THE PROPAGATION OF THE HIGHBUSH BLUEBERRY

THESIS FOR THE DEGREE OF M. S.

Stanley Johnston

1930

The Propagation of the Highbush Blueberry

Thesis

Submitted to the Graduate Faculty of the Michigan
State College of Agriculture and Applied
Science in partial fulfillment
of the requirements for
the degree of Master
of Science

by

Stanley Johnston

1930

Approved June 5, 1930
V. R. Gardner

THESIS

The Propagation of the Highbush Blueberry

V. Corymbosum

Stanley Johnston

The highbush blueberry, Vaccinium corymbosum, has for many years been recognized as a native fruit of great possibilities. Its introduction into cultivation and its improvement have been retarded by three factors: an adequate supply of berries from the wild area, lack of knowledge concerning the plant's soil requirements, and the difficulty of propagation. At present, however, the crop from the wild areas does not supply the demand. More accurate information concerning the soil requirements of the blueberry plant has been made available through the investigations of Coville[1]. Though considerable information has been published concerning methods of propagation, the highbush blueberry is still considered so difficult to propagate that the price of plants remains too high to permit rapid development of a cultivated blueberry industry.

Review of Literature

The early investigators of blueberry propagation worked largely with seedlings and experienced considerable difficulty in germinating and growing them. Dawson[2] of the Arnold Arboretum was one of the first to grow seedlings successfully. He was successful also in layering shoots but does not report any investigations in rooting cuttings. At about the same time, Sargent, also of

the Arnold Arboretum, succeeded in growing seedlings. Munson[3] reported in 1901 growing seedlings successfully but does not mention work with cuttings. Card[4] apparently carried on the first extensive studies in rooting blueberry cuttings. His investigations extended from 1898 to 1903 inclusive. Hardwood cuttings were tried in the greenhouse bench without success. Root cuttings were tried in a greenhouse bench and also in trenches in a garden. Root-grafts also were used. Sand and a combination of sand and moss were used as rooting media, the latter proving more satisfactory. In March, 1903, Card concluded that root cuttings and root grafts offered fairly successful means of propagation. In 1921, Coville[5] described several methods used in propagating the highbush blueberry without presenting data on the percentages of rooting obtained with the different methods. Beckwith and S. Coville[6] reported in 1927 that the difficulty in propagating plants has held back the more rapid development of the blueberry industry. They gave general recommendations on methods of handling hardwood cuttings. No data were presented on any investigational work. Crowley[7] in 1928 reported successful use of the tubering method of propagation in the state of Washington, although no data were given. Mowry and Camp[8] in the same year gave general directions for the handling of cuttings of the southern blueberry, Vaccinium virgatum. Hildreth[9] reported in 1929 that the lowbush blueberry could be rooted successfully by rhizomes. No data were presented on investigations with

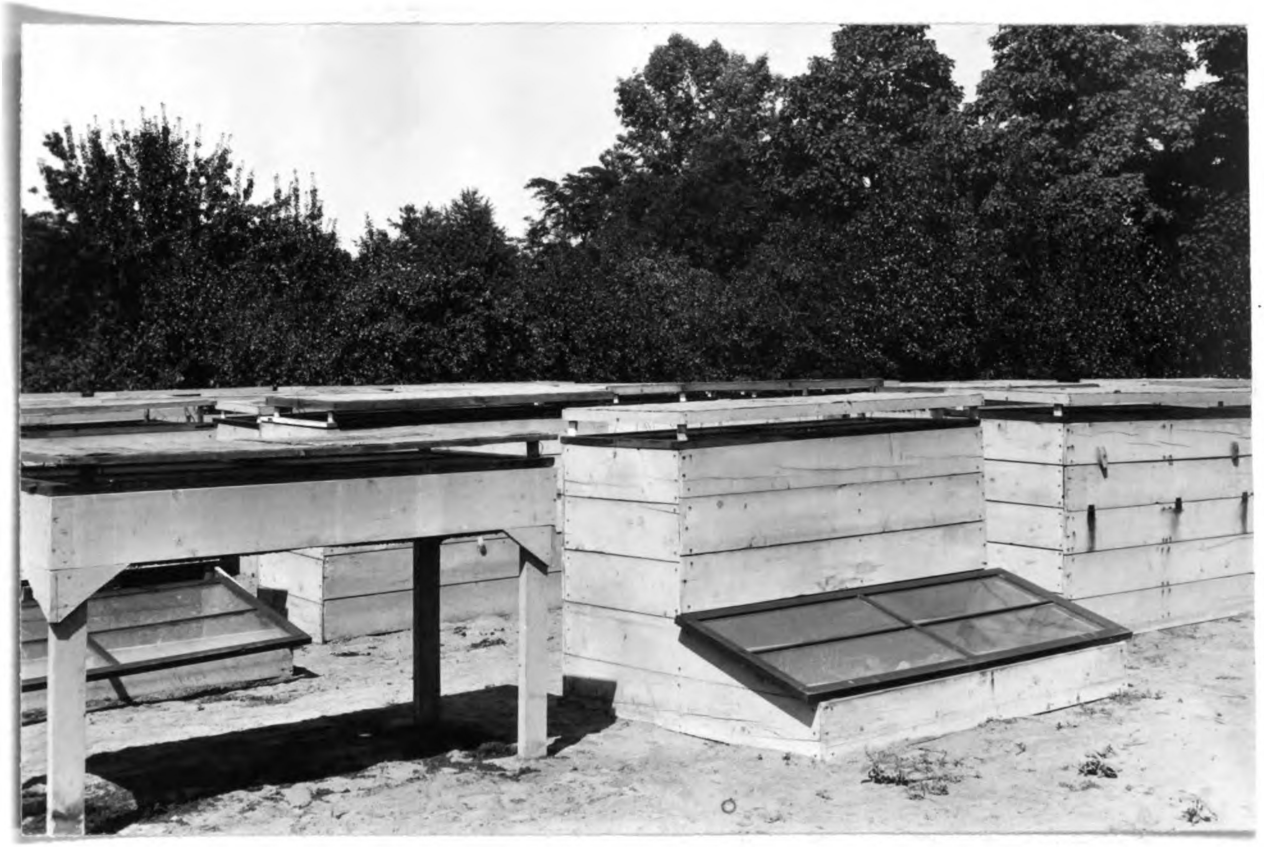

Fig.1.- The propagating frame in the center is the solar frame, at the right is the box frame, and at the left the open frame. Note the lower sash on the solar frame. This must be opened on hot clear days. The box frame has one board on hinges so that the frame can be ventilated on extremely hot days.

the highbush blueberry.

Various Methods of Propagating the Highbush Blueberry.

Of all the methods described for propagating the blueberry, the rooting of cuttings, either hardwood or softwood, if feasible, is the most logical and economical way of producing large numbers of plants without seriously disturbing the parent plant. However, plants propagated from cuttings have been available for the trade only in a very limited quantity. Division has been tried and is still used as a method of propagating the blueberry. The old plants are dug and split into pieces, each piece has a portion of stem and a few roots. A large portion of the blueberry plants now sold by nurseries are either obtained by division or are nursery-grown seedlings. Seedlings, however, are of limited value except in the quest for new varieties, as they do not reproduce the original variety. Budding and grafting are of little value, because the bush sends forth a number of new shoots from the crown each year. Though Card[4] reported some success with root cuttings, Coville[5] had little success with them. He found that most of the pieces that rooted were not true root cuttings, but were really stem-base cuttings. Since the root system of the blueberry is fine and very much branched, the taking of root cuttings of sufficient size would result in a very severe root pruning. Stumping requires cutting down the plant, mounding the crown, and rooting the new

shoots as they push through the soil. Mound layering is an attempt to root the old and new shoots at the base without resorting to pruning as in stumping. Both of these forms of layering are successful but they are slow and result in the diversion of either all or part of the plant from fruit bearing. Tubering, a method described by Coville, requires old wood from one-quarter to an inch or more in diameter. It is difficult to get a large amount of such wood without heavily pruning the parent plant. Due to the objections to other methods of propagation, the data presented in this paper are largely on investigations in rooting hardwood and softwood cuttings, with the exception of some brief comments on attempts to use root cuttings in the greenhouse and on germinating and growing blueberry seedlings.

Investigations on Rooting Cuttings in the Greenhouse

During the winter of 1926, and to a lesser extent in 1928 and 1929 rather extensive trials were made with different methods of rooting hardwood cuttings and root cuttings of the highbush blueberry* in the greenhouse. Though the results were almost entirely negative, a brief outline of the work is presented to show the scope of the investigation.

A. Hardwood cuttings.

a. With bottom heat. House temperature 60° - 70°F.
   1. Ordinary 4 inch cuttings.
   2. Heel cuttings.
   3. Mallet cuttings.

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

b. Without bottom heat.

1. Same three treatments as listed above under a.
2. Sucrose 2% for three days before planting.
3. " 2% " one week before planting.
4. Potassium permanganate .01 mol. sol. 36 hrs. before planting.
5. Boric acid .001 mol. sol. 36 hrs. before planting.
6. Mono-potassium phosphate .002 mol. sol. 36 hrs. before planting.
7. Phosphoric acid 2 cc in 1000 cc then to sucrose 2% 48 hrs. before planting.
8. pH 3* solution for 5 days prior to planting.
9. " 4* " " " " " "
10. " 5* " " " " " "
11. " 6* " " " " " "
12. " 7* " " " " " "
13. " 8* " " " " " "
14. Half of the above mentioned cuttings in various pH solutions were not planted but left continuously in the solutions.
15. Carbon dioxide treatment of cuttings for one week prior to planting.

c. Special treatments with peat extracts.

1. Cuttings left continuously in raw peat extract.
2. " " " " bacterized peat extract.
3. Cuttings in sand watered with raw peat extract.
4. " " " " " bacterized peat extract.

B. Root cuttings.

a. With bottom heat. House temperature 60 to 70°F.
   1. Root cuttings scarified in various ways.
   2. " " split at the butts.
   3. Without treatment.
b. Without bottom heat
   1. Above treatments repeated
c. Same chemical treatments as with hardwood cuttings.

C. Tubering

a. With bottom heat. House temperature 60° to 70°F.
   1. Two and three-year wood placed horizontally and covered with about an inch of soil.
   2. Cuttings of one-year wood treated as under 1.
b. Without bottom heat.
   1. Repeated as under a.

*These solutions were tap water to which was added enough dilute sodium hydroxide or hydrochloric acid daily to maintain the desired reaction.

Fig. 2.- A general view of part of the propagating frames used for rooting blueberry cuttings at the South Haven Experiment Station.

The cuttings used in the greenhouse experiments in 1926 were taken from wild plants of V. corymbosum, which in subsequent years produced a high percentage of rooting in solar frames. There is nothing to indicate that cuttings taken from wild plants, barring slight individual differences, are more difficult to root than cuttings taken from the cultivated varieties. Fifty cuttings were used in each treatment; they were kept in muslin shade and watered when necessary. The rooting medium was a mixture of half sand and half American peat. No significant differences could be noticed in 1926 as a result of any of the treatments.

Later investigations with various types of propagating frames out-of-doors showed that German peat was a very satisfactory rooting medium. Accordingly, in the winter of 1928, seventy-five cuttings were placed in a greenhouse bench with German peat as the rooting medium. Twelve per cent of these cuttings rooted, which was a higher percentage than had been obtained by any of the treatments in 1926.

It is possible that the season at which the cuttings were taken and set in the propagating benches was responsible for the unsatisfactory results obtained in the greenhouse experiments, but it is also possible that the answer to the question might rest in the methods used. At any rate, the question cannot be answered with the data available.

Investigations With Different Types of Propagating Frames in the Open

The cuttings used in the various investigations with different types of propagating frames out of doors at South Haven were all taken from plants of the improved varieties, including Rubel, Pioneer, Cabot, and Adams. The hardwood cuttings were taken during the first week of April and the softwood cuttings were taken early in July, the exact date depending upon the season. German peat was the rooting medium used. All of the frames received, as nearly as possible, the same care.

The cold frame has been used for many years for rooting cuttings of different kinds of trees and shrubs. Several investigators and propagators have used it in propagating the blueberry. In these investigations the cold frame was used for five years with unsatisfactory results. The percentage of rooted hardwood cuttings varied from 5 to 15, depending upon the rooting medium used and the season. Less than one per cent of softwood cuttings were rooted in the cold frame.

The solar frame (Fig. 1) was developed by U. S. Department of Agriculture investigators, for rooting cuttings of citrus and other subtropical plants. It was probably used first for blueberry cuttings, by F. V. Coville and E. May, Jr. It has also been used to some extent by Joseph White & Company of Whitesbog, New Jersey. In these investigations, the solar frame was first used in 1927, with good results. In 1928 and 1929, this type

Fig. 3.- Softwood cuttings rooted in American peat, German peat, and sand. The two at the left were rooted in American peat; the two in the center in German peat, and the two at the right in sand.

of frame was used much more extensively and high percentages of rooted cuttings were obtained.

The solar frame operates on the principle of receiving bottom heat from sunlight. Of course the heat varies in its intensity and amount. On clear, hot days it is necessary to open the lower sash to avoid excessively high temperature in the cutting bed. This frame allows very good aeration of the rooting medium.

The box frame (Fig. 1), as far as is know, is an original type of frame which was first constructed to test the value of the bottom heat derived from sunlight by the solar frame. It was found that this type of frame gave excellent results in propagating both hardwood and softwood cuttings. The box frame has two important advantages over the solar frame; first, it does not require as constant attention on hot days; second, it is about 50 per cent cheaper in construction.

The box frames used in these experiments were six feet in length, 27 inches in width, and 40 inches in height. However, these dimensions are not arbitrary, they can be changed to accommodate glass sash of various sizes that may be on hand. Storm windows can be used on blueberry frames during the summer. The 40 inch height is a convenient one for taking care of the cuttings without too much stooping. Eight inch spruce lumber has proved to be a very satisfactory building material. 2 x 2 pieces are used for the corners. One board in front is left on hinges to provide for ventilation on unusually hot days. The cutting tray

of frame was used much more extensively and high percentages of rooted cuttings were obtained.

The solar frame operates on the principle of receiving bottom heat from sunlight. Of course the heat varies in its intensity and amount. On clear, hot days it is necessary to open the lower sash to avoid excessively high temperature in the cutting bed. This frame allows very good aeration of the rooting medium.

The box frame (Fig. 1), as far as is know, is an original type of frame which was first constructed to test the value of the bottom heat derived from sunlight by the solar frame. It was found that this type of frame gave excellent results in propagating both hardwood and softwood cuttings. The box frame has two important advantages over the solar frame; first, it does not require as constant attention on hot days; second, it is about 50 per cent cheaper in construction.

The box frames used in these experiments were six feet in length, 27 inches in width, and 40 inches in height. However, these dimensions are not arbitrary, they can be changed to accommodate glass sash of various sizes that may be on hand. Storm windows can be used on blueberry frames during the summer. The 40 inch height is a convenient one for taking care of the cuttings without too much stooping. Eight inch spruce lumber has proved to be a very satisfactory building material. 2 x 2 pieces are used for the corners. One board in front is left on hinges to provide for ventilation on unusually hot days. The cutting tray

is made of four-inch spruce lumber with eighth-inch 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 below the top. The cutting tray can be removed so that the same frame can be used for both hardwood and softwood cuttings. The small space between the end of the cutting tray and the frame can be filled with pieces of burlap or paper while the frame is in use. The inside of the box below the cutting tray is lined with tar paper which prevents excess ventilation through the cracks and helps to maintain a more uniform temperature. After the cuttings are planted, the glass sash and shade are placed on top, as shown in Fig. 2. Details of box frame construction are shown in Figure 10.

The open frame (Fig. 1) was constructed in an effort to find a satisfactory propagating frame even simpler and less expensive than the box frame. It has been used only one year, Although the results obtained with it were much better than those with the cold frame, it did not prove as satisfactory as the box or solar frames.

Table 1 shows the results obtained in rooting hardwood cuttings of Pioneer and Cabot in the several types of frames.

Table 1. Rooting hardwood cuttings in different types of frames. (1929) (German peat used as the rooting medium)

	Pioneer		Cabot	
	Number cuttings	Per cent rooted	Number cuttings	Per cent rooted
Cold frame	20	25	20	20
Solar frame	59	89.8	45	84.4
Box frame	119	89.9	70	78.5
Open frame	112	69.6	72	70.8

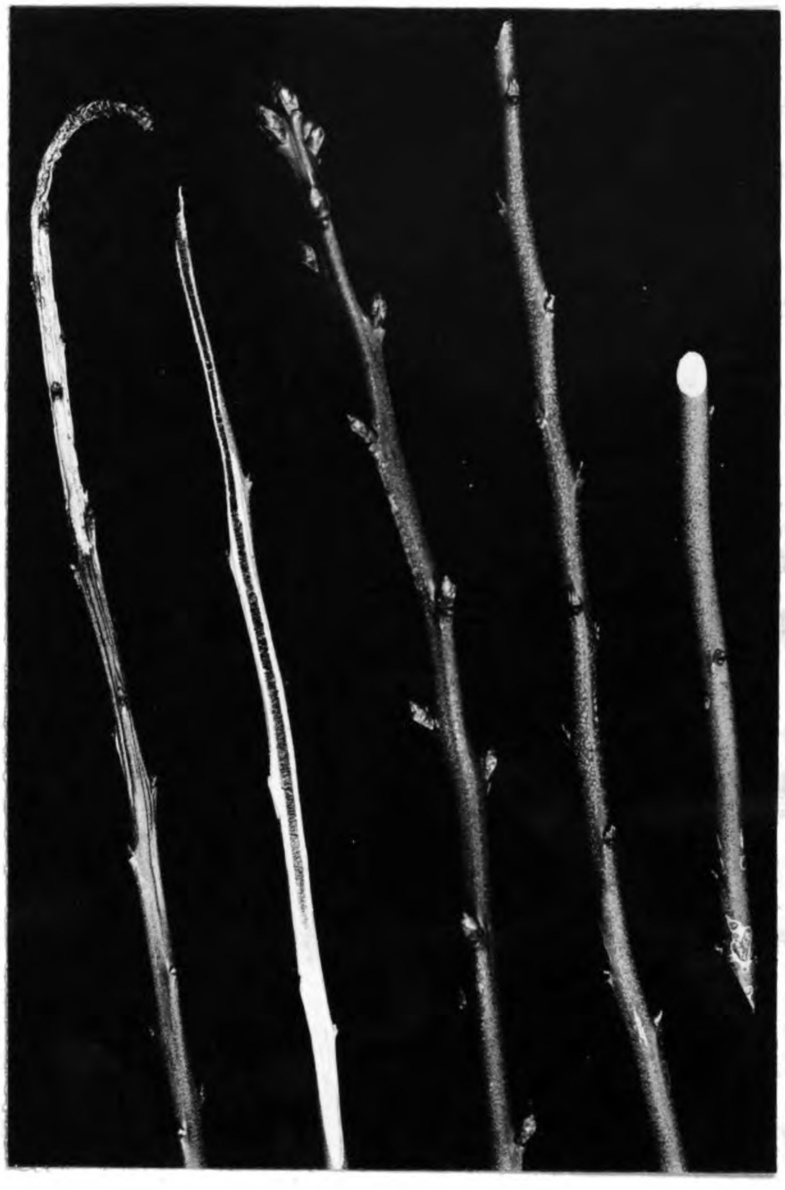

Fig. 4.- The blueberry shoot at the left shows winter injury, while beside it is another shoot showing the extent of the injury. The shoot in the center is undesirable for cuttings because of prevalence of fruit buds. The shoot at the right illustrates the best type of wood to use for hardwood cuttings. At the extreme right is a hardwood cutting ready for planting.

The data in Table 1 show that the cold frame gave the lowest percentages of rooted cuttings. The open frame gave rather high percentages of rooted cuttings, although not as high as the solar or box frames. The cuttings also rooted much more slowly in the open frame. Similar results were obtained in previous years with the cold frame and the solar frame, and, in 1928, with the box frame.

Table 2. Rooting softwood cuttings in different types of propagating frames (1929) (German Peat used as the rooting medium)

	Rubel		Cabot		Adams	
	Number cuttings	Per cent rooted	Number cuttings	Per cent rooted	Number cuttings	Per cent rooted
Cold frame	40	0	20	0	20	0
Solar frame	126	84.1	126	84.1	126	82.5
Box frame	120	85.0	120	83.3	120	81.6

The data presented in Table 2 show that softwood cuttings of Rubel, Cabot, and Adams failed to root in the cold frame, while very good results were obtained with softwood cuttings of the same varieties in the solar and box frames.

Approximately 11,000 softwood cuttings and an equal number of hardwood cuttings of Rubel, Adams, Cabot and Harding were handled in box frames during the 1929 season with high percentages of rooting. Equally satisfactory results were obtained in 1928 with smaller numbers of cuttings. Pioneer, which is probably the most difficult of all the cultivated varieties to root from cuttings, gave high percentages of rooted hardwood cuttings in both the box and solar frames during the 1928 and 1929 seasons. Softwood cuttings of Pioneer have given such variable results that it is considered wise to concentrate on the use of hardwood cuttings of this variety.

Influence of Different Rooting Media on Rooting Cuttings.

Sand, peat, peat moss, and various combinations of peat and sand were used as rooting media, with results shown in Table 3.

Table 3.- Rooting hardwood cuttings in various materials (1929).

	Rubel		Cabot		Adams	
	No.	Per cent rooted	No.	Per cent rooted	No.	Per cent rooted
German Peat	40	87.5	20	70	20	60
American Peat	40	55.0	20	35	20	5
German Peat and sand	40	72.5	20	45	20	30
Sand	40	57.5	20	45	20	15

German peat proved superior to other materials in 1928 and 1929. Results with sand and combinations of peat and sand varied from year to year.

Table 4.- Rooting softwood cutting in various materials. (1928)

	Rubel		Adams.	
	No.	Per cent rooted	No.	Per cent rooted
German Peat	75	86.6	30	86.6
American Peat	75	40.0	30	90.0
German Peat and sand	75	6.6	30	10.0
Sand	75	10.6	30	13.3

Table 4 shows the results of rooting softwood cuttings in various materials in 1928. Similar results were obtained in 1929, except that the percentages of stand in sand and in peat and sand were lower.

Fig. 5.- Note the secondary growth starting just above the last large leaf. This is the stage of growth at which softwood cuttings should be taken.

Fig. 6.- A softwood cutting ready for planting in the cutting bed.

Table 5.- Time of taking hardwood cuttings as a factor in rooting. (1929) (German peat used as the rooting medium).

	Rubel		Pioneer		Cabot		Adams	
	No.	Per cent rooted	No.	Per cent rooted	No.	Per cent rooted	No.	Per cent rooted
February 19	84	92.8	40	80.0	50	64.0	67	58.2
April 2	25	92.0	59	89.8	45	84.4	38	31.5

Cuttings which are taken in the winter and stored will root as well as those taken early in the spring and placed at once in the propagating frames. It will be observed, however, that Adams gave lower percentages of rooted cuttings than the other varieties. This was true of cuttings of this variety taken in February and in April. The new shoots of Adams, and sometimes of Cabot, are somewhat susceptible to winter injury. Cuttings made from this winter-injured wood root very poorly. It would be prudent, therefore, to take cuttings of such varieties in early winter and store them in a cool, moist cellar. This would be especially desirable if the site on which the plants are growing is particularly liable to be subjected to low temperatures during the winter.

Table 6.- Time of taking softwood cuttings as a factor in rooting. (1928) (German peat used as rooting medium).

	Rubel		Pioneer		Cabot	
	No.	Per cent rooted	No.	Per cent rooted	No.	Per cent rooted
July 5	42	83.3	35	71.4	18	88.8
July 13	54	100.0	38	92.1	27	100.0
July 23	38	81.6	24	58.3	15	100.0
August 1	32	87.5	22	50.0	14	71.3
August 7	35	82.8	25	60.0	13	76.9
August 23	34	0	23	8.6	13	23.0

Approximately the middle of July proved to be the best time for taking softwood cuttings in 1928 and in 1929. Only a small percentage of cuttings taken in late August of both years produced roots. Fruit bud differentiation had taken place in many of the lateral buds. However, due to the differences in growing seasons in the same and different sections of the country, probably the condition or stage of development of the new growth would be a better index as to the proper time of taking softwood cuttings than exact dates. The blueberry plant makes an initial flush of growth early in the growing season, usually terminating the latter part of June or early in July in southern Michigan. Secondary growth then takes place from a few of the lateral buds. The best time for taking softwood cuttings, regardless of date, is just as the secondary growth is starting. (Fig.6).

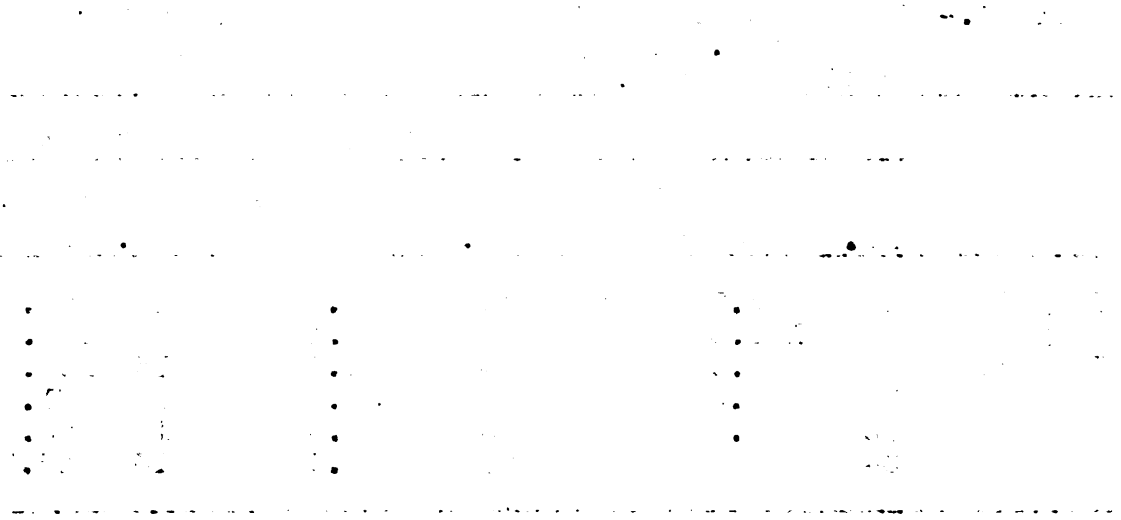

Fig. 7.- A propagating frame recently planted with softwood cuttings. Note that they are planted in a slanting position. Hardwood cuttings are planted in the same manner. The glass sash on the frames are open for ventilation.

Influence of Chemical Treatments on Rooting Cuttings.

As several investigators have reported success with chemical treatments in rooting cuttings of other plants, some of the most promising materials were used in this experiment. The solutions were made at the strengths indicated in Table 7, and the cuttings were allowed to stand in the solutions for 24 hours prior to planting.

Table 7. Chemical treatments with hardwood cuttings. (1929) (German peat rooting medium)

	Rubel		Pioneer		Cabot	
	No.	Per cent rooted	No.	Per cent rooted	No.	Per cent rooted
Potassium permanganate .01 mol. sol.	20	95	20	100	20	65
Potassium permanganate .001 mol. sol.	20	100	20	95	20	55
Copper sulphate .001 mol. sol.	20	90	20	75	20	50
Manganese sulphate .001 mol. sol.	20	95	20	90	20	35
Potassium ferro cyanide .001 mol. sol.	20	100	20	100	20	30
Sucrose (2% solution)	20	100	20	90	20	55
Acetic Acid (.52% vinegar solution)	20	95	20	90	20	65
Check	20	95	20	85	20	80

The chemical treatments were used in both 1928 and 1929 with very nearly the same results. There is some indication that in some instances somewhat better results were obtained

with certain chemical treatments. On the whole, however, the differences have not been great or consistent enough to indicate that the treatments are of any great value. The treatments appeared to be harmful with softwood cuttings in some instances, the succulent wood turning black after contact with the solution.

The Influence of Temperature and Aeration of Rooting Cuttings.

An attempt has been made in these investigations to determine the relative influence of temperature and aeration on rooting blueberry cuttings. It has already been shown that the solar frame, box frame, and open frame, all of which have the suspended cutting bed, have all been superior to the cold frame for rooting both hardwood and softwood cuttings. Tables 8 and 9 give the average temperatures of the rooting media in these various types of propagating frames throughout the season. It will be noted in Table 8 that the average soil temperature of cold frame at 7 A.M. was only 1.6° F. lower than that of the solar frame, the noon temperature of the cold frame was only 1.4° F. higher than the solar frame, and the evening temperature of the cold frame was but 3.5° F. lower than the solar frame. In spite of these small differences

in temperature, the cold frame produced only 25 per cent of rooted hardwood cuttings of Pioneer, while the solar frame produced 89.8 per cent. The same comparison can be made from the data presented in Table 9. These facts suggest that the better rooting in the suspended types of propagating beds was due to better aeration, rather than temperature differences.

Table 8.- Degrees F., May 20 to July 11, 1929, of German peat in different types of propagating frames. (Hardwood cuttings)

	Average at			Absolute		No. of times registering		
	7A.M	Noon	5P.M	Max.	Min.	80-84°F	85-90°F	91°F
Cold frame	59.3°F	72.4°F	71.9°F	82°F	42°F	7	0	0
Solar "	60.9	71.0	75.4	86	48	11	2	0
Box "	61.8	72.2	77.0	90	45	9	11	1
Air				88	33	8	4	0
Open "	58.5	73.5	76.8	95	39	8	13	3

Table 9.- Degrees F., July 26 to October 3, 1929, of German peat in different types of propagating frames. (Softwood cuttings).

	Average at			Absolute		No. of times registering		
	7A.M	Noon	5P.M	Max.	Min.	80-84°F	85-90°F	91°F
Cold Frame	60.9°F	73.6°F	74.3°F	91°F	46°F	16	4	0
Solar "	60.2	69.9	73.8	84	42	10	0	0
Box "	62.4	72.2	75.0	94	44	15	9	1
Air "				88	35	16	9	0

Fig. 8.- Rooted softwood cuttings in solar and box frames. These cuttings were planted July 14 and the photograph taken early in October.

Information is lacking with regard to rooting blueberry cuttings in propagating frames where the temperature is definitely controlled. Ovservation indicates that low temperatures, while not harmful to the cutting,do not stimulate root formation. Very high temperatures are likely to cause death. It is possible that certain localities, due to differences in temperature, may prove more desirable than others for rooting blueberry cuttings.

Notes on Handling Cuttings

The improved varieties vary considerably in their ability to develop roots. Rubel, for instance, roots more readily than the other varieties, either from hardwood or from softwood cuttings. Pioneer is probably the most difficult of all the varieties. Hardwood cuttings of this variety usually root satisfactorily, but the softwood cuttings are unreliable, often giving poor results. Adams and Cabot root readily from hardwood cuttings provided the wood has not been winter-injured. Softwood cuttings of each of these varieties root readily. Both types of cuttings of Harding root successfully.

Hardwood cuttings are made from the new shoots produced the previous season. Wood showing any winter injury should be discarded. The upper third of most shoots is also usually

discarded, due to the prevalence of fruit buds (Fig.4). The cuttings are made about four inches in length, the lower cut being made directly behind a bud and the upper cut being made just above a bud (Fig.4). To facilitate handling, the butts of the cuttings should all be placed the same way. Bunches of cuttings can be held together conveniently with rubber bands.

Softwood cuttings (Fig.5 and 6) are made of the current season's growth. They should be from three to four inches long and the cuts made in the same manner as for the hardwood cuttings. All leaves are removed except the upper two, and the upper half of each of these is cut away. Succulent wood should be discarded as cuttings made from this wood turn black soon after being placed in the cutting bed.

A tray four inches deep, covered on the bottom with hardware cloth of one-eighth inch mesh, is placed in the top of the propagating 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 pushed into the peat at a slant (Fig.7). 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.

The cuttings should be covered with a glass sash, and shade made of burlap should be placed about four inches above the sash. This shade should be kept on the sash at all times.

Fig. 9.- A view of part of the nursery at the South Haven Experiment Station. On the right, plants grown from softwood cuttings rooted the year previous. Center, blueberry seedlings one year old. Left-center, trays of hardwood cuttings taken from the propagating frames after rooting had taken place.

The peat should be kept saturated. Any excess water will drain off readily through the wire mesh at the bottom of the tray. During cool weather in the spring the cuttings often can go several weeks without watering. During hot summer weather, they may require watering once a week.

Ventilation should not be given until the cuttings are rooted; then it should be afforded gradually. After the sash has been removed, the burlap shade should remain over the cuttings for a few weeks. If the solar frame is used, it will be necessary to open the lower sash, to prevent extremely high temperatures in the frame. The box frame has one of the boards on the side hung on hinges. On extremely hot days this board should be lowered.

The frames should be examined at least twice a week to see that the peat is well supplied with moisture, and to remove all cuttings that are dying. This sanitation measure is very 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 cutting beds.

Cutting beds 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. 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 at South Haven provided some protection is given. Eight-inch boards should be placed around the outside of the trays and soil banked against them. Additional peat or sand should be sifted over the cuttings, leaving most of the tops exposed. Lath shade laid over the top helps to catch and hold the snow and thereby tends to prevent alternate freezing and thawing. Softwood cuttings are not well rotted until October. The sash and shades should be removed as soon as possible after rooting has started 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 cool, moist cellar. The roots are so fine and soft that the least amount of heaving breaks them.

In the following spring, the largest of the rooted hardwood cuttings can be set permanently in the field. The smaller rooted hardwood cuttings and all of the rooted softwood cuttings should be grown a year in the nursery row before setting in the field.

Growing Blueberry Seedlings.

Blueberry seedlings are of little direct commercial value due to the variability in the type of fruit produced on individual plants. However, a knowledge of successful

methods of growing seedlings is essential for the investigator in search of new varieties.

If seeds of the blueberry are planted as soon as they are removed from the mature fruit, a large percentage 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 trays of German peat, and then covering lightly with fine, sifted peat. In November, half of the seedlings were placed in a greenhouse and half were placed in a cold pit. At that time, the seedlings were about one-half inch in height and had their first two leaves. Those which were carried through the winter in the greenhouse were planted in beds of peat and sand about May 1. Those which were carried through the winter in the cold pit were transplanted to other trays and set out-of-doors under shade. Early in July, they were transplanted again to beds of peat and sand. At the end of the growing season, the seedlings carried through the winter in the greenhouse had produced three or four shoots each from eight to ten inches long. These seedlings were at least three or four times as large as those carried through the winter in the cold pit. Though seedlings can be started in the fall and brought through the winter in a cold pit, the use of a greenhouse will increase their growth to such an extent that they can be planted in the field one year earlier than would be possible otherwise.

Fig. 10.- At the right is a box frame and at the left a cutting tray showing the construction of each. The hinged board in front is open as it would be on very hot days. The cutting tray is in place ready to be filled with peat. See text for complete description of this type of frame.

Discussion

The material presented in this paper has been gathered from five years of investigation. The conclusions drawn are substantiated by experiences derived from handling thousands of cuttings in a commercial manner. Approximately 35,000 cuttings were handled in 1929, being half hardwood and half softwood. The success of the large and small scale experiments leads to the belief that the propagation by cuttings of the highbush blueberry is entirely practicable, that a considerable degree of success can be realized, and that plants can be produced at a reasonable cost. The rooting of blueberry cuttings requires considerable equipment, a comparatively long time, and more or less constant attention. Lack of attention will certainly result in failure. It is not likely that blueberry plants can ever be sold as cheaply as some other fruits such as currants, gooseberries, and grapes, but it is probable that they can be produced at a price low enough to permit commercial growing of the improved varieties.

Acknowledgements.

The writer wishes to express his appreciation to Messrs. V. R. Gardner, J. W. Crist, F. C. Bradford, of the Department of Horticulture, and Alex Laurie, now of Ohio State University, for many valuable suggestions and criticisms and aid in organizing this manuscript. Mr. W. C. Dutton of the Department of Horticulture contributed several photographs.

Summary

Attempts to root hardwood cuttings in the greenhouse during winter were generally unsuccessful. Root cuttings also gave negative results.

Four types of propagating frames were used in these investigations; the solar frame, the box frame, the open frame, and the cold frame. The use of the cold frame resulted in a low percentage of rooted cuttings. The open frame was only fairly satisfactory. The solar frame and the box frame were equally successful. The box frame is recommended because it is only half as expensive to build and requires less attention in operation.

German peat proved superior to American peat, sand, sphagnum moss, and combinations of peat and sand as a rooting medium.

Hardwood cuttings of varieties like Adams and Cabot which are susceptible to winter injury should be taken in early winter and stored in a cool, moist cellar. Where winter injury is not a factor, satisfactory results can be obtained by taking the cuttings late in March or just before growth starts and planting directly in the propagating frames.

Softwood cuttings of all varieties should be taken as soon as the plant starts its secondary growth. In Southern Michigan, this is usually early in July.

Chemical treatments were of little value in stimulating rooting of hardwood cuttings. With softwood cuttings their use may be even detrimental.

Information on rooting cuttings under carefully controlled temperatures is lacking. Rooting media in the four different types of propagating frames showed only slight temperature differences; nevertheless, the solar frame, box frame, and open frame, each having a suspended propagating bed allowing better aeration, gave high percentages of rooted cuttings as compared with the cold frame. These facts indicate that the better rooting in the suspended cutting beds was due to aeration, rather than temperature difference.

Varieties vary in their ability to root from cuttings. Rubel roots the most readily of any of the cultivated varieties from either hardwood or softwood cuttings. Hardwood cuttings of Pioneer root fairly readily, but poor results followed the use of softwood cuttings. The new shoots of Adams and Cabot are susceptible to winter injury. Cuttings made from injured shoots will not root, but both varieties root readily from sound cuttings. They also root readily from softwood cuttings. Both types of cuttings of Harding root successfully.

Blueberry seedlings can be grown fairly easily if the seeds are removed from the mature fruit and planted at once in German peat. They can be carried through the winter in a greenhouse or, at South Haven, in a cold pit. Winter growth under glass increases growth so that they can be planted in the field one year earlier than would otherwise be possible.

Literature Cited

1. Coville, F. V., Experiments in Blueberry Culture,- U. S. D. A. Bur. of Pl. Ind., Bul. 193, 1910.

2. Dawson, J., Garden and Forest, Page 183, 1888.

3. Munson, W. M., 17th Ann. Rep. Me. Agr. Exp. Sta. 1901.

4. Card, F. W., Bush Fruits.- R. I. Agr. Exp. Sta. Bul. 91, 1903. Also R. I. Agr. Exp. Sta. Rept. 1903.

5. Coville, F. V., Directons for Blueberry Culture, U. S. D. A. Bul. 974, 1921.

6. Beckwith, C. S. and Coville, S., Blueberry Culture, N. J. Agr. Exp. Sta.Cir. 200, 1987.

7. Crowley, D. J., 36th Ann. Rep. Wash. Agr. Exp. Sta. 1926

8. Mowry, H. and Camp, A. F., Blueberry Culture in Florida,- Fla. Agr. Exp. Sta. Bul. 194, 1928.

9. Hildreth, A. C.,- Proc. Am. Soc. Hort. Sci. 1929.

10. Swingle, W. T. and Robinson, T. R., and May, jr., E.- The Solar Frame for Rooting Citrus and Other Subtropical Plants., U. S. D. A. Cir. 310, 1924.