The Cultivation of the Highbush Blueberry
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The Cultivation of the Highbush Blueberry

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THE CULTIVATION OF THE HIGHBUSH BLUEBERRY

*Vaccinium corymbosum**

In the wild state, the blueberry is one of our most promising native fruits. Many species are scattered over the North American continent. The blueberry is probably more abundant in Michigan than in any other middle western state, for the southern half of the Lower Peninsula is dotted here and there with swamps containing the highbush blueberry, while a large part of the northern half of the Lower Peninsula and great areas in the Upper Peninsula are covered with the lowbush blueberry.

In the early days, the Indians and white settlers used such quantities of the fruit as were needed, vast amounts going to waste. Later, as the country became more thickly settled, there was a demand for blueberries in various city markets and a profitable business in harvesting and selling wild blueberries was developed. This industry still exists, but on a less extensive basis than 25 years ago. Its present value, in Michigan, is variously estimated at from one-quarter to one-half a million dollars, depending on the crop and market conditions. The decline of this industry can be traced to the fact that better methods of preventing forest fires have resulted in a growth of competing vegetation that has crowded out large areas of lowbush blueberry plants. Furthermore, many blueberry swamps in the southern part of the state have been drained, cleared, and planted to other crops.

A small amount of investigational work was carried on with the blueberry during the last half of the preceding century. The supply of wild fruit was so abundant, however, that there was not much incentive to push the work vigorously. The gradually diminishing supply of wild blueberries in recent years created a greater interest in the possibilities of improving this fruit and growing it under cultivation. In 1908, Dr. F. V. Coville, United States Department of Agriculture, became interested in improving the blueberry, and his work in determining its soil requirements and in breeding and selecting varieties of unusually large size has been of great value in developing the cultivated blueberry industry. Another pioneer in the improvement of the highbush blueberry was Miss Elizabeth White of Whitesbog, New Jersey. She started her work by paying her pickers, who were harvesting wild blueberries, a premium for locating bushes producing very large fruit. A few of these bushes served as the parent stock of several excellent named varieties, one of the most outstanding being Rubel.

Various state experiment stations have taken up the work of improv-

*The plants used in the experiments described in this paper were either V. corymbosum, or, in some instances, possible hybrids of that with some other closely related species.

ing the highbush blueberry. The most extensive work is being carried on in New Jersey, Massachusetts, Washington, and Michigan. Several southern states are working with the southern blueberry, *Vaccinium virgatum*, a species that probably is unsuited to Michigan conditions. *Vaccinium corymbosum*, the principal species of the highbush blueberry grown in the northern states apparently is not adaptable to southern conditions.

The Michigan Experiment Station started investigational work with the blueberry in 1923. Sufficient progress has been made so that several acres of the improved varieties are in bearing in the State, and a large number of growers have made a start in growing blueberries under cultivation. Several nurseries have begun to propagate the improved varieties and they soon will have a considerable number of plants for sale. Michigan probably has more land suited to the cultivation of the highbush blueberry than any other state in the middle west. The land is located near very good markets, and there is every reason to believe that the cultivated blueberry industry should develop as rapidly as plants of the improved varieties are made available.

Lowbush and Highbush Blueberry Areas in Michigan

It has already been mentioned that Michigan has areas suited to both the low and highbush species of blueberries. The line dividing the areas in which these two species are grown is rather distinct. It extends approximately from Bay City, located near the lower end of Saginaw Bay, southwest across the State to a point about 20 miles north of Grand Rapids. As the line approaches Lake Michigan, it turns northwest to some extent, due, probably, to the moderating influence of the lake on the climate. South of this line the highbush species of blueberries are found growing naturally, while north of the line, including the Upper Peninsula, only the lowbush species have been found. There is considerable doubt as to the suitability of the highbush blueberry north of this line. Test plantings have been made in various places in the northern part of the state to obtain information on this point.

Though Michigan has extensive areas suited to both the low and highbush species of blueberries, by far the most investigational work has been done with the highbush species, due to the fact that the highbush type offers the best possibilities commercially. The bushes attain large size, reaching a height of six feet or more, making them easier to handle in all cultural operations. They are more productive, and, as a rule, the fruit is somewhat larger than that of the lowbush species. Investigational work has been started with the lowbush species, but it will be a few years before substantial progress can be reported. The data and the discussion presented in this paper apply to the highbush blueberry, except that in some measure the information given on the preparation of the land, propagation, planting, cultivation, fertilization, harvesting and marketing and insects and diseases could apply to the lowbush blueberry.

Choosing the Location for Blueberry Growing

There are many locations in southern Michigan that are suitable for growing the highbush blueberry. Probably, the most extensive areas are located in the southwestern part of the State, particularly in the western parts of Van Buren, Allegan, and Ottawa counties. The southeastern part of the State, including Lenawee, Monroe, Wayne, and Macomb counties, has a much smaller amount of blueberry land. The central part of the area, including Kalamazoo, Calhoun, Jackson, Barry, Eaton, and Ingham counties, has many good wild blueberry swamps and other land adapted to highbush blueberry culture. Parts of the Thumb District are also adapted to the highbush blueberry. On the whole, nearly all of the counties located in the highbush blueberry area of Michigan have more or less suitable land.

Such factors as good roads, nearness to market, and a population large enough to supply sufficient pickers are always of value in the growing of any small fruit. However, the blueberry will remain on the bushes longer after maturity and will stand shipment better than any of the other small fruits commonly grown. The fruit can be grown, therefore, in situations less favorably located for marketing, although the deliberate selection of such locations is not advised.

Selection of the Site

The early history of blueberry culture is plentifully supplied with instances of failure due to a lack of knowledge concerning the plant's soil requirements. Coville first showed that the blueberry plant is very sensitive to soil conditions and that failure is certain unless the proper soil is selected. His work showed that the blueberry plant requires an acid soil and that plants set on a neutral or alkaline soil make very little growth and many of them die.

In order to demonstrate the necessity of an acid soil for the blueberry plant, an experiment was started in which sand and muck soils of different degrees of acidity were placed in a series of wooden boxes buried in the soil. These boxes were 12 feet long, four feet wide, and two feet deep. They were lined with heavy roofing paper to prevent the passage of soil moisture between the boxes. Three sandy soils were used having pH tests of 6.8, 5.5, and 4.4, and four muck soils having pH tests of 6.8, 5.5, 4.4, and 3.4.* Each box was planted with 12 Rubel plants, all plants being as uniform as possible. Fig. 1 shows the plants as they were after being set and at the end of the second year's growth.

The plants in the very acid sand (pH 4.4) made a very good growth. During the second year, they produced nearly 50 ounces of fruit and in the third year about 203 ounces. The plants in the slightly (pH 6.8) and moderately (pH 5.5) acid sands made a much smaller growth, the foliage being sparse, of abnormal color, and dropping prematurely. Production also was much lower, being eight and five ounces respectively the second year and two and seven ounces the third year.

Of the plants growing in the various muck soils, those growing in the very acid muck (pH 4.4) made the best growth. The growth in the extremely acid muck (pH 3.4) was almost as good. In the slightly (pH 6.8) and moderately (pH 5.5) acid mucks growth was small and the foliage was abnormally colored and dropped prematurely. The

*A soil having a pH test of 7 is considered neutral. Soils testing above pH 7 are alkaline while those testing below are acid. A soil having a pH test of 5 is ten times more acid than one having a pH test of 6, while a soil having a pH test of 4 is 100 times more acid than one having a pH test of 6.

plants growing in the very acid muck produced approximately 100 ounces of fruit the second year and 301 the third while those in the extremely acid muck produced approximately 45 ounces of fruit the second year and 138 the third. The plants growing in the slightly and moderately acid mucks produced one-eighth ounce of fruit in each plot the second year and no fruit and 17 ounces, respectively, the third year.

The average size of the berries was practically the same in all plots.

It might appear from these results that the extremely acid muck (pH 3.4) was too acid. This muck was obtained from an extremely wet place where no vegetation was growing and it was very raw. It

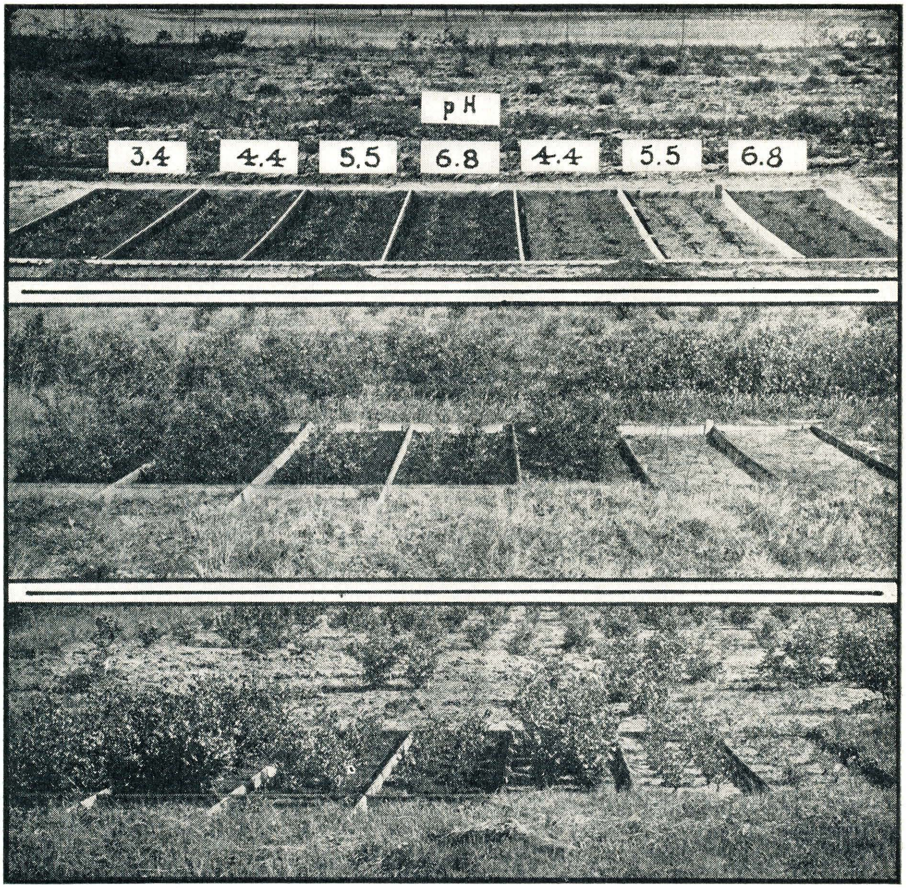

Fig. 1. Rubel plants set in muck and sand soils of various degrees of acidity. Above: Plants soon after setting. Center: Same plants after two year's growth. Below: Same plants after three year's growth. From left to right: Extremely acid, very acid, moderately acid, and slightly acid muck soils (pH 3.4, 4.4, 5.5, and 6.8 respectively); and very acid, moderately acid, and slightly acid sand soils (pH 4.4, 5.5, and 6.8 respectively). The plants in the slightly and moderately acid sand and muck soils are making poor growth, the leaves are abnormally colored, and they drop prematurely.

is possible that the physical condition of this muck was an important factor in the results obtained.

Many inquiries have been received regarding the possibility of acidifying slightly acid or neutral soils by artificial means, thereby making them suitable for growing blueberries. Various materials have been used for this purpose, including leaves, sawdust, apple pomace, rotted wood, and acid peat. Of these materials, acid peat mixed with the soil has given beneficial results in some small garden plantings. Sulphur and aluminum sulphate have also been used. Harmer (2) found benefit from the use of sulphur on blueberries, and Coville (3) has reported success from the use of aluminum sulphate on rhododendrons, azaleas, heather, and other plants related to the blueberry. Though these materials have given good results in small tests, they cannot be recom-

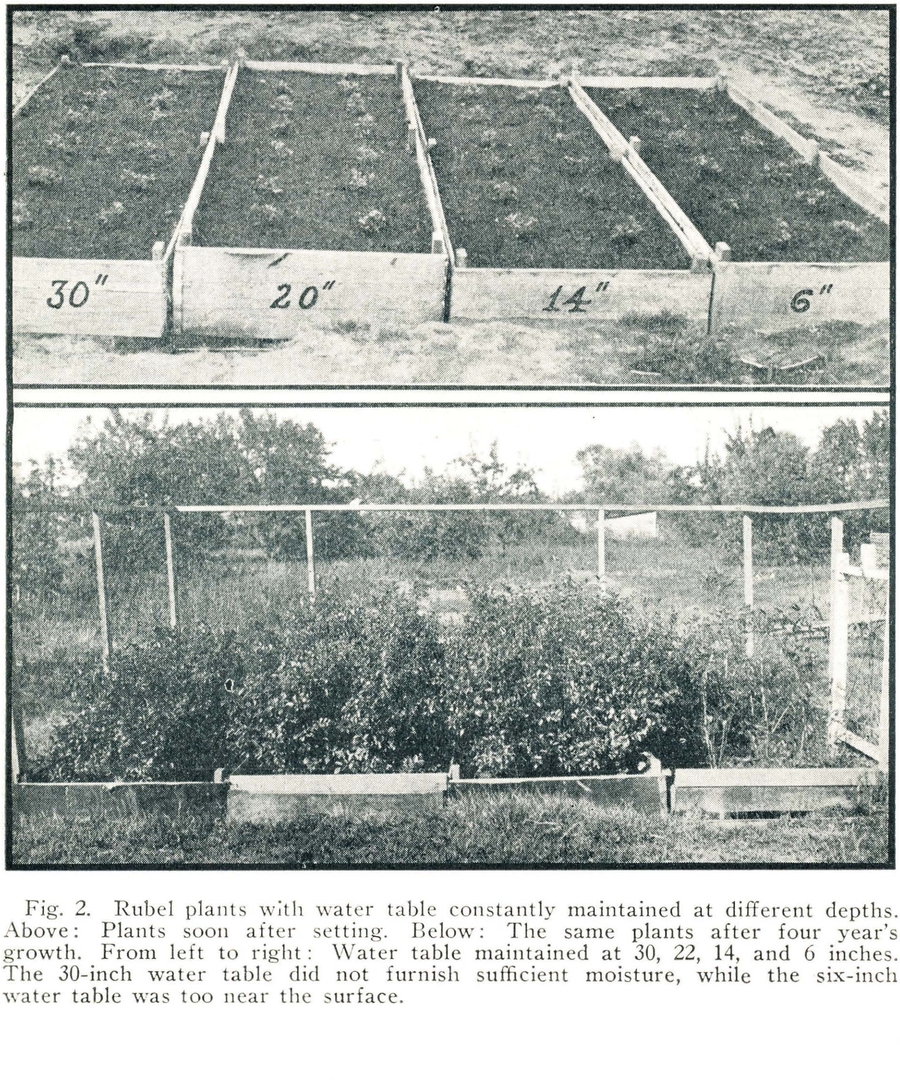

Fig. 2. Rubel plants with water table constantly maintained at different depths. Above: Plants soon after setting. Below: The same plants after four year's growth. From left to right: Water table maintained at 30, 22, 14, and 6 inches. The 30-inch water table did not furnish sufficient moisture, while the six-inch water table was too near the surface.

mended for commercial plantings until they have been more extensively used experimentally. Good blueberry land at low prices is rather abundant in Michigan and it probably would be wise to use naturally suitable land first.

The evidence presented shows clearly that it is extremely important to use a very acid soil for blueberry growing. Results obtained in field and greenhouse tests indicate that blueberry plants grow best on soils having a pH test between 4.4 and 5.1. Though blueberry plants do reasonably well on a soil having a pH test below 4.4, they fail rapidly in growth and production on soils having a pH test above 5.1. In view of the fact that the degree of soil acidity is so important, it would be well for the prospective grower to have a sample of his soil tested by some reliable agency.

The Influence of Soil Moisture

The amount of moisture in the soil is another important factor in the growth and production of the highbush blueberry. In order to determine the importance of the height of the water table in the soil, four large galvanized iron pans, 12 feet long, four feet wide, and six inches deep, were made. These were placed at different levels in the soil, one being six inches from the surface, one 14 inches, one 22 inches, and one 30 inches. Boxes were built of matched lumber from the pans to the surface and these boxes were lined with heavy roofing material. The boxes and pans were then filled with a uniform soil mixture of sand and acid muck. Twelve uniform Rubel plants were planted in each box, as shown in Fig. 2. The pans were kept filled with water at all times. Beginning the year after planting, all plants received equal amounts of complete fertilizer. The differences in growth in the different boxes were apparent at the end of the first year and became increasingly obvious until the end of the experiment after four seasons.

Table 1. Summary of yields from plots in water table experiment. Twelve Rubel plants in each plot. Planted in 1930.

Water Table	Total yields in quarts 1931-1933 inclusive	Average number of berries per quart
6 inch	19.33	1,134
14 inch	45.56	978
22 inch	34.62	1,073
30 inch	11.51	1,114

Table 1 presents a summary of the data obtained in this experiment for the years 1931 to 1933 inclusive. It is obvious that the 14-inch water table gave the best results in total yield and also in size of fruit. It was readily apparent to all observers that the two extremes had been reached in this experiment, the six-inch water table being too high and the 30-inch being too low.

The plants growing where the water table was maintained at six inches made a comparatively small growth, the foliage being sparse,

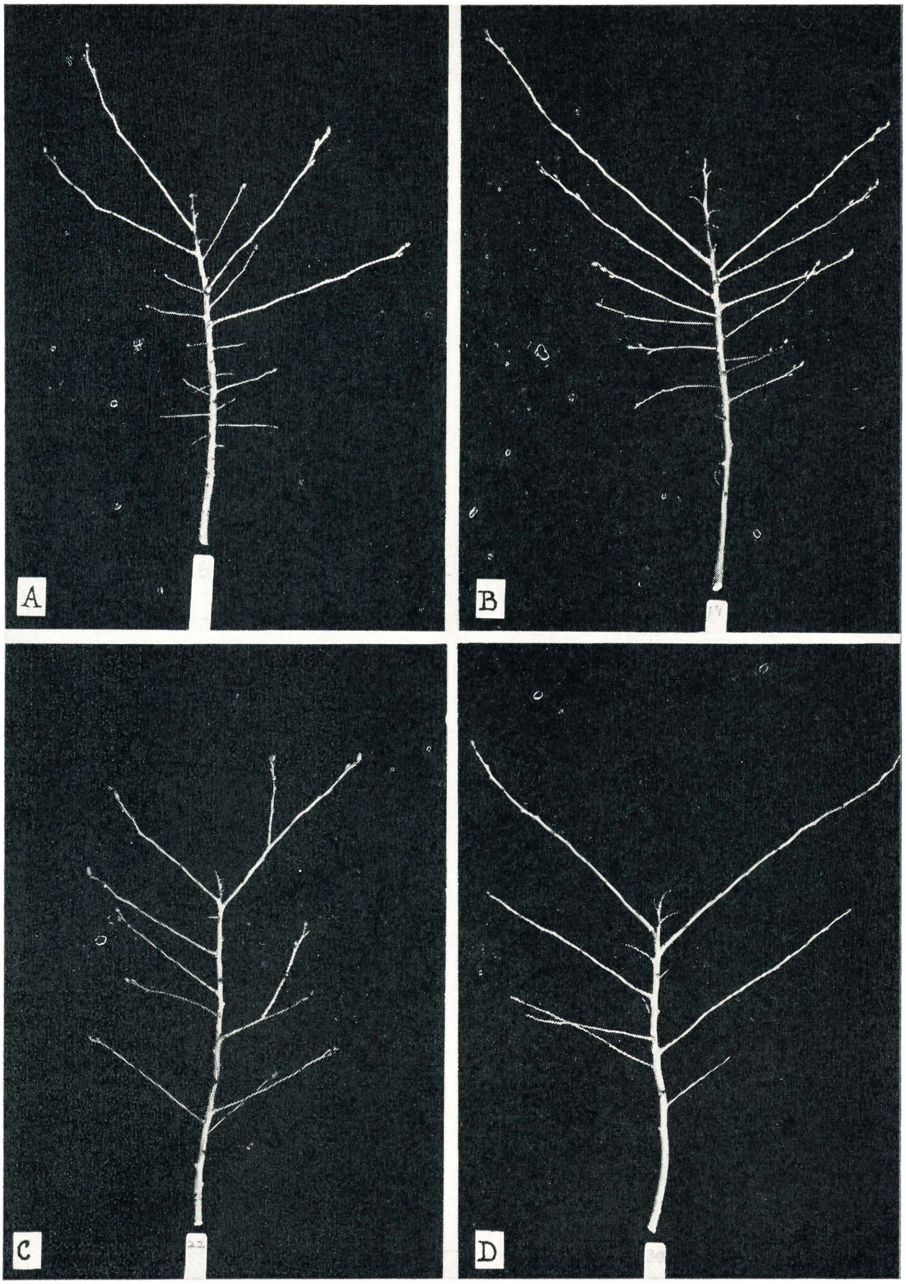

Fig. 3. Typical branches of the same length from plants with water table at: 6 in. (A); 14 in. (B); 22 in. (C); 30 in. (D). Fruit buds limited in A and D; most abundant in B. Ranking in yield: B (highest), C, A, D.

abnormally colored, and dropping prematurely. Where the water table was maintained at 30 inches, the plants made a small growth, although the foliage was almost normal in appearance. Their production, however, was the lowest of any. The plants growing where the water table was maintained at 22 inches appeared normal in every way. In total growth and production, however, this plot was not as good as the 14-inch water table. This experiment indicates that a water table at a depth of about 14 inches in the soil is best. Field tests show that very good results can be obtained where the water table is between 14 and 22 inches, particularly in April, May, and June.

Fruit bud formation was decidedly influenced by the height of the water table in this experiment, as is shown in Fig. 3. It is apparent that a deficiency of moisture retarded fruit bud development. Another

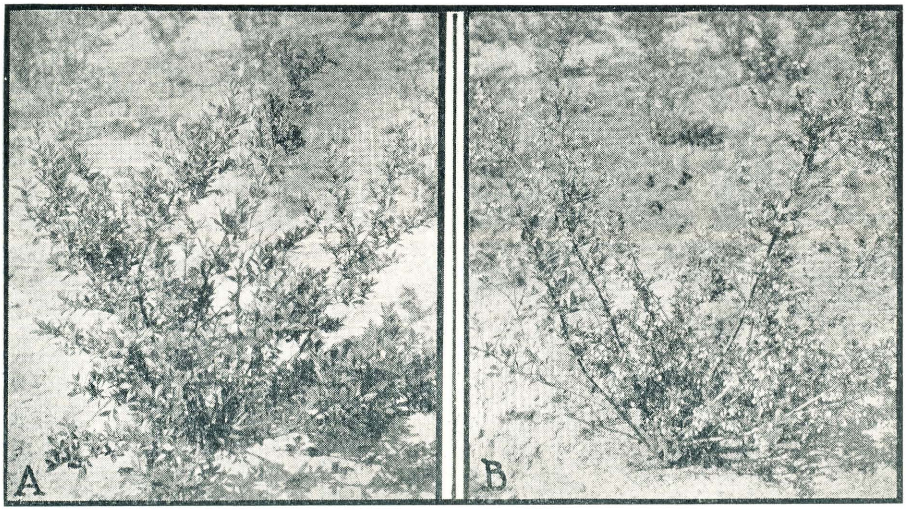

Fig. 4. Four-year-old Rubel bushes in May, 1931. A on knoll where water supply during dry summer of 1930 was insufficient to mature crop and produce fruit buds for 1931. B grew but a few feet from A but had better moisture supply in 1930. Note abundance of blossoms on B, absence on A.

striking example of this condition was observed in the field in 1930, which, according to the official weather records, was the driest year in Michigan between 1931 and 1887 when the records were started in 1887. At South Haven, the total precipitation was 24.75 inches, 9.01 inches below normal. Every month in the year was below normal in precipitation, except April, and this month was only 0.14 inch above normal. In the spring of 1931, it was observed that many blueberry bushes on the higher locations scattered about the plantation were not blossoming, while bushes located on the lower levels where more moisture was available were blossoming normally. Fig. 4 (A) shows a Rubel bush growing on a dry location that had failed to set any fruit buds due to the severe drought of 1930. Fig. 4 (B) shows another Rubel bush only a few feet away that had received sufficient moisture the preceding summer to mature its crop and produce a supply of fruit buds for the coming year.

Another example of the influence of moisture on growth and production is shown in Table 2. By means of gas pipe wells, water table readings were taken in 1933 at two locations in the blueberry plantation from April until the end of the fruiting season in August. The water table at station A was typical of the larger part of the plantation, while station B was located on a knoll in which the water table was considerably lower than at Station A. Yield records were obtained for the plant located closest to each station. These plants were of the

Fig. 5. Six-year-old Rubel bushes, at time of third picking. A: Water table at proper depth; yield 7.5 quarts. B: On slight elevation, water table too low; yield 1.1 quarts, all harvested at this time. Stakes five feet high in both cases.

Rubel variety and in their seventh growing season. The plant at Station A, (Fig. 5), produced 7.5 quarts of fruit, while that at Station B, (Fig. 5), produced 1.1 quarts. It is true that the soil at Station A was somewhat more fertile than at Station B, although both had received like amounts of commercial fertilizer. However, much of the difference in growth and yield must be attributed to the difference in moisture supply.

The readings in Table 2 show a gradual receding of the water table throughout the growing season. This is true every season, although a severe drought during August was experienced in 1933 which lowered the water table considerably. Observations throughout several seasons indicate that it is important to have the water table approximately 14 to 22 inches from the surface throughout April, May, and June for best

Table 2. Average depth in inches of the water table in the soil at stations A and B in 1933 (April-August, inclusive) and yield of seven-year-old Rubel plant at each location.

Station	April	May	June	July	August	Total yield in quarts
A.	14.91	21.14	21.97	34.41	42.66	7.5
B.	27.21	27.11	35.89	41.06	50.16	1.1

results. On such locations, a further proportionate receding of the water table in July and August apparently is not attended with serious results. However, if the water table is much lower than 14 to 22 inches during April, May, and June, the effect on growth and production is likely to be serious.

Instances of blueberry plants dying from a deficiency of moisture have been observed. Fig. 6 shows a portion of Dr. Keefe's blueberry plantation, at Grand Junction, in which some plants have died and others are dying, while thousands in the same field are growing satisfactorily. The unthrifty plants were set on a knoll a few inches higher than the remainder of the field. The plants were set in the spring of 1930, and each year following a few of them died. In 1933, during a severe drought in August, several plants on the knoll dried up completely, while those on the lower land a few feet away were making normal growth.

Blueberry plants are sometimes killed by excess of water. One Michigan grower planted a large number of plants in a pocket or "kettle-hole" and they grew nicely for four years. In the spring of 1929, the lake and river levels rose to unusual heights and water filled the "kettle-hole" until the crowns of the plants were completely covered. It was impossible to drain away the water until late in June and a large portion of the plants were killed. Several growers lost plants in the spring of 1933, due to heavy rains following planting. Care should be used to avoid land that is likely to be flooded during some growing seasons. Moderately wet land can be planted provided the plants are placed on mounds or back furrows.

The experiments described and the examples cited indicate clearly the important part that moisture plays in the culture of the highbush blueberry. The prospective grower should select his land carefully with reference to the conditions that will influence the available moisture in the soil. The owner of a blueberry plantation already in existence may be able to improve his production by properly managing his drainage ditches so as to increase or reduce the amount of water as desired.

Irrigation may also be useful, although no information concerning its value in blueberry growing is available at the present time. For commercial blueberry growing, undoubtedly it would be wise to select land naturally supplied with the proper moisture conditions, rather than to select land deficient in moisture and depend on irrigation. The installing of an irrigation system would be expensive, and failure properly to irrigate the plants for any reason would result in partial or complete crop failures and possibly in the death of the plants. Future investigational work may show that irrigation would be profitable on the best locations during certain years.

The Influence of Soil Texture

In Coville's (1) experiments, blueberry plants did not thrive on a heavy clay soil though Crowley (5) has reported reasonably satisfactory growth on certain clay soils in Washington. Observations on small plantings made in Michigan on clay soils indicate that the blueberry plant does not do well on such soils. The plants remain small, the foliage does not have normal color, and often the plants die outright.

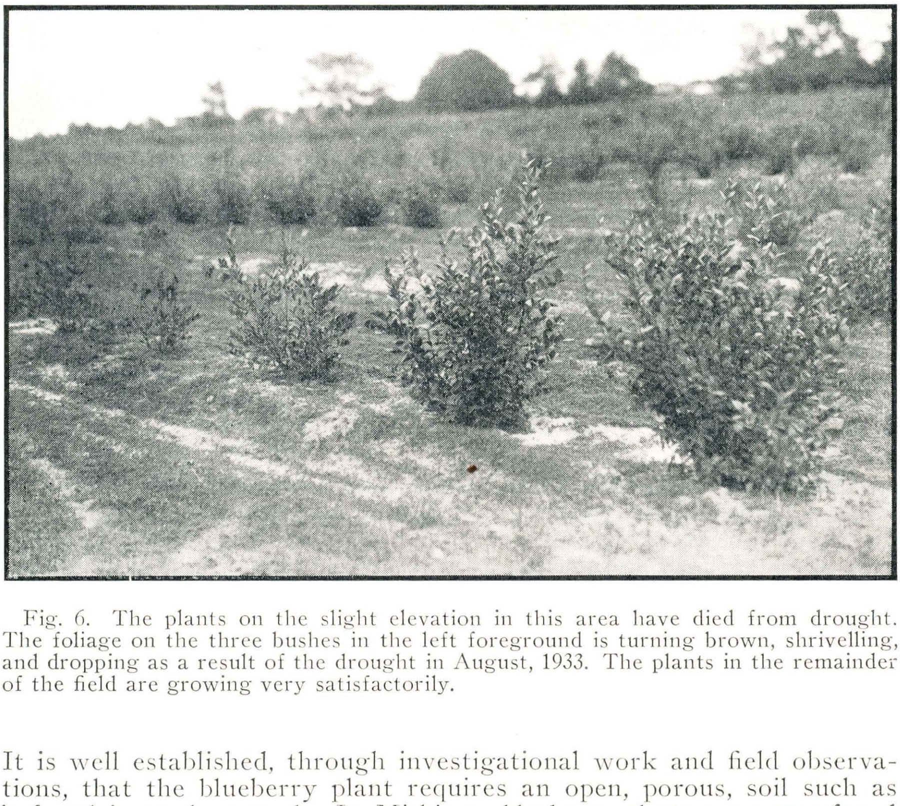

Fig. 6. The plants on the slight elevation in this area have died from drought. The foliage on the three bushes in the left foreground is turning brown, shrivelling, and dropping as a result of the drought in August, 1933. The plants in the remainder of the field are growing very satisfactorily.

It is well established, through investigational work and field observations, that the blueberry plant requires an open, porous, soil such as is found in sand or muck. In Michigan, blueberry plants are never found growing naturally on clay soils and the prospective grower would do well to avoid them.

Injury to Blueberry Plants from Low Temperatures

The highbush blueberry apparently is hardy within the area of southern Michigan in which it grows naturally. Just how far north of this area it can be grown without injury is now being determined by test plantings scattered throughout the rest of the state. The improved varieties that have been tested are apparently hardy with the exception of Cabot, a Coville hybrid, which shows evidence of rather serious winter injury some years. Winter injury is accentuated when the plants do not mature properly in the fall. This condition is likely to occur in small pockets or "kettle-holes" surrounded by trees. The added protection in such places allows the plants to grow too late in the fall, entering the winter in an immature condition. Such locations should be cleared of trees or avoided entirely.

Injury from spring frost is much more common than from severe winter temperature and often seriously reduces the crop in wild highbush blueberry swamps. In certain districts in the southern part of the State, the wild blueberry swamps are located in depressions or "kettle-holes" in the hills. These places are particularly susceptible to frost, for the cold air from a considerable distance around drains into them with no means of outlet. It is not uncommon to lose, entirely or partially, two or three crops out of five in such locations. Large, open areas are not as susceptible to frost as "kettle-holes" and are to be preferred in selecting a site for blueberry growing.

In order to obtain information on the frost hazard in cultivated blueberry plantations, recording thermometers were placed in the experiment station plantation at South Haven and in a plantation at Grand Junction. The former location is only about one-half mile from Lake Michigan, which affords considerable protection against frost, while the latter is 10 miles inland and experiences considerably lower temperatures at blossoming time. Another thermometer was placed in a wild blueberry swamp about a mile from Grand Junction.

Table 3 shows the blooming dates for certain blueberry varieties at Grand Junction in 1931. The blooming dates for South Haven were about two days later.

Table 3. Blooming dates of blueberry varieties at Grand Junction—1931.

Variety	First bloom	Full bloom
Cabot	May 4	May 20
Adams	May 5	May 21
Harding	May 5	May 22
Rubel	May 7	May 26

On May 24, when practically all varieties were in full bloom, the most severe frost of the season occurred. The temperature at the South Haven plantation was 26° F.; at the Grand Junction plantation it was 21° and 23° F. in different locations; and, at the wild swamp nearby, the temperature was 19° F. No damage occurred at South Haven. At the Grand Junction plantation there was apparently no damage in the center of the plantation where the temperature was 23° F. In the north end, which is lower, the temperature was 21° F. Here the Rubel crop was reduced about 12 per cent and the Cabot crop nearly 50 per cent. At the wild blueberry swamp, where the temperature reached 19° F., there was a heavy loss involving over half the crop.

The temperature in the wild swamp was four degrees lower than in the major portion of the Grand Junction plantation and only two degrees lower than in the lowest portion where little damage occurred, except to Cabot. Though such a difference in injury might result easily from only two degrees difference in temperature, it is probable that the differences among these seedling plants were due at least in part to varying degrees of resistance to cold naturally present in each plant. No doubt the selection involved in obtaining some of the named varieties of blueberries has been a factor in their apparently greater resistance to frost.

Serious damage from frost sometimes comes to the blueberry crop after the fruit is set and is one-third to one-half grown. For instance, a severe freeze occurred on June 12, 1933, at Grand Junction when the fruit was about one-third grown. The exposed berries turned a reddish hue the next day, and those that were injured most severely began to shrivel. The damage was not as great in the cultivated plantations as was at first supposed. However, the same frost reduced the crop in some wild highbush swamps throughout the southern part of Michigan and severely injured the lowbush blueberry crop in the northern part of the state.

Besides injury to the fruit, young plants are sometimes seriously injured by low temperatures in the spring. Instances of this type of injury have been observed in three different locations, all of which were depressions or pockets where air drainage was lacking. Due to the protection afforded in such places, temperatures are higher on warm spring days and the plants grow more rapidly than those in more exposed locations. However, temperatures are lower in these depressions on frosty nights. The combination of advanced vegetative growth and lower temperatures often results in serious injury, sometimes actually killing some plants.

Proximity to fairly large bodies of water has been mentioned by Coville (4) as a protection against frost. He states that wild blueberry plants growing near cranberry reservoirs or cranberry bogs which are temporarily flooded to prevent frost or insect injury often escape frost damage at blossoming time. Many owners of wild blueberry swamps in Michigan have stated that they were more certain of a crop if there was some water in the swamp while the blueberries were in bloom and that they feared a loss from frost if the swamp was dry at that time.

Fruit growers, familiar with the damage that would result to peaches, cherries, or other fruit crops from such temperatures as are experienced by the blueberry, might gain the impression that it should be just about frost-proof. The highbush blueberry grows on naturally frosty land, and nature no doubt has provided it with an unusual degree of resistance to frost injury. However, on occasions, frost has taken, and will continue to take, a heavy toll from the blueberry crop of the State, and prospective growers should keep this fact in mind in selecting locations for blueberry growing.

Injury to Blueberry Plants from High Temperatures

Since blueberries have been grown under cultivation in Michigan, a few instances have been observed where young plants have been seriously injured by excessive heat. An outstanding example of this was observed at Dr. Keefe's plantation at Grand Junction. A field of about 11 acres was planted in 1931 and 1932. Along the western edge of this field, there is a large county drain ditch, beside which a dense row of shade trees grow. The land just to the east of the ditch is slightly lower than the surrounding land. The sun shines into this area with great intensity at times during the summer, while the windbreak effectively deflects the prevailing westerly winds. The plants in this area started all right when they were set but in midsummer began to show a decided burning on the tips of the young shoots and on the leaves. Many of the plants in this area died, as shown in Fig. 7 (A). These plants were replaced and the same condition occurred the following year. In the meantime, the plants growing farther east, away from the windbreak grew very satisfactory [Fig. 7 (B)]. In 1933, recording

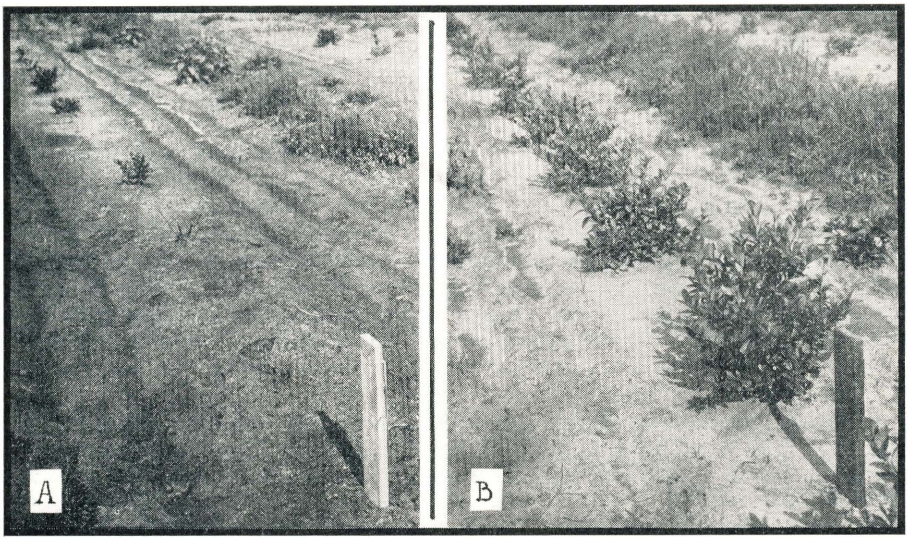

Fig. 7. Effects of high temperature. Maximum temperatures in the sun in 1933: At A, 125° F.; at B, 113° F. These two points were only a few rods apart, the difference in temperature being due to the proximity of A to a windbreak.

thermometers indicated that the temperature in the sun where the plants were dying reached a maximum of 120° F. between July 22 and August 16, and of 125° F. between August 17 and September 21. The maximum temperatures recorded where the plants were growing satisfactorily were 104° F. and 113° F., respectively, for the same periods. Two other instances have been observed of growers setting their plants in small pockets nearly surrounded by trees that prevented the circulation of air. The temperature in these locations became sufficiently high to blister the shoots and leaves of the young plants, and, in a few instances, to kill the plants outright.

It is apparent from these observations and those on frost injury, that pockets or "kettle-holes" are likely to be frosty in the spring and excessively hot in the summer. The use of such places for blueberry growing, therefore, can be considered as decidedly hazardous.

Blueberry roots have no root hairs and consequently the absorptive capacity of the root system is limited. Part of the injury attributed to excessively high temperatures is probably due to the inability of the root system to furnish moisture as fast as it is transpired by the leaves under such conditions.

Propagation

The development of the cultivated blueberry industry has been retarded by the difficulty originally experienced in propagating plants, and also by the scarcity of propagating wood of the improved varieties. Naturally, these two factors resulted in an almost prohibitive price for plants. Sufficient progress has been made in methods of propagation so that any careful person should be able to root blueberry cuttings with a fair degree of success. Propagating wood of the improved varieties is also gradually becoming more plentiful.

In May, 1930, Special Bulletin No. 202, Propagation of the Highbush Blueberry, was published by the Michigan Experiment Station. This bulletin summarized the results of several years of investigational work in blueberry propagation. Since that time, additional experimental work has been carried on with the object in view of further testing some of the observations previously made, and also to ascertain if the equipment already in use could be still further simplified. The work undertaken might be classified as follows:

1. To find out whether lower propagating frames would give as good results as the higher ones, thereby reducing the cost of construction.
2. To determine whether or not glass sash could be eliminated safely.
3. To test further the value of German peat as a rooting medium in comparison with American peat, and with combinations of American peat and sand.

Rooting Cuttings in Box Frames of Different Heights—The data presented in Table 4 show the percentages of rooted hardwood cuttings obtained in propagating frames ranging from 40 to six inches in height having suspended cutting trays and also having the cutting tray placed in the ground. The cuttings were rooted in German peat. These figures show that a somewhat higher percentage of rooted cuttings was obtained in the higher frames. Some additional experiments at Grand Junction, located 10 miles inland from Lake Michigan, showed a slight advantage for the 16-inch frame. The average daily temperature at Grand Junction, during the summer months, is considerably higher than at South Haven. The higher frames expose more surface to the sun and wind, and, in locations similar to Grand Junction, it probably would be somewhat better to use the 16-inch frame. The lower frame also requires less lumber in its construction. However, in locations where high temperatures are not an important factor, the higher frames will give somewhat better results and are more convenient to work around.

Table 4. Percentages of rooted hardwood cuttings obtained in frames of different heights, 1932. German peat used as the rooting medium.

Variety	40-inch frame	30-inch frame	16-inch frame	6-inch frame tray in ground
Rubel	87.5	80.0	72.5	75.0
Pioneer	80.0	72.5	60.0	40.0

NOTE:—Rubel is considered the easiest of the standard varieties to propagate while Pioneer is one of the most difficult.

Good results were obtained regularly with softwood cuttings in the higher propagating frames. Accordingly, in 1933, a comparison was made between a 16-inch frame, a 6-inch frame with the cutting tray set in the ground, and a 6-inch frame without a cutting tray, the peat simply being placed on the ground. The data obtained from this experiment are presented in Table 5. It is evident that the 16-inch frame with the suspended cutting tray gave much better results than either of the other two frames.

Table 5. Percentages of rooted softwood cuttings obtained in box frames of different heights, 1933. German peat used as the rooting medium.

Variety	16-inch frame with suspended tray	6-inch frame with tray in the ground	6-inch frame without tray
Rubel	90.0	23.3	10.0
Adams	100.0	90.0	60.0
Cabot	66.6	73.3	30.0

Previous experiments with an ordinary cold frame gave very unsatisfactory results. Recently, fairly good results have been obtained with a 6-inch box frame having the cutting tray set in the ground. Results were not nearly as good when the cutting tray was not used and the peat simply placed in the soil. Apparently, the cutting tray has some beneficial influence on moisture or aeration conditions. There is also considerable difference between an ordinary cold frame and a shallow 6-inch box frame, for the air space between the cuttings and the glass sash in the former is much greater than in the latter, which possibly is an important factor in the results obtained.

The suspended propagating bed, as used in the 40, 30, and 16-inch frames, offered several advantages over the frames in which the propagating bed was placed on the ground. These are listed as follows:

1. The suspended propagating bed gave a higher percentage of rooted cuttings.
2. The cuttings rooted more quickly in the suspended bed and the root systems were considerably larger at the end of the growing season.

3. The cutting beds on the ground dried out more quickly than the suspended beds and required more careful watering.
4. The cutting trays lasted much longer when suspended than when buried in the ground.
5. The suspended beds were easier to work around than those placed in the ground.

Rooting Cuttings Under Different Covering Materials—The standard covering for blueberry propagating frames has been glass sash covered with a burlap shade. Experiments were undertaken to determine whether or not the glass sash could be eliminated safely. Cuttings were handled under identical conditions, except that part of them were covered with glass sash and burlap, part with a lath shade alone, and part with a close-fitting burlap shade alone.

Table 6. Percentages of rooted hardwood cuttings obtained under different covering materials. 16-inch box frame. German peat used as the rooting medium.

Variety	Glass with burlap shade		Lath shade alone		Burlap shade alone	
	1932	1933	1932	1933	1932	1933
Rubel..........	70.0	95.0	30.0	77.5	65.0	97.5
Pioneer........	65.0	75.0	47.5	55.0	62.5	57.5

The data presented in Table 6 show the percentages of rooted hardwood cuttings obtained under different covering materials. A lath shade alone did not prove satisfactory. The close-fitting burlap shade gave almost as good results as the glass sash and burlap shade.

Table 7. Percentages of rooted softwood cuttings obtained under different covering materials. 16-inch box frame. German peat used as the rooting medium.

Variety	Glass with burlap shade		Lath shade alone		Burlap shade alone	
	1932	1933	1932	1933	1932	1933
Rubel..........	91.1	90.0	68.8	20.0	82.2	53.3
Adams.........	97.7	100.0	17.7	30.0	64.4	46.6
Cabot.........	77.7	66.6	51.1	26.6	55.5	70.0

The data presented in Table 7 show the results of the same tests with softwood cuttings. Again the lath shade alone was unsatisfactory. The close-fitting burlap shade gave fairly good results but was considerably inferior to the combination of glass sash and burlap shade.

Observations made in these experiments indicate that a good percentage of hardwood cuttings can be rooted under a close-fitting burlap shade without the use of a glass sash. However, much better results were obtained with softwood cuttings by the use of the standard combination of glass sash with a burlap shade. To be successful with the burlap shade alone requires very careful attention to watering, for the evaporation of water takes place more rapidly than under the glass sash.

A comparison was also made between ordinary glass sash and glass cloth. In this test, 94.3 per cent of Rubel cuttings rooted under ordinary glass, while 53.3 per cent rooted under glass cloth. The cuttings under the ordinary glass also rooted more quickly and had larger root systems at the end of the growing season. It is likely that the glass cloth is too opaque and did not allow enough light to reach the cuttings.

A Comparison of Different Materials Used as the Rooting Medium— In the original investigations on propagation, it was found that German peat gave better results as a rooting medium than various American peats and combinations of American peat and sand. The German peat is a pure sphagnum moss peat that is free from weed seeds and is nearly sterile. It also holds large quantities of water without becoming water-logged. The American peats used were of a different composition, contained many weed seeds, and tended to become water-logged.

In 1933, a new source of American peat was found that yielded material more nearly approaching the German peat in appearance and texture than any previously available. It was tried in comparison with German peat under identical conditions with the result that 97.6 per cent of Rubel cuttings rooted in the German peat and 52.4 per cent in the American; 66.6 per cent of Adams cuttings rooted in the German peat, and 26.2 per cent in the American. Another mixture of American peat and sand was used in comparison with German peat. In this experiment, 91.7 per cent of Rubel cuttings rooted in the German peat and 46.7 per cent rooted in the mixture of American peat and sand; 74.1 per cent of Pioneer cuttings rooted in the German peat, and 59.1 in the mixture.

These results indicate that German peat is still the best material available for use as a rooting medium for blueberry cuttings. Possibly, a source of satisfactory American peat will be found eventually. In the meantime, the cost of the German peat is not excessive, since enough peat for 500 cuttings costs only about 50 cents.

Building the Propagating Frame—The box frame developed in previous investigations was six feet long, 27 inches wide, and 40 inches high. Results with modifications of this frame which have already been given indicate that a frame 16 inches high may be advisable in regions of high temperatures. The dimensions for length and width also can be changed to accommodate glass sash of various sizes that may be on hand. For instance, storm windows can be used on blueberry propagating frames in the summer. Eight-inch spruce lumber has proved a very satisfactory building material. Pieces 2 x 2 are used for the corners. If the higher frame is used, one board in front is left on hinges to provide for ventilation on unusually hot days. This is not required on the lower frame. The cutting tray is made of 4-inch spruce lumber with one-eighth inch mesh hardware cloth stapled on the under side. The hardware cloth has been superior to wooden bottoms. The cutting tray rests on braces nailed on the inside of the frame eight inches from the top. The cutting tray can be removed without disturbing the cuttings, which facilitates handling and also makes the same frame available for both hardwood and softwood cuttings in the same season. The small space between the end of the cutting tray and the frame can be filled with pieces of burlap or paper. The inside of the box below the cutting tray is lined with tar paper, thus preventing excess ventilation through the cracks and helping to maintain a more uniform temperature. After the cuttings are planted, the glass sash and shade are placed on top, as shown in Fig. 8. If a sash is not used,

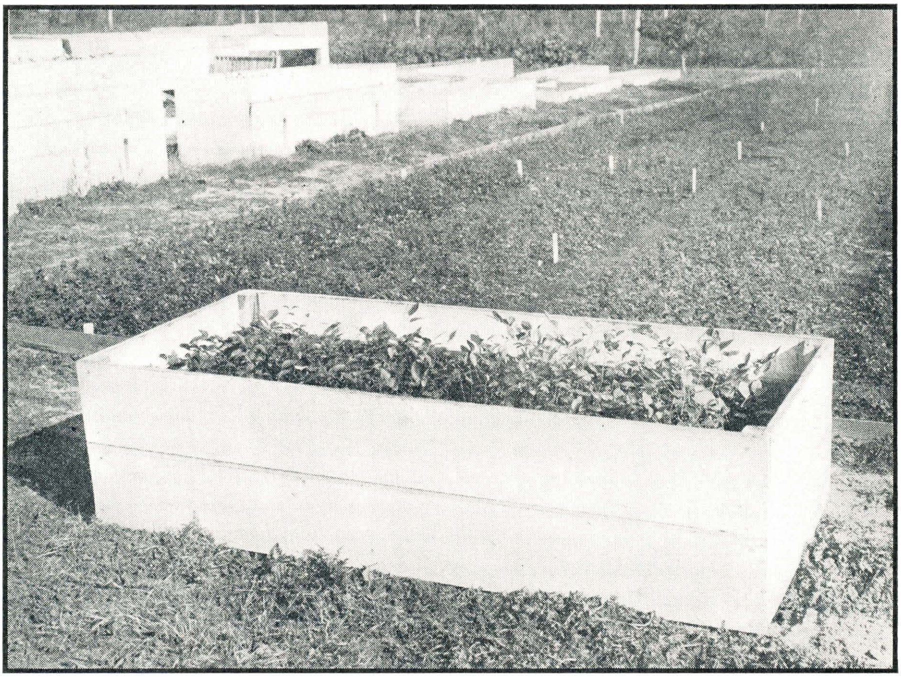

Fig. 8. A low box propagating frame, 16 inches high. In left background the higher box frames.

the burlap shade should fit snugly around the top of the frame to prevent excessive evaporation of moisture. Burlap similar to that used for bran sacks is most desirable as closely woven burlap does not admit enough light. Details of box frame construction are shown in Figs. 8 and 9.

Notes on Making and Handling Cuttings—Two types of cuttings, known as hardwood and softwood, are used in propagating the blueberry. Of these, the hardwood cuttings are more convenient under ordinary circumstances. The cuttings can be made and stored in the winter when the grower is not unusually busy and they can be planted late in March or early in April before the rush of spring work. Softwood cuttings must be made and planted during the harvesting season. Furthermore, the softwood cuttings only become nicely rooted by fall and require two years additional time in the nursery to produce plants large enough for setting in the field. Hardwood cuttings will produce satisfactory plants in two years. Care must be taken in collecting shoots for softwood cuttings not to remove too many as a severe summer pruning is detrimental to most fruit plants. In spite of these objections, softwood cuttings are useful in propagating some varieties that do not root easily from hardwood cutting or in increasing the supply of plants of some new variety as rapidly as possible.

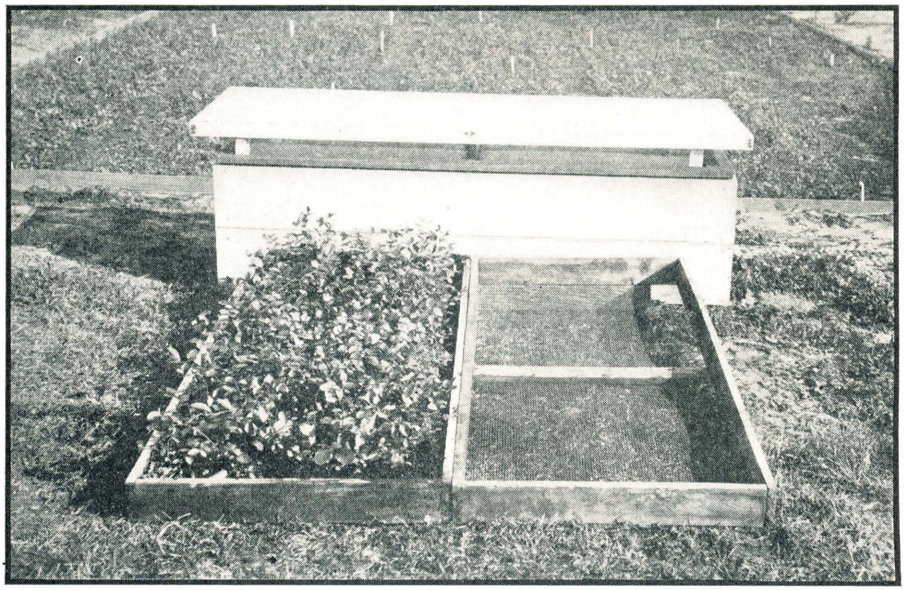

Fig. 9. Low propagating frame with glass sash and burlap shade in place. In front an empty cutting tray and one filled with rooted cuttings. These trays set in the top of the propagating frame (see Fig. 8), and, being movable, provide a very convenient way of handling cuttings prior to planting in nursery.

Hardwood Cuttings—Hardwood cuttings are made from shoots produced the previous season. These cuttings can be made any time during the winter and are stored in moist peat or sphagnum moss, or they can be taken early in the spring before growth starts. Wood showing any winter-injury should be discarded. The upper third of most shoots also is usually discarded, due to the prevalence of fruit buds (Fig. 10). The cuttings are made about four inches in length, the lower cut being made directly below a bud and the upper cut just above another bud. To facilitate handling, cuttings should be bunched with all the butts pointing the same way. Bunches of cuttings can be held together conveniently with rubber bands.

A tray, already described, is placed in the top of the propagating

Fig. 10. Shoot at left shows winter injury; beside it is another shoot showing the extent of the injury. Shoot in center undesirable for cuttings because of the prevalence of fruit buds. Shoot at right illustrates best type of wood for hardwood cuttings. At the extreme right is a hardwood cutting ready for planting.

frame. This tray is filled with German peat that has been thoroughly soaked with water. The peat should not be tamped or packed, simply smoothed off. The cuttings are placed in the peat at an angle. Do not press the peat around them. Plant in rows two inches apart and space the cuttings slightly over an inch apart in the row. Sprinkle thoroughly after the cuttings are in place.

It already has been shown that the best results can be obtained if a grass sash and burlap shade are used over the cuttings. However, a very good percentage of hardwood cuttings can be rooted by the use of a close-fitting burlap shade alone, provided careful attention is given to watering. If a glass sash is used, the burlap shade should be kept on the sash at all times.

The peat should be kept saturated. Any excess water will drain off readily through the wire mesh at the bottom of the tray. Cuttings growing under burlap shade alone will require watering more frequently than those growing under a glass sash. More frequent watering is necessary also in hot weather. Watering is best done in the morning before the propagating frame has become very warm. It is best to use luke warm water on cuttings growing under glass.

If glass sash are used, ventilation should not be given until the cuttings are rooted and then it should be afforded gradually. Of course, if a burlap cover only is used, attention to ventilation is not necessary. If the higher box frame is used, the ventilating board in the side should be opened on extremely hot days.

For best success, propagating frames should be examined every morning, or at least on alternate mornings, to see that the peat is well supplied with moisture, and to remove all cuttings that are dying. This sanitation measure is important, for destructive fungi may spread from the dying cuttings and cause considerable loss. Cuttings that do not appear healthy should be removed when first observed for they will not form roots and they are a menace if left in the propagating beds.

Cutting beds or trays used in the propagating frames should be movable in order that the same frame may be used for a planting of hardwood cuttings, followed by one of softwood cuttings. It is also very convenient to handle the cuttings in trays prior to setting in the nursery. The hardwood cuttings are usually rooted by late June or early July. The tray can then be removed and placed on the ground where it can remain the balance of the summer. Another tray can then be placed in the frame, filled with peat, and used for softwood cuttings.

Hardwood cuttings can be carried through the winter out-of-doors in southwestern Michigan with only a little protection. Sand is usually sifted over the trays, covering the peat and leaving the tops of the cuttings exposed. In more severe climates, it might be advisable to place boards around the outside of the trays and bank soil against them. Lath shades laid over the tops would also help to catch and hold the snow, thereby preventing alternate freezing and thawing.

Softwood Cuttings—Softwood cuttings are made of the current season's growth (Fig. 11). They are best taken when the first secondary growth is appearing on the new shoots. At South Haven, this usually occurs early in July . Cuttings taken earlier are likely to be too succulent, while those taken later do not root as well and may form fruit buds instead of leaf buds in the axils of the leaves. The cuttings should be three to four inches long and the cuts made in the same manner as for hardwood cuttings. All leaves are removed except the upper two and the upper half of each of these is usually removed to facilitate handling and to reduce the transpiration of moisture.

Fig. 11. Secondary growth starting above the last large leaf on shoot at left. This is the stage of growth at which soft wood cuttings should be taken. At the right, a prepared soft wood cutting.

Crowley (5) reported that he had obtained good results with the heel type of softwood cuttings, but poor results with the straight type of cutting. Very good results have been obtained with the straight type of softwood cutting at South Haven. If softwood cuttings were restricted to the heel type, the number obtainable from a blueberry plant would be reduced considerably. Also, heel type cuttings are not as easy to make as the straight type.

The softwood cuttings are planted and handled in the same manner as the hardwood cuttings. They are usually well rooted by late September or early October. The sash and shades should then be removed gradually so that the cuttings will drop their leaves and harden their wood to some extent. For best results, softwood cuttings should be wintered in a cold pit or in a cool, moist cellar. The roots are so fine and are so loosely attached to the cutting that the slightest amount of soil heaving will break them.

The following spring, the tray of softwood cuttings should be removed from the cellar, placed in the ground, and covered with a lath or burlap shade until the cuttings become well established. The cuttings are rather tender when first removed from the cellar and it may be necessary to protect them from frost until they become hardened. Experience has shown that better results will be obtained if the cuttings are allowed to remain in the tray a year before setting. Severe loss has sometimes followed the planting of softwood cuttings in the nursery the spring after rooting.

Tubering—Tubering is a method of propagation devised by Coville (4). Old wood from one-quarter to an inch or more in diameter is used. This wood is cut into pieces about four inches long. These pieces are laid flat in a cutting tray that contains about two and one-half inches of German peat. The pieces are then covered with peat until they are about one inch below the surface. These pieces develop adventitious buds from which shoots are produced. These new shoots develop roots on the portion in the peat. The old piece of wood simply keeps the shoots alive until they become established.

This method of propagation is not as satisfactory as by means of cuttings. It does, however, serve a useful purpose when the plants are old enough to require pruning, as the additional wood removed can be utilized for propagation purposes.

Growing Blueberry Plants in the Nursery—A piece of very good blueberry land should be selected for the nursery so as to insure a good stand of satisfactory plants for setting in permanent locations (Fig. 12). It should be planted as soon as it can be prepared in the spring. The rooted cuttings should be set about six inches apart in rows 18 inches apart. The plants can be cultivated with hand cultivators and hoes. Ordinary clean cultivation is usually all that is required. Cultivation should cease in August so that the plants will have an opportunity to mature properly before winter.

Fig. 12. Blueberry nursery at Dr. Keefe's blueberry plantation at Grand Junction, Michigan. Year after rooting.

Growing Blueberry Seedlings

Blueberry seedlings are of doubtful commercial value due to the variability in the type of fruit produced by individual plants. Seedlings of the improved varieties do, however, produce a rather large percentage of plants which bear fruit superior to the ordinary wild varieties. Available plants of the improved varieties are limited in number and rather high in price. Under these conditions, the use of seedlings of the improved varieties of blueberries might be of value in establishing the plantation until sufficient plants of the improved varieties would be available for future plantings, though the principal use of seedlings is in the selection of new varieties.

If seeds of the blueberry are planted as soon as they are removed from the mature fruit, a large percentage will germinate in five to eight weeks. If the seeds are removed and dried they are likely not to germinate for two years. Very good results have been obtained by removing the seeds from the fruit and planting at once in small trays of German peat. American peat also is apparently satisfactory. The berries should be cut open and the seeds removed on a knife blade and planted on the peat more or less in clusters. After planting, the seeds are covered with a thin layer of fine, sifted peat. The trays are then placed in an ordinary blueberry propagating frame and watered when necessary. Germination starts in a few weeks and the trays are left

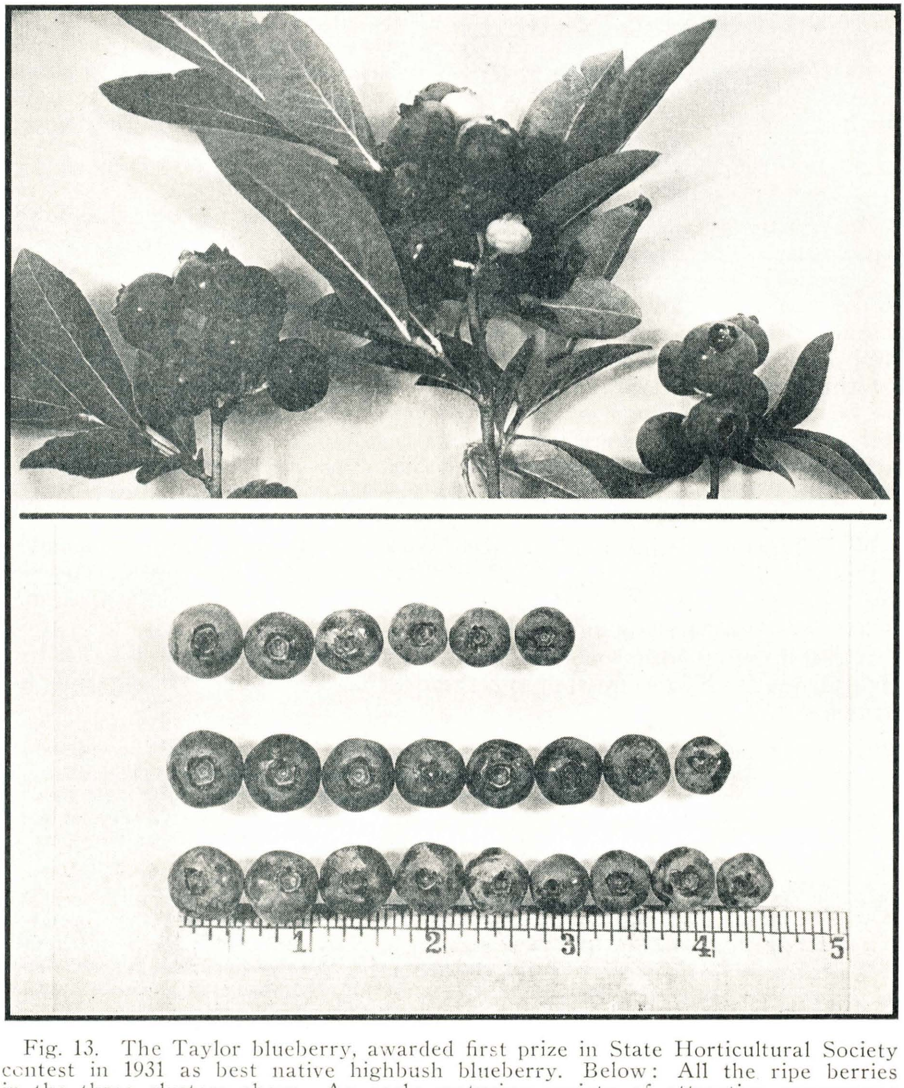

Fig. 13. The Taylor blueberry, awarded first prize in State Horticultural Society contest in 1931 as best native highbush blueberry. Below: All the ripe berries in the three clusters above. An early maturing variety of attractive appearance and excellent quality.

in the frames until early November when they should be removed to a greenhouse where they are left until spring.

The first two leaves appear on the seedlings in the fall and then growth practically ceases until late in February when new leaves appear. It is beneficial if the seedlings can be transplanted into larger trays at this time. A mixture of equal parts of acid peat and acid sand is satisfactory for use in the larger trays. The seedlings should be spaced about one inch apart. About May 1, the trays can be removed from the greenhouse and placed on the ground under shades. As soon as the seedlings are about two inches high they should be transplanted to a prepared nursery bed which has the same soil mixture as used in the larger trays. The seedlings should be shaded with lath or burlap shades until early fall. They can be wintered over in the bed without protection, although a mulch of leaves will prevent soil heaving to some extent. In the spring, they may be large enough to plant in the field but it is often advisable to leave them in the nursery bed another year.

Blueberry Varieties

The improved blueberry varieties being grown in Michigan at the present time are largely those selected by Dr. Coville and Miss White as a result of their work in New Jersey. Selections from wild blueberry swamps in Michigan have been made for several years. A few of these show promise for commercial use and also for breeding work. The Michigan State Horticultural Society has sponsored two contests, one for the best native highbush blueberry of normal season, and one for the best native highbush blueberry of very late season. (Fig. 13.) Several promising plants were located as a result of these contests. Several hundred seedlings developed through breeding work are now in fruiting. Some of these show considerable promise. At present, about 20,000 cross-bred seedlings are in the nursery beds awaiting planting in the field. Efforts are being made in this work to develop varieties that will extend the harvesting season in both directions, surpass the quality of some present varieties, and to surpass the habit of growth of some other varieties now being grown.

The following notes on standard varieties have been compiled after several years of observation on their behavior under Michigan conditions:

Cabot This is the first of the named varieties to ripen, with the exception of June which has not been thoroughly tested in Michigan. The bush is low and spreading. It is somewhat susceptible to frost and winter injury on cold locations. It is rather difficult to propagate from hardwood cuttings but easy from softwood cuttings. The fruit is large, ships well, and is of excellent quality.

Adams Begins to ripen a day or two later than Cabot but has a longer harvesting season. The bush is vigorous, an upright grower, and very productive. It is rather difficult to propagate from hardwood cuttings, but roots very easily from softwood cuttings. The fruit is medium in size, dark blue, fairly good in quality. It can be shipped moderate distances satisfactorily.

Pioneer Matures 10 days to two weeks after Cabot. The bush is spreading, fairly vigorous, hardy and productive. Hardwood cuttings root readily, but poor results are obtained with softwood cuttings. The fruit is large, light blue, firm, ships well and is very good in quality.

Concord Matures about with Pioneer. The bush is upright, vigorous and productive. The fruit is large and of good quality. This is a new variety and not much is known about it yet under Michigan conditions.

Rubel Ripens about two weeks later than Cabot. The bush is upright, very vigorous hardy and productive. It is the easiest of the standard varieties to propagate by means of hardwood cuttings and it also roots fairly well from softwood cuttings. The fruit is medium-large, light blue, very firm and ships well. The quality is fairly good, although somewhat acid. From the standpoint of growth characteristics, this variety is almost ideal. It is unfortunate that the eating quality is not a little better. (Fig. 14.)

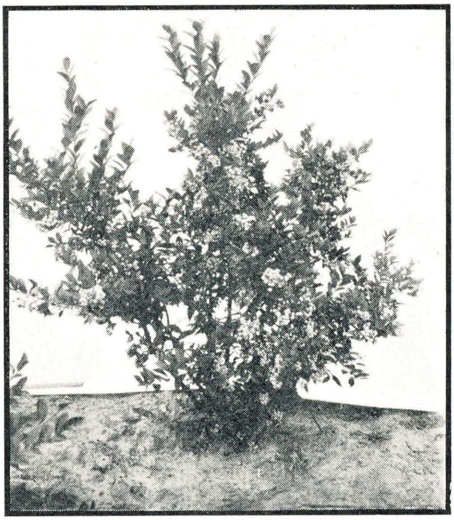

Fig. 14. A six-year-old Rubel bush carrying a full crop.

Rancocas Matures with Rubel. The bush is vigorous, upright, and productive. It roots readily from hardwood cuttings. The fruit is larger than Rubel, light blue, firm, ships well, and the quality is very good. This is a promising new variety and no doubt will be used more extensively as soon as sufficient plants are available.

Jersey Matures about with Rubel or slightly later. The bush is upright, vigorous and productive. The fruit is large, firm and of good quality. This variety is new, but is attracting favorable comment in New Jersey. It appears to have promise in Michigan.

Harding Ripens about with Rubel, although extending the season later to some extent. The bush is spreading, moderately vigorous and very productive. It is not difficult to propagate, although it roots more readily from hardwood than softwood cuttings. The fruit is medium in size, dark, and of excellent quality. The berries are a little soft but will stand shipping moderate distances. This variety has several faults which are offset to some extent by some good features. It probably will be gradually displaced by better varieties.

Three new varieties from New Jersey, June, Stanley, and Scammell, are being tested but not enough information concerning them is available at the present time to justify recommending them for planting in Michigan.

Four old varieties, Sam, Grover, Dunfee, and Katherine, have been tried for several years and have been discarded. They are not recommended for planting in Michigan.

Pollination

Observations on the pollination of highbush blueberry varieties in New Jersey by Coville (4) and also by Beckwith (6), have been interpreted as indicating that varieties of the highbush blueberry are incapable of setting satisfactory crops with their own pollen. Work done at South Haven by Merrill (7) indicates that under Michigan conditions all varieties studied are capable of setting fruit satisfactorily with their own pollen (Table 8).

Table 8. Self pollination as indicated by two methods of testing. (Per cent of flowers maturing fruit.)

Variety	Flowers sacked no hand application	Pollen applied by hand
Rubel	45.1	84.5
Cabot	8.6	80.8
Adams	31.9	81.6
Pioneer	4.9	91.5

The data show that better results were obtained by hand pollination than by simply sacking the flowers without applying the pollen by hand. Merrill also hand-pollinated the blossoms on several Rubel plants growing in the greenhouse with their own pollen and obtained a very good set of fruit. This work was done in late winter when no other blueberries were in bloom and Rubel was the only Blueberry variety in the greenhouse. Careful measurements by Merrill showed that berries resulting from self-pollination were as large in every case as those resulting from cross-pollination. Merrill states, "in view of the fact that in blueberry blossoms the stigmas project considerably beyond the anthers, it seems probable that mechanical disturbances occasioned by the visits of bumble bees and honey bees are important factors in securing a set of fruit, even in self-pollination. Regardless of the importance of insects, however, it seems clear that mixed planting is not essential to, or even helpful in, securing a good set of fruit."

It is interesting to note, also, that a planting of 48 Rubel bushes growing at the South Haven Experiment Station bore heavy crops of fruit for three years with no other blueberry bushes nearer than two miles.

From a practical standpoint, the blueberry grower need not worry greatly about provisions for cross-pollination as he will be planting several varieties maturing at different seasons to provide a continuous supply of fruit for the market. He can plant a greater number of plants of one variety, however, if he wishes, and he can be relieved of the necessity of mixing his varieties to the extent that cultural operations are made more burdensome.

Preparation of the Land and Planting

In many cases, land suitable for blueberries is covered with a dense growth of poplar, pin cherry, soft maple, and other trees and shrubs. Old peat bogs are usually full of stumps and logs. It is expensive to clear such places. It is true that the soil in these places is usually in better condition for blueberry culture than the soil in some cleared fields where the organic matter has been reduced to a great extent through cropping. If the land to be used for blueberry growing is located on the farm of the grower, he will have to do whatever clearing needs to be done; but, if the prospective grower is purchasing the land, the cost of clearing is an item that should receive careful consideration.

Any land should be prepared at least a year in advance of planting; newly cleared land requires a longer preparation for complete control of wild growth. The more thoroughly the land is worked before planting, the easier will be the subsequent care of the plants.

The planting distance recommended for the highbush blueberry is 10 by 4 feet. Though closer spacing between rows has been used, it must be considered that the bushes eventually attain a height of six feet or more and spread proportionately. Provision should be made, also, for the possible necessity of spraying the bushes with power sprayers. The blueberry plant is long-lived, many native bushes being from 50 to 75 years of age. The land on which they are grown is usually inexpensive. When all of these factors are taken into consideration, it seems unwise to plant at distances that may prove too close.

Various methods of marking out the field can be used. Any method that will keep the plants in perfect alignment is satisfactory. One convenient method has been with a check wire for a corn planter, with the links four feet apart. With the two ends of the field marked off with stakes 10 feet apart and in alignment, the wire is stretched the length of the field and moved over one space at a time. The holes can then be dug at the intersections of the links, digging on the same side of the wire each time it is moved. This method is suited to large fields and is much easier than marking with sled or wheel markers. For small plantings, a sled marker would probably be more satisfactory.

The plants should be handled so that they will not dry out during the planting operation. They should ordinarily be set slightly deeper than they had previously grown in the nursery. However, if the land is very wet and likely to be flooded during part of the growing season, the plants should be set on mounds or backfurrows. If this is done and if the soil is worked to the plants to keep them somewhat ridged, they can be grown on land that may flood to some extent during the growing season, while otherwise, they would be very likely to die from excess water.

Cultivation

The clean cultivation and cover crop system is recommended for blueberry culture in Michigan (Fig. 15). Though the crop has been grown without cultivation, especially where some mulching material has been used, better yields and larger fruit will be obtained by good cultivation.

If the blueberry plantation is not very badly infested with weeds and grass, practically all of the horse cultivation can be done with the spring tooth harrow. Some land is too heavily covered with weeds and grass for this simple treatment and the plow or disk must be used. The disk should be used very carefully, if at all, in the blueberry plantation, because the plants are very shallow rooted and disking close to them destroys many roots. Plowing, if necessary, should be shallow and not very near the plants. To keep them slightly mounded, plowing to the plants should be more frequent than plowing away.

After the spring preparation of the soil, the plantation should be cultivated about once every 10 days until picking starts. Cultivation during the picking season is often objectionable as it makes picking conditions more unpleasant and the fruit becomes very dirty from the blowing sand or muck. About three hand hoeings of the plantation are required each season. All cultivation should be shallow on account of the nearness of the roots to the surface.

As soon as the picking season is over, it is desirable that the plantation be cultivated and a cover crop of oats sown. In New Jersey, is is common to cultivate throughout the fall to keep down weeds. This practice might be hazardous in Michigan, where winter temperatures are often more severe than in New Jersey.

Fig. 15. Part of plantation at the South Haven Experiment Station; third growing season.

The Influence of Various Fertilizers

In 1929, a fertilizer experiment involving 2,250 Rubel plants was started at Dr. Keefe's plantation at Grand Junction. The plants were growing on a soil classified as a Saugatuck loamy fine sand; it is a dark-gray loamy fine sand grading into a light gray subsoil. The hardpan layer is not well developed in this particular field as it is in some soils of this type. Though this soil type is rated as a naturally inferior soil, due chiefly to acidity, poor drainage, and, in some places to a hardpan layer in the subsoil, blueberries are very often found growing naturally on it. The future principal use of this soil type in certain parts of Michigan may be for blueberry culture.

The Rubel plants were in alternate rows, the barrier rows consisting a Cabot, Adams, and Harding plants. The rows were 225 plants in length and were divided for purposes of this experiment into three sections of 75 plants each. The fertilizers used were sulphate of ammonia, superphosphate, and a complete fertilizer including these materials and sulphate of potash. Three complete rows were fertilized with sulphate of ammonia, three with complete fertilizer, two with superphosphate, and two were unfertilized and used as checks. The treatments were alternated across the field. The berries from the rows and sections in each row were picked and recorded separately to obtain a complete check on soil variations or other variable factors.

The first fertilizer applications were made in 1929 when the plants had been in the field one year. Subsequent applications were made each year. Table 9 shows the data obtained for 1932 and 1933, when the plants were five and six years old, respectively. Average yields per section are given rather than individual section yields, due to the large number of sections involved. Sulphate of ammonia gave poor results, the plants producing somewhat less fruit than those receiving no fertilizer. The application of sulphate of ammonia was heavier than appears, since it was made in a circle extending only as far as the plants did. Since the plants have not yet reached their maximum size and cover only about one-third of the land, the application was really rather heavy. Very good results followed the use of 335 pounds of superphosphate per acre. Good results also were obtained from the use of a 5-10-12 fertilizer at the rate of 335 pounds per acre.

In 1932, three more treatments were added for the purpose of obtaining data on the use of nitrate of soda, a double amount of superphosphate, and an increase of 50 per cent in the amount of complete fertilizer. The plants used in this experiment were in the same rows as those in the experiment already described. Parts of certain sections already receiving superphosphate now received a double amount; parts of other sections receiving complete fertilizer received a 50 per cent increase in application; while parts of sections receiving sulphate of ammonia were changed to nitrate of soda. Though the number of plants used is smaller, the results are of interest and probably of some value (See Table 10). Nitrate of soda failed to show any greater response than sulphate of ammonia. Doubling the amount of superphosphate (to 670 pounds per acre) resulted in an increased yield of 38.2 per cent in 1932 and 23.4 per cent in 1933. Increasing the amount of complete fertilizer 50 per cent (to 503 pounds per acre) resulted in an increase in yield of 13.4 per cent in 1932 and 29.2 per cent in 1933. Comparing the cost of the additional fertilizer with the value of the increased crop, the increased applications were very profitable.

Consistently satisfactory results were obtained from the use of superphosphate. The plants in the superphosphate plots did not have as green foliage as those in the other plots, the leaves dropped earlier in the fall, and the wood apparently matured earlier. However, the amount of new wood present in these plots at the end of the experiment was conspicuously larger than in any of the other plots.

Though precise evaluations of yield as affected by (1) vegetative growth with consequent differences in number of blossom buds (2) number of blossoms per cluster (3) set of fruit (4) size of berries cannot be attempted on the basis of the records now available, some observations may have significance. The increased vegetative growth on plants receiving superphosphate or complete fertilizer has been conspicuous and great enough clearly to affect the number of blossom buds. In addition, the plants receiving complete fertilizer show an apparent depressing effect of high production in 1933 on vegetative growth during that season which may have some effect on the 1934 crop.

Though complete evidence regarding the use of potash alone is lacking in these experiments, there is some indication that it was of value. In 1933, the application of 503 pounds of complete fertilizer per acre produced the largest quantity of fruit of any treatment (Fig. 16). One-half of this amount of fertilizer, or 251.5 pounds, was superphosphate. Comparing this amount of superphosphate with the 670 pounds used alone, it is evident that another factor besides phosphorous was responsible for the gain. Since nitrogen alone was clearly not beneficial, potash can be considered as being responsible. It is also apparent that the size of the fruit was better on the complete fertilizer plots than on those plots that received superphosphate alone.

Apparently, the forms of nitrogen used were of no value. A Spurway (8) test of this particular soil reveals a possible reason for this. The test showed nitrates present at the rate of 100 pounds or more per acre. This field was cleared many years ago and used for mint, onions, and other truck crops. It was then allowed to remain in sod for about 15 years before being prepared for blueberries. At the time it was plowed, the sod was thick and there was a fairly dense growth of low shrubs that were turned under. The soil was, therefore, well supplied with organic matter. The Spurway test showed also that only six pounds of phosphorous and eight pounds of potassium per acre were present, which might account for the satisfactory results obtained from the use of these two elements.

The fact that no response was made by the plants receiving applications of sulphate of ammonia or nitrate of soda is of interest also in view of the fact that some investigators believe that the blueberry, as well as other members of the Ericaceae family, receives available nitrogen from a mycorrhizal fungus infesting the root system. Coville (1) and Rayner (9) have demonstrated that a mycorrhizal fungus is present in the roots of the blueberry and both considered the relationship between the fungus and the host plant as symbiotic—this is, mutually beneficial.

The investigation of Ternetz (10) with several species of cranberry and heather, plants closely related to the blueberry, led her to believe that the mycorrhizal fungus present in the root systems of these plants had the ability to obtain nitrogen from the air. Coville, though he believed that the fungus might have the ability to obtain nitrogen from the air, thought that the chief supply of nitrogen was obtained through the ability of the fungus to convert the non-available form of nitrogen found in certain kinds of organic matter, such as peat, into a form available for the use of the plant. Other investigators working on the mycorrhizal fungi found in other plants, particularly certain forest trees, have also held the same theory. In return for the available nitrogen, the fungus receives carbohydrates manufactured by the host plant. If this theory is correct, it might account for the lack of response on the part of the plants, fertilized with sulphate of ammonia and nitrate of soda, for the plants in this experiment were growing on a soil well supplied with organic matter. Good results have been obtained by Beckwith and Coville (11) from the use of nitrate of soda on the sandy blueberry soils of New Jersey. However, the blueberry soils of New Jersey, as observed by the writer, do not contain as much organic matter as the soil in which the plants in this experiment are

Fig. 16. Above: Typical plant in a sulphate of ammonia plot; no response to this fertilizer. Below: Typical plant in a complete fertilizer plot. A large part of this response was probably caused by phosphorus. Some response may be attributed to potash.

Table 9. Results of the application of various fertilizers to blueberry plants, five and six years old, growing on a Saugatuck loamy fine sand.

Treatments	1932		1933	
	Average yield in quarts per section of 75 plants	Average number of berries per quart	Average yield in quarts per section of 75 plants	Average number of berries per quart
Sulphate of Ammonia—100 pounds per acre	(9 sections) 127	884	183	951
Superphosphate—335 pounds per acre	(6 sections) 217	1022	243	891
Complete Fertilizer—335 pounds per acre	(9 sections) 246	1012	274	792
Check	(6 sections) 167	968	197	915

NOTE:—The complete fertilizer was home-mixed according to the following formula:
One-fourth—20.56% sulphate of ammonia
One-fourth—48% sulphate of potash
One-half —20% superphosphate

Table 10. Results obtained from the use of nitrate of soda, increased amounts of superphosphate, and sulphate of potash on blueberry plants.

Treatments	1932		1933	
	Average yield in quarts per section of 75 plants	Average number of berries per quart	Average yield in quarts per section of 75 plants	Average number of berries per quart
Nitrate of soda—118 pounds per acre	(3 sections) 132	904	182	845
Superphosphate—670 pounds per acre	(2 sections) 300	1031	300	1012
Complete fertilizer—503 pounds per acre	(3 sections) 279	996	354	900
Check	(2 sections) 179	1002	198	1015

NOTE:—The sections actually included 37 plants but the yields were computed on the basis of 75 plants in order to compare with data given in Table 9. The nitrate of soda contained 16% nitrogen.

growing. Chandler and Mason (12) also have reported good results from the use of sulphate of ammonia on the lowbush blueberry in Maine. This result might be expected on the light sandy soils on which lowbush blueberries commonly grow.

The influence of the various treatments on the size of the berries cannot be considered as of great importance, with the possible exception of the double application of superphosphate. In this instance, there seemed to be a definite tendency to produce smaller berries.

It is true that the data obtained in this experiment apply only to one type of blueberry soil. Many of our native blueberry swamps are on peat soils and many of the new plantings in the State are being made on those soils. Detailed experiments on these soils have not been completed. Very good results have been obtained in a native planting on a peat soil with the use of 250 pounds per acre of the complete fertilizer used in the experiment at Grand Junction.

Based on present knowledge of conditions in Michigan, it is recommended tentatively that a mixture of 350 pounds of superphosphate and 150 pounds of sulphate of potash per acre be used on mature highbush blueberry plantations growing on sandy soils well supplied with organic matter. It is possible that considerably more potash could be used to advantage on peat soils. If the sandy soil is deficient in organic matter, a response might be obtained from the addition of 175 pounds of nitrate of soda per acre. It is believed that nitrate of soda should be used in preference to sulphate of ammonia. The amounts to be used on young plantings should be reduced proportionately.

The Influence of Various Pruning Treatments

The highbush blueberry is naturally very prolific, provided growing conditions are satisfactory. The average plant, after it is well in bearing, develops far more fruit buds than are necessary to produce a crop. If all of these buds are allowed to remain and no frost or other adverse weather condition thins the crop, the plant will produce a large number of small berries. Large size is imperative in fancy blueberries. In the

Table 11. Results obtained from different kinds of pruning of Rubel bushes in their fifth and sixth seasons.

Treatment	1932		1933	
	Average yield in quarts per bush	Average number of berries per quart	Average yield in quarts per bush	Average number of berries per quart
Fine wood removed	2.61	1,015	2.34	775
Fine wood removed and about one-third of old shoots headed back one-third	1.93	885	3.04	875
Fine wood removed and about one-third of old shoots headed back severely	2.07	898	2.18	837
Check—No pruning	3.15	1,384	1.77	762

opinion of Beckwith and Coville (11) based on their experience in New Jersey, pruning is the largest single cultural factor in producing fancy fruit.

The blueberry produces its fruit on the previous season's growth. Observation has indicated that the best fruit is produced on vigorous shoots. Unless some pruning has been done, the new growth becomes very fine and bushy in appearance. This fine wood produces a large number of small berries.

In 1932, a pruning experiment was started on five-year-old Rubel bushes. Four plots of 10 plants each were laid out as follows:

Fig. 17. A. Five-year-old Rubel plant before pruning. B. Same after pruning, which consisted largely of removing the fine wood throughout the plant.

1. The fine wood that had accumulated in the center and around the base of the bush was removed. No heading back was done.
2. The fine wood was removed and one-third of the old shoots were headed back about one-third their length.
3. The fine wood was removed and about one-third of the old shoots were headed back to within a few inches of the ground.
4. This plot was used as a check, no pruning being given.

The data obtained from this experiment are shown in Table 11. During the first year of the experiment, the check plot produced the largest yield. Though the yield was large, the berries were much smaller than on any of the pruned plots. In fact, they were too small to be sold as fancy fruit. In 1933, the check plot produced the lowest yield, due to the fact that the plants had over-produced the previous year and relatively few fruit buds were produced for 1933. Apparently, the pruning given in the third plot, where the fine wood was removed and about one-third of the old shoots were cut back nearly to the ground, was too severe, as the total yield for the two years was somewhat lower than for the other plots. There was less response in new shoot growth from the old shoots that were cut back nearly to the ground than from those cut less severely. The first plot, where the fine wood was removed but no heading back was done, made a good record for the two years. However, due to the fact that no heading back was done the supply of vigorous new wood will gradually decrease each year with this type of pruning. This experiment and other observations indicate that the type of pruning given in the second plot in which the fine wood was removed and part of the oldest shoots headed back moderately each year should maintain satisfactory yields and size of fruit over a long period of years.

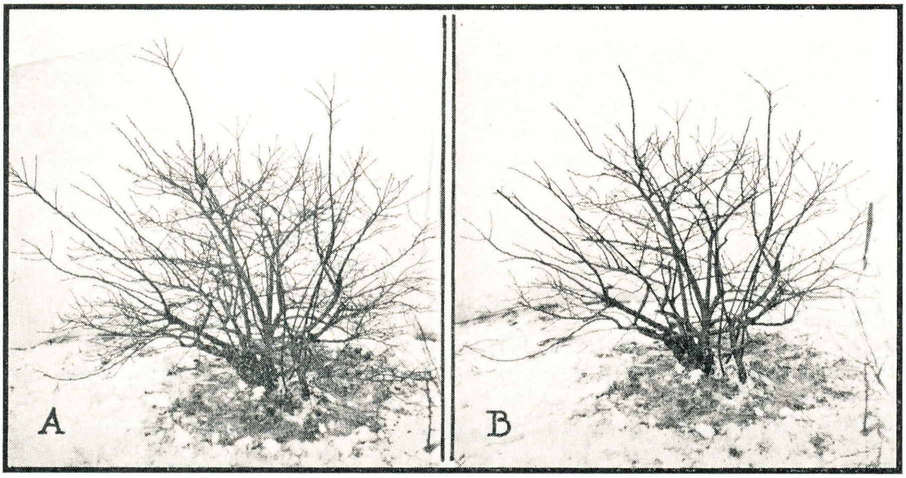

Fig. 18. A. Six-year-old Pioneer bush before pruning. B. Same after pruning. The fine wood and some of the lowest branches have been removed. Pioneer is a spreading type while Rubel grows upright. The spreading type requires more pruning about the base to force growth upward and keep the lower branches out of the soil.

Two types of growth are commonly shown by different blueberry varieties. Rubel, for instance, is a tall, upright growing bush (Fig. 17). Pioneer is a low, spreading bush (Fig. 18). The upright type is much more convenient to care for in almost all cultural operations. An effort should be made while pruning the spreading type of bush to force its growth upward by removing the lowest branches and heading back those that are spreading out too far. These branches should be headed back to side branches that tend to grow up rather than down.

It is unlikely that pruning will be necessary or profitable the first three years after planting. There is little danger of overbearing during this period because the plant is vigorous and not oversupplied with fruit buds. After the third or fourth year, pruning will have to be done systematically and thoroughly if fancy blueberries are to be produced.

Fruit Thinning

Frequently, blueberry bushes set too heavy a crop, particularly if they are not well pruned. It is necessary, then, to thin the crop. This is done with hand pruning shears. It is difficult to tell exactly how much fruit to remove but a reasonable balance between leaves and fruit should be the object of the thinner. The thinner can become overzealous and reduce the crop rather easily.

Harvesting and Marketing

The first berries from the improved varieties of blueberries are usually harvested about July 10 in the vicinity of South Haven. The picking season continues until about August 20. The berries hang on the bushes exceptionally well after maturity, so that it is not necessary to pick as frequently as is required with most small fruits. Picking once each week is usually often enough.

Picking should be done carefully. The picker should remember that he is handling a fancy product and that the consumer expects to receive clean, sound fruit of good quality. Care should be used to pick only ripe berries, fruit still having a reddish hue is very sour. Each picker should have a carrier holding four boxes. He should pick into a small pail holding about two quarts and transfer the berries from the pail to the boxes. Sticks, leaves, and sand can be eliminated in the transferring operation. The picker should also be required to pick each bush cleanly so that no overripe berries will be left for the next picking. See p. 43 for the importance of clean picking in the control of blueberry maggot.

Records show that the average picker will pick from 30 to 40 quarts of cultivated blueberries in a day of about eight hours. The maximum turned in by any picker was 60 quarts in one day. The price paid to pickers varies with the year and the picking conditions. During 1932 and 1933, the average price paid per quart during the height of the season was five cents. As high as 10 cents a quart has been paid for the last picking, when the berries were scarce. Usually, however, the price obtained for these late berries is sufficiently high to justify the extra cost of picking.

The berries should be delivered to a central packing shed where they can be prepared for shipment. The person in charge of the packing shed should keep a careful check on the pickers to make certain that they are bringing in clean fruit. The following method of preparing fruit for shipment has been used successfully at the South Haven Experiment Station.

The American ventilated 16-quart crate has been used. The quart boxes have turned corners to keep berries from slipping out or from being crushed in the corners. The boxes are filled rounding full. A piece of No. 350 plain, transparent cellophane, cut nine inches square, is then placed over the top of the box and forced down around the edges by the use of a square frame that fits over the top rim of the box, something like two embroidery rings which overlap each other. This frame holds the cellophane in place until it is fastened down with a narrow band of sticker tape. A gummed label is then placed in the upper left hand corner of each box. On this label is printed, "Improved

Blueberries, South Haven Experiment Station, South Haven, Michigan". The boxes are then placed in a crate and made ready for shipment (See cover illustration).

Various other types of packages and packs have been tried, including different types of wooden and cardboard crates, cardboard quart boxes, but the buyers have preferred the method of packing described.

Yields and Prices

Records of the improved varieties growing on a very good site show that the following yields were obtained:

Second year	25 quarts per acre
Third year	100 quarts per acre
Fourth year	1,000 quarts per acre
Fifth year	2,000 quarts per acre
Sixth year	3,000 quarts per acre

Blueberries require from eight to 10 years to reach full production. Plantations located on good soil, well protected from frost and properly managed should ultimately yield between three and four thousand quarts per acre. The average yield of a large number of plantations, growing under a wide range of conditions, will naturally be smaller.

The improved varieties have sold in reçent years for an average price of approximately 30 cents per quart, wholesale. This is slightly more than twice as much as wild blueberries sold for at the same time. It must be remembered, however, that only a small quantity of the improved blueberries are being offered for sale at the present time. When production becomes heavier, prices naturally will go down. Even at a somewhat lower price, blueberry culture, under proper conditions, should provide a satisfactory return on the capital and labor invested.

Insects

Phipps (13) reported the collection, by himself and others, of 292 species of insects on the blueberry and huckleberry. A few of these were of economic importance in the lowbush blueberry areas of Maine where most of the collections were made. These included the blueberry maggot, blueberry thrips, certain cutworms, measuring worms, and sawflies. Of these, the blueberry maggot is considered the most serious pest wherever blueberries are grown in the northern United States. This insect has been a serious pest on the blueberry in the eastern states for many years. Though Michigan has had a light infestation for several years, it was not until 1932 that they became plentiful enough in many parts of the State to require serious attention.

Blueberry maggots are the larvae of flies. When infested, berries drop to the ground, the maggots wriggle out, burrow in the soil and remain there until the following year, when the berries are again ripe. At that time, they change to flies again, emerge and lay eggs in the ripe berries for the next generation. The blueberry maggot fly cannot insert its eggs into the fruit until it is fully ripe. As a consequence, overripe fruit is more likely to be infested. Maggots have not been found in cultivated blueberries which are picked as fast as they ripen.

Working in the lowbush blueberry areas of eastern Maine, Lathrop and McAlister (14), United States Department of Agriculture, found that the maggot could be controlled by two applications of calcium arsenate dust applied at the rate of from six to seven pounds per acre, the last application being made two weeks before harvesting. This time limit is variable, however, depending on local rainfall. These recommendations applied only to fruit used for canning where any possible arsenical residue would be removed in washing the fruit prior to canning. Since practically all of Michigan's blueberry crop is sold on fresh fruit markets, the possibility of arsenical residue needs consideration.

In 1933, one bush was dusted once, another twice, and another three times with calcium arsenate. The final application was made nine days before the berries were harvested. The berries from each bush were picked and sent to the chief chemist of the State Department of Agriculture for analysis. Part of the berries were unwashed and part were washed and dried before shipment. The data obtained show that in every case the unwashed fruit had an arsenical residue greater than .010 grains of arsenic trioxide per pound of fruit (Table 12). The washed fruit had an arsenical residue below that tolerance but the shipping and eating qualities of the fruit were much inferior to those of the unwashed fruit.

Table 12. Arsenical residue on Cabot blueberries after dusting with calcium arsenate for blueberry maggot control, 1933.

Number of applications	Pounds of calcium arsenate dust used per acre	Grains of arsenic trioxide present before washing	Grains of arsenic trioxide present after washing
One	6.7	.013	.004
Two	17.4	.014	.004
Three	28.9	.016	.009

(Analysis made by W. C. Geagley chief chemist, Michigan State Department of Agriculture.)

At the present time, the use of calcium arsenate dust for the control of the blueberry maggot cannot be recommended in Michigan for the following reasons.

1. Most Michigan blueberries are picked from wild areas that are not suited to the application of spraying and dusting materials. This is particularly true of the highbush blueberry swamps, many of which are almost impassable.
2. It is necessary to make the dust applications so near the harvesting season that the fruit is likely to be confiscated for having excess arsenic.
3. The amount of calcium arsenate dust per acre recommended for each application is so small, six to seven pounds, that there is a great possibility of too heavy applications on some bushes.
4. Washing the fruit apparently impairs both its shipping and eating qualities.

Previous mention has been made of the fact that the blueberry maggot fly cannot insert its eggs into the fruit until the fruit is fully ripe. This fact offers an excellent opportunity to combat this pest by careful picking and sorting. This method of control has been used successfully in the cultivated blueberry fields of New Jersey. The following suggestions for avoiding maggots are made.

1. Pick fruit by hand as cleanly and as often as practicable. Such picking methods as the use of blueberry rakes and batting the berries off the bushes are based on allowing as many berries to ripen as possible before harvesting. These methods should be discontinued, otherwise infested fruit will almost certainly be harvested.
2. Systematic picking of all blueberry areas is highly desirable. Often wild blueberry areas are picked at such infrequent intervals that overripe berries are likely to be included.
3. The berries should be sorted carefully before packing. All overripe and misshapen berries should be removed. Bury deeply or burn all soft berries sorted out.

Owners of highbush blueberry swamps will find it profitable to clean out competing brush and trees, prune the blueberry bushes, and open paths or roads. Besides making conditions much more suitable for clean and thorough picking, a decided increase in yield and quality of fruit will be obtained.

Cutworms have been reported by Phipps (13) as destructive to the lowbush blueberries of Maine in certain years. They are not known to have caused any damage in the cultivated plantations or wild highbush blueberry swamps in Michigan. Cutworms have caused some damage early in the spring to rooted cuttings still in trays that were placed on the ground over winter. They have been easily controlled, however, by the use of poisoned bran-bait. The bait is sown around the cuttings in the evening. One application is usually sufficient, although an additional application is sometimes necessary. The formula for the bran-bait follows.

20 pounds wheat bran
1 pound white arsenic
½ gallon cheap molasses
2 ounces amyl acetate of good grade (banana oil)
Water to moisten

The arsenic and molasses can be dissolved in five or six gallons of water. Stir thoroughly into the bran and add enough water to make the bran sufficiently sticky so that it will stay in small lumps when sown. Add the banana oil just before using. Evening is the best time to apply the bait.

Diseases

Though a few diseases of minor importance have been reported on the blueberry, only one has been of any importance in Michigan. Crown-gall, which attacks a large number of different kinds of plants, including many important fruit plants, has caused the loss of a few plants each year in the cultivated blueberry plantations of the State.

The disease usually does not appear until the plants are from two to five years old. Its presence is first indicated by the premature discoloration of the foliage in the summer. Healthy plants normally have dark-green foliage at this time, while the diseased plants have foliage of a reddish hue. As the disease becomes worse, the leaves become a yellowish-brown, and some defoliation occurs. Digging around the crown of the plant will usually reveal the galls. The only control for this disease is the prompt removal and destruction of all infected plants. Crown-gall can become very serious in the blueberry plantation if the removal of infected plants is delayed or neglected.

At least two new diseases have been discovered recently on blueberries. Just how serious these will become remains to be seen. Though the blueberry plant is comparatively free from serious diseases at the present time, the prospective grower should not get the impression that this condition will always exist. The history of other fruits brought from the wild to a cultivated state shows that eventually serious diseases have been encountered. This may be true of the blueberry.

The Maintenance of Wild Blueberry Plantations

Scattered over the southern part of Michigan are many wild highbush blueberry swamps. The value of the fruit produced in these places amounts to many thousands of dollars each year. Almost invariably however, the plants have been allowed to shift for themselves. The removal of competing trees and shrubs, pruning, or the application of fertilizers apparently have never been considered to any extent. In order to test the value of some of these cultural practices in wild blueberry plantations, some cooperative experiments were conducted in the Charles DeHaven plantation near Bangor.

The plants in the DeHaven plantation are growing on raw muck or peat. The plants taken from ordinary wild stock were planted between 30 and 40 years ago. They have made a reasonably uniform growth. A few years after planting, competing vegetation such as soft maple and pin cherry was allowed to grow and in 1929, when the experiment was started, the soft maples and pin cherries were very large and in some instances had caused the death of many blueberry plants. (Figs. 19 and 20.) Five experimental plots laid out in this plantation were treated as follows:

Plot A.	(324 plants)	No treatment.
Plot B.	(315 plants)	Removal of competing trees and shrubs.
Plot C.	(330 plants)	Removal of competing trees and shrubs plus a moderate thinning out type of pruning.
Plot D.	(431 plants)	Removal of competing trees and shrubs plus a heavy dehorning type of pruning.
Plot E.	(428 plants)	Removal of competing trees and shrubs plus the application of 250 pounds per acre of a complete fertilizer.

The plots were laid out and records taken on them for two years, 1929 and 1930, before the treatments were started. This was done to make certain that the check plot could be compared fairly with the

Fig. 19. Pin cherry and soft maple trees taking possession of a wild blueberry swamp. Unless these are removed, the blueberry plants will die. Compare with Fig. 20.

Fig. 20. Wild blueberry plants killed by the competition of pin cherry and soft maple. At one time thrifty blueberry plants grew where only stumps remain.

Fig. 21. Wild blueberry plants after receiving a thinning out type of pruning, which increased yields to some extent besides greatly improving picking conditions. These plants were planted in rows about 30 years ago. The plants were of native wild stock selected at random, and, a few years after planting, were allowed to grow wild.

other plots. This precaution was taken due to the variability of the wild plant material.

The treatments were started in the spring of 1931 and continued through 1933. The total average yield per plant in the check plot during this three year period was 5.22 quarts. The soft maples and pin cherries became so plentiful and large during the time of the experiment that the plants were suffering severely from the competition.

The total average yield per plant in Plot B was 6.01 quarts, or an increase of .79 quarts over the check plot. Since there were about 1089 plants per acre in this plantation, this increase in yield would amount to 860.31 quarts per acre. Assuming an average price for wild blueberries during this period of 15 cents per quart, the total value of this increase in yield for the three-year period would be $129.04. Figuring labor at 30 cents an hour, the cost of clearing an acre similar to Plot B was $26.14, leaving a net profit of $102.90 per acre for the three year period over the check plot.

The total average yield per plant in Plot C was 6.52 quarts, an increase of 1.30 over the check plot. (Fig. 21.) On an acreage basis, this would amount to an increase of 1,415.70 quarts, valued at $212.35. The cost of removing the competing vegetation, pruning the blueberry bushes, and removing the prunings from an acre such as Plot C would be $58.80, leaving a net profit for this treatment, above the check, of $153.55.

The plants in Plot D, which received the dehorning type of pruning, produced a total average yield per plant of 1.7 quarts, a reduction of 3.52 quarts below the check. (Fig. 22.) On an acreage basis, the total loss in quarts per acre in this plot would be 3,833.28, valued at $574.99. To this loss in crop would also have to be added the cost of the dehorning pruning which amounted to $55.54 an acre. The total loss, therefore, due to this dehorning type of pruning for the three-year period of the experiment would be $630.53 per acre.

The total average yield per plant in Plot E was 8.21 quarts, an increase of 2.99 above the check. On an acreage basis, this would amount to an increase of 3,256.11 quarts for the three-year period valued at $488.42. The fertilizer was a 5-10-12 analysis and was applied yearly at the rate of 250 pounds per acre. The cost of the fertilizer for the three years plus the cost of removing the competing vegetation was $41.14, leaving a net profit for this treatment over the check of $447.28.

Counts made at each picking on the number of berries per quart showed that the differences were not significant for any of the treatments. This corroborates other observations that wild blueberries show but slight increases in size due to ordinary cultural treatments. The increased yield obtained through pruning, cultivation, and the use of fertilizer usually offsets any increase in the size of the fruit. Fruit thinning, provided the bush is overbearing, will increase size to some extent.

The following conclusions can be drawn from this experiment: First, that the removal of competing trees and shrubs was beneficial. Second, that a moderate thinning out type of pruning was also beneficial, but that a heavy dehorning type of pruning reduced yields greatly. Third, that the application of a complete fertilizer was very profitable. It might even appear that the removal of competing vegetation and the use of fertilizer alone need be used and that pruning is unnecessary. Moderate pruning is necessary, however, to remove dead wood, the oldest wood, branches that are close to the ground, and those that are too high. Pruning also makes clean picking much easier, thus aiding in the control of the blueberry maggot. There can be little doubt but that owners of wild blueberry plantations will find it profitable to put these practices into effect.

Fig. 22. In foreground, wild blueberry plants that received a dehorning type of pruning. This was entirely too severe, greatly reducing yields.

Summary

The blueberry is one of our most promising native fruits. An abundance of wild fruit, however, delayed the growing of blueberries under cultivation for many years. Since the supply of wild blueberries is no longer adequate to meet the demand, considerable interest in growing blueberries under cultivation has developed in recent years.

The early investigations of Dr. F. V. Coville, United States Department of Agriculture, regarding the soil requirements of the blueberry and his work in developing varieties with fruit of large size were of great importance in developing the cultivated blueberry industry. Another early pioneer in this work was Miss Elizabeth White of Whitesbog, N. J. Some of the important varieties now being grown were selected by Miss White.

Michigan probably has more land suited to the culture of the highbush blueberry than any other state in the middle west. The southern part of the Lower Peninsula has many areas suited to the growing of the highbush blueberry, while the remainder of the State has large areas of wild lowbush blueberries.

In selecting a location for growing the highbush blueberry, care should be used to keep within the areas that are known to be suitable. Markets, transportation facilities, and population sufficient to furnish pickers are also important factors to be considered.

The blueberry plant is very exacting with regard to its soil requirements. The soil must be very acid, well supplied with moisture, and of the proper texture. Sand or muck soil or a mixture of the two are preferable. Clay soils are unsatisfactory. If the soil is not sufficiently acid, plants make very poor growth and many of them die. A water table from 14 to 22 inches below the soil surface has been found most satisfactory. Insufficient moisture in the soil will result in lack of production and, in severe cases, in the death of the plants. Blueberry plants also can be stunted in growth or killed by excess water during the growing season.

The improved blueberry varieties, with the possible exception of Cabot, are apparently free from serious winter injury in the highbush blueberry areas of southern Michigan. Frost frequently causes loss to the blueberry crop. Large, open areas that provide some movement of air are preferred to pockets or "kettle-holes". Proximity to fairly large bodies of water also affords some protection against frost.

Young blueberry plants are sometimes injured or killed by very high temperatures. Plants in pockets or in places well protected from prevailing winds are most susceptible to this type of injury.

At one time, the blueberry plant was considered very difficult to propagate. Good results have been obtained with both hardwood and softwood cuttings in box frames. German peat has given better results as a propagating medium than any other material. Glass sash and burlap shades over the cuttings gave the best results, but fairly good results, particularly with hardwood cuttings, have been obtained with a close-fitting burlap shade alone. Lath shade alone was unsatisfactory. The use of glass cloth as a substitute for glass was also unsatisfactory.

Most of the improved blueberry varieties being grown in Michigan are those developed and selected by Dr. Coville and Miss White. Valuable native seedlings have been discovered in Michigan and breeding and selection work are now being done. The principal varieties now grown include Cabot, Adams, Pioneer, Rubel, Rancocas, Harding, Concord and Jersey. Scammell, June and Stanley are promising new varieties.

All of the standard varieties tested by Merrill at the South Haven Experiment Station were found to be self-fertile. Insects, particularly bumble bees and to some extent honey bees, play an important part in transferring pollen. Interplanting to ensure cross pollination is not necessary.

Wild blueberry land is usually expensive to clear, although the organic matter has not been depleted. This type of land should be prepared for two years before planting. One year is sufficient for land that has previously been cleared.

The plants should be set 10 by 4 feet. The highbush blueberry attains great size and lives 75 years or longer. Too close planting distances, therefore, should not be used.

Cultivation should be frequent enough to keep down weeds. It should also be shallow, for the blueberry plant is very shallow rooted. As soon as the picking season is over, a cover crop of oats should be sown.

Experiments on a sandy soil with sulphate of ammonia, nitrate of soda, superphosphate, and sulphate of potash showed no response from the use of sulphate of ammonia or nitrate of soda, and very good response from superphosphate. Evidence is not conclusive as to the value of potash but points to possible benefits.

Beginning about the fourth year, blueberry bushes should receive a moderate pruning. The old fine wood should be removed and about one-third of the old shoots should be headed back to some extent each year. A continuous supply of vigorous new wood is necessary if fancy blueberries are to be produced.

Blueberries should be picked frequently enough to prevent any of the berries from becoming overripe. Also, only well-colored berries should be picked as immature berries are very acid. The improved blueberry is a fancy product and should be picked and handled accordingly.

In marketing, good results have been obtained by covering each quart box with cellophane held in place by sticker tape. A gummed label placed on each box designates the product and where it was produced.

Highbush blueberry plants will bear a few berries the year after planting. Plants growing on a good soil, well protected from frost, and properly cared for, produced 100 quarts per acre the third year, 1,000 quarts the fourth, 2,000 quarts the fifth, and 3,000 quarts the sixth year. Maximum production under good conditions will probably be from three to four thousand quarts per acre. Eight to 10 years are required to attain maximum production.

Prices for blueberries, like other fruit crops, vary from year to year. The improved blueberry sold for an average price of approximately 30 cents per quart wholesale in 1932 and 1933, or approximately twice as much as wild blueberries brought at the same time. The production of the improved varieties of blueberries in Michigan is still very small, and as the production becomes greater, the price may be expected to decline.

The blueberry maggot is the most serious insect pest attacking the blueberry. Dusting or spraying are not recommended for berries that are to be sold on the fresh fruit market. The blueberry maggot fly lays its eggs only in overripe fruit, and it has been demonstrated that this pest can be controlled by frequent and thorough picking and careful sorting of the berries to remove all misshapen and overripe specimens.

Crown-gall is the most serious disease of blueberries in Michigan. Plants attacked by this disease can be detected in midsummer by the abnormal coloring of the foliage. Digging around the crown of the plant will usually disclose the galls. Infected plants should be removed promptly and destroyed.

Investigations on methods of improving wild blueberry swamps showed that the removal of competing trees and shrubs, a moderate pruning, and the application of a complete fertilizer were all profitable. A heavy, dehorning type of pruning caused a heavy reduction in yield.

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