins. An egg is laid in the flower among the anthers. The egg hatches in a few days, and the grub consumes the entire contents of the flower and part of the ovary, leaving a shell that soon drops to the ground. The grub pupates in the flower on the ground.

#### Control

Where the field is kept clean by cultivation, injury is usually confined largely to the edges of the field where the weevils congregate when they leave hibernation from surrounding wild land. Therefore, it is usually necessary to spray only the edges of the field on the side where the infestation is entering. A spray of 10 gallons of liquid lime-sulfur, 4 pounds of lead arsenate, and 90 gallons of water, applied as soon as the weevils show up in numbers on the bushes but before the first leaf stands out from the cluster, controls this insect and Putnam scale.

Sprays or dusts of technical benzene hexachloride may also be used, but applications about 7 days apart from the time blueberry buds start to swell until blossom is opening are necessary to give protection. Spray with 3 pounds of 5 or 6 percent gamma benzene hexachloride per 100 gallons of water at the rate of 150 to 200 gallons per acre, or dust with  $1\frac{1}{2}$  percent gamma benzene hexachloride dust at the rate of 25 pounds per acre.

Burning unused land immediately surrounding the fields in spring before buds begin to swell and when there is least danger to the blueberry plants kills large numbers of hibernating weevils, and this practice together with clean cultivation of the field may keep the infestation so low that sprays or dusts are unnecessary.

#### BLUEBERRY BUDWORM

As the fruits swell in spring, they are sometimes eaten by cutworms of various kinds, especially the blueberry budworm (*Rhyncagrotis anchocelioides* (Gn.)). Elimination of leaves and trash on the field helps to keep down the infestation, and poison bran mash may be used to kill many of the insects. Leaves do not ordinarily accumulate if clean cultivation is practiced.

#### FOREST TENT CATERPILLAR

Occasionally blueberry fields are defoliated by the migrating larvae of the forest tent caterpillar (*Malacosoma disstria* Hbn.). Ditches or

other physical barriers for stopping such migrations are the best means of control. Knocking the worms off the bushes into a pail is also effective but somewhat slow.

#### FALL WEBWORM

A common unsightly pest in the blueberry fields is the so-called fall webworm (*Hyphantria cunea* (Drury)). It actually occurs in both spring and fall. A colony makes a web at the end of a twig enclosing some foliage, which is its first food. After eating all these leaves, the entire colony moves to another limb, spins a new web, and repeats the feeding process. As the webs are easily seen, they are readily removed by hand and the worms destroyed.

#### DATANA WORM

One of the most obvious leaf-feeding worms is the datana worm (*Datana* spp.). It usually feeds in colonies of about a hundred individuals—a large enough group to defoliate a bush entirely if not removed. When disturbed, it has a peculiar habit of raising its head and anal segments as though assuming a fighting position. It can be identified by its dark head and body, yellow "neck," and longitudinal yellow stripes along its body.

#### Control

The most effective control measure is to remove the young colonies by hand. Insecticides, except rotenone, are impractical because of the presence of ripe fruit at the time the insect is feeding.

#### LEAF ROLLERS

Several species of leaf rollers are common, but they are seldom, if ever, injurious on cultivated blueberries. They are held in check by parasites and by insecticidal applications for other pests.

#### BLUEBERRY BUD MITE

Blueberry fields in North Carolina and to a lesser degree in New Jersey are often seriously infested by the blueberry bud mite (*Aceria vaccinii* (Kief.)). These mites are too small, about  $\frac{1}{128}$  of an inch long, to be seen with the naked eye. Under magnification, they are elongate, pearly white, and have four legs near the head end. Mites are present in all stages of development throughout the year. During fall and winter, 50 or more mites may be present between the scales of a single bud. The buds may be destroyed, the flowers may be distorted and fail to set, the berries may only partially develop, or the skin of fully developed berries may be rough. In severe attacks the entire crop may be destroyed, but the damage is sporadic. Red, blistered, misshapen flowers and red, warty, misshapen berries are the first obvious signs of injury (fig. 27). Most commercial varieties are attacked, but serious damage occurs most often on Weymouth, Cabot, Rancocas, Pioneer, June, Scammell, and Harding. No visible damage is usually found on Burlington.

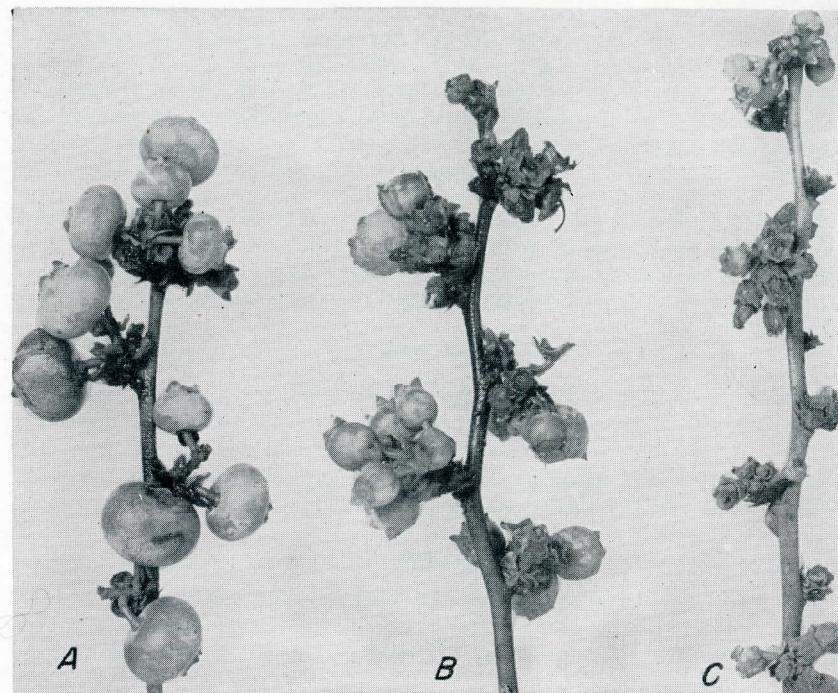


FIGURE 27.—Blueberry mite injury: A, Infested branch with some buds destroyed, but the rest developing normal berries; B, infested branch with some destroyed buds and abnormal or injured berries; C, infested branch on which all buds have been destroyed. The roughening of the surface of buds or berries is characteristic of mite injury.

#### Control

Two applications of a summer oil, diluted to 2 percent actual oil, made in late August and September, control this pest. These oil applications, if desired, may be combined with the fall sharp-nosed leaf-hopper sprays by substituting 2 quarts of 25 percent emulsifiable DDT for the 2 pounds of 50 percent wettable DDT to each 100 gallons of the diluted summer oil spray.

#### SCALE INSECTS

Blueberry bushes are often infested with scale insects, the most common of which is Putnam scale (*Aspidiotus ancyclus* (Putn.)). It occurs in most of the older fields and causes considerable injury. Bushes that are not pruned regularly to remove the old wood are more heavily infested than others. The scale infests chiefly rough wood, where hundreds of individuals occur in the protected spots, often with one scale overlapping another. Such spots may be injured to such an extent as to deform the stem. The scale occurs singly on the new twigs, on the leaves, and sometimes on the fruit. On the fruit it appears as a gray or black spot about  $\frac{1}{16}$  of an inch in diameter. The part under and around the scale grows more slowly than normal and so produces a flat or dented area in the berry.

Several other scale insects have been collected from blueberries, but they do not ordinarily cause serious damage. Among the most common and troublesome of these is the terrapin scale (*Lecanium nigro-fasciatum* Perg.), which secretes large quantities of honeydew, on which develops an unsightly sooty mold that often coats the leaves, berries, and branches.

#### Control

Putnam scale and other blueberry-infesting scales can be controlled with a dormant spray of winter-strength lime-sulfur (1 gallon lime-sulfur to 9 gallons of water), by the lime-sulfur lead arsenate spray for blossom weevil, and by the summer oil applications for blueberry bud mite.

#### STEM GALL

The common insect gall, frequently occurring on occasional blueberry bushes, is caused by the chalcid fly (*Hemadas nubilipennis* (Ashm.)). It may become numerous enough to reduce the fruitfulness of the bush if allowed to reproduce undisturbed. As many as 200 galls have been counted on a single bush.

#### Control

The galls should be cut from the bushes, removed from the field, and destroyed during the winter pruning. The flies emerge and reinfest the plants if the galls are allowed to remain on the ground.

#### STEM BORER

Occasional young stems of the blueberry plant are girdled 3 to 6 inches from the tip during late June or July. Two parallel girdles, or rings of punctures, are cut around the stem about  $\frac{1}{2}$  inch apart, between which an egg is laid under the bark. The grub that hatches from the egg is the stem borer (*Oberea myops* Hald.). It tunnels the stem and, if undisturbed, emerges as an adult after 3 years. The first year it tunnels but a few inches, the second it may reach the base, or crown, of the plant, and the third it may enter another stem from the crown. The adult is a slender beetle usually about  $\frac{5}{8}$  of an inch long, with dark antennae almost as long as the body. The body itself is light brown, and the wing covers are black. The eyes are black and almost surround the base of the antennae.

#### Control

Cutting the wilted tips well below the girdled area during July will keep this pest under control. Any missed at this time may be found during pruning. No tunneled shoot should be left on the bush. The cut pieces may be thrown between the rows, as the borer cannot get back to the bush.

#### CRANBERRY ROOTWORM

The cranberry rootworm (*Rhagoletis picipes* (Oliv.)) feeds as a grub on the roots and as an adult on the leaves of blueberries and related plants. The root-feeding injury is important, whereas the foliage-feeding injury is of minor consequence. When new land is

planted, rootworm grubs that were feeding on the roots of wild host plants concentrate on the blueberry plants and often cause serious injury unless they are controlled. Injury may also become serious at any time in established fields that are mulched or have been allowed to become excessively weedy for several seasons. As indicated by the name, the grub of this insect attacks the roots, eating the bark of the larger roots and completely consuming the fine roots. The injured plant turns yellow and wilts and in extreme cases dies. The beetle measures about  $\frac{1}{4}$  inch in length and is shiny mahogany brown. The grubs are white, with a light-brown head, and when full-grown are about the size of a grain of rice. The beetles are active from mid-June until late July; they feed on blueberry leaves low on the bush on cloudy days and at night, cutting characteristic oblong holes in the leaves. Eggs are laid in the soil while the adults are in the fields. The grub feeds until cold weather in fall and again in spring until pupation in late May.

#### Control

Grubs are not troublesome if areas to be planted are plowed and kept fallow for a full year previous to planting. If, for any reason, the land is not fallowed before planting, rootworm grubs can be killed by disking in 25 pounds of actual DDT or 10 pounds of actual chlordane per acre before planting. In established fields rootworms can be controlled by applying 6 ounces of 5 percent DDT per plant or 2 ounces of 5 percent chlordane per plant and thoroughly working it into the soil within about a 2-foot radius of the base of the plant.

Any of these treatments will control other white grubs that may also be present in the soil of blueberry land.

#### OTHER INSECTS

There are many insects that attack blueberries set out in locations in which these insects are common. Japanese beetle, rose chafer, and European corn borer are but a few of the more common pests in garden plantings. Many commercial plantings are near cranberry lands, and many of the blueberry pests are those attacking cranberries and other related native plants.