ALKALINE FLOODING WATER IN CRANBERRY GROWING

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INTRODUCTION

For the past fifteen years the Wisconsin Department of Agriculture and Markets has maintained a field investigator\(^1\) who specialized in cranberry problems. Although the work was devoted chiefly to the control of insects and diseases of the cranberry, the nature of the industry and the interests of the growers made it inevitable that some attention should be given to many phases indirectly related to the main problem. The present paper discusses one of these, the apparent relation between the use of alkaline flooding water and certain cultural problems. In view of the importance of the subject and the fact that there is little prospect of the relationship being experimentally studied within a reasonable time, it seems desirable to record our opinions and the evidence on which they are based in order that they may be available to cranberry growers and to later investigators. We fully realize that experimental work may invalidate some or all of our conclusions and regret our inability to carry out such experimental work ourselves.

Until such experiments are made, however, we are strongly of the opinion that anyone considering the development of new cranberry marshes will do well to have the water analyzed and not undertake development if it shows a pH much above 7 or more than 25 parts per million of bound carbon dioxide.

In response to the natural question as to why the relation between cultural problems and the alkalinity of flooding water has not been noted by other investigators if it is as important as the writers believe, it is necessary only to point out that the greater amount of the investigation of cranberry problems has been done in the eastern states, particularly in Massachusetts, and that nowhere in Massachusetts or New Jersey, or on Long

\(^1\) Bain, 1926-28; Rogers, 1929-36; Stevens, 1937-40.
Island, New York, has any cranberry property been found which uses even slightly alkaline water.

It is our conviction that the use of alkaline water in flooding cranberry marshes greatly increases the difficulties of producing profitable crops of berries.

That the difficulties tend to become greater as the alkalinity of the water is higher.

That the effects are, to a certain extent, cumulative, being more evident and more serious in older marshes, after alkaline water has been used for a number of years.

That the effects of alkaline water are evidenced in some or all of the following ways.

Different and sometimes more serious weeds.
Excess vine growth.
Overgrowth and absorption of flower buds.
Excess leaf drop, not fully controllable by known methods.
Abnormally small crops over a period of years.

That when a certain degree of alkalinity is passed, profitable cultivation of cranberries over a long period becomes impossible by any methods now known.

These opinions rest on our study of the history of the cranberry industry in Wisconsin and on the known record and present condition of certain marshes in that state. They can thus be defended only by stating the evidence, as we understand it, in some detail.

**THE IMPORTANCE OF WATER IN CRANBERRY CULTURE**

As is well known to all interested in the industry, flowage water in large amounts is essential to intensive cranberry culture by modern methods. As pointed out by Bain (2 p.12), the severe climate of Wisconsin has resulted in marsh construction being dominated by the water systems. In 1929 he found that in the Cranmoor district there were on the average 7 acres of reservoir to one acre of vines, a ratio considered fairly typical of conditions throughout the state. However, this extensive development of flooding systems is relatively recent.

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* Bain, H. F. Cranberry Industry in Wisconsin.  
SOURCES OF FLOODING WATER

At the time of the survey on which the 1929 publication was based, only 8 Wisconsin marshes obtained water directly from streams or natural lakes. This number has been increased somewhat since that time, but flooding water for cranberry marshes in Wisconsin still comes predominantly from artificial reservoirs, many of which are, of course, fed to some extent from streams.

Comparison of the sketch map\(^3\) of the larger Wisconsin lakes with the map\(^2\) of the locations of cultivated cranberry marshes, shows how small a part of the cultivated cranberry acreage is to be found in the great lake districts of the state.

The foregoing should not be interpreted as meaning that lakes should be considered as a unit as regards their suitability for flooding cranberry marshes. Actually, as the careful work of various Wisconsin agencies has demonstrated, they show a wide variation in many respects. As regards alkalinity, the characteristic discussed in this paper, lakes within the state differ very widely. Each lake should, therefore, be tested and studied separately, but certain general statements may be made which are of interest in connection with the history of the cranberry industry in Wisconsin. Birge and Juday\(^3\) (3 p.76) state that all of the lakes in the southeastern part of the state, except Devil's Lake, have very hard water, ranging from an average of about 60 to nearly 100 parts per million bound carbon dioxide. The lakes in northeastern Wisconsin show a wide variation in hardness, but Juday, Birge, and Meloche\(^4\) point out a distinction which may be of considerable practical usefulness in cranberry culture. They distinguish between seepage lakes and drainage lakes. By seepage lakes they mean those lakes which do not have an inlet or an outlet. They receive water through precipitation on their surface and from the surface drainage of limited basins. Any gain or loss to the ground water takes place through the process of seepage; hence they have been designated as seepage lakes. In general seepage lakes are characterized by very soft water (4 p.5). Those bodies of water which have temporary

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or permanent outlets have been called drainage lakes. Some of them show characteristics much like those of the seepage lakes because they have no inlets and their outlets possess water only for a brief period each year and sometimes only at intervals of several years.

**Types of Water and Their Distribution**

Wherever possible throughout this paper we have expressed the condition of the water used on the various marshes in two ways—pH (hydrogen-ion concentration) and in parts per million of bound carbon dioxide. It is possible that if we understood conditions better some other measurable character such as mg. of calcium per liter might more accurately express the differences from the point of view of cranberry culture. pH is, however, generally used in describing the acidity of agricultural soils, and the Wisconsin Geological and Natural History Survey, the Wisconsin State Planning Board and at least some units of the Federal Bureau of Agricultural Economics, all express hardness of water in parts per million of bound carbon dioxide. The following table is that used by Professor Juday to indicate the "nature" of the water in relation to its bound carbon dioxide content.

<table>
<thead>
<tr>
<th>Parts per Million</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Very soft water (V.S.)</td>
</tr>
<tr>
<td>5-10</td>
<td>Soft water (S.)</td>
</tr>
<tr>
<td>10-20</td>
<td>Medium water (M.)</td>
</tr>
<tr>
<td>20-30</td>
<td>Medium hard water (M.H.)</td>
</tr>
<tr>
<td>Over 30</td>
<td>Hard water (H.)</td>
</tr>
</tbody>
</table>

There is, of course, some relation between the pH (hydrogen-ion concentration) and the bound carbon dioxide content. On the basis of observations made in 499 Wisconsin lakes, the writers already quoted found that in drainage lakes (those which have an outlet) the neutral points in the pH scale, 7.0, often comes at or near the dividing line between soft and medium
water, i.e., at about 10 parts per million of bound carbon dioxide. Our own rather limited observations indicate that water in cranberry reservoirs may sometimes have a considerably higher bound carbon dioxide content, with a pH close to 7.0.

The pH of lake water varies from time to time. In a study of the pH of surface samples from 245 Wisconsin lakes in different years, Juday, Birge, and Meloche (4 p.49) found that in 222 of them, or 90 per cent of the total number, the difference did not exceed 1.4 pH units in the various years, but in six lakes the annual difference exceeded 2 pH units. They also report (4 p.50) that in certain lakes the summer pH was lower than that of the spring, in others the pH of samples taken in summer was higher than that of those taken in the spring, while in 9 cases the spring and summer readings were the same. There was even a difference between readings taken in a single lake on the same day. For example, they note that at Trout Lake on August 15, 1933, the readings taken during the daytime fell between 7.5 and 7.7, but were somewhat lower in the evening, or pH 7.2 to 7.3. Likewise the differences between surface and bottom waters varied from zero to 2.6 units.

Annual variations in bound carbon dioxide were small in seepage lakes whereas in the drainage lakes they varied from less than 2 to as much as 8.5 parts per million (4 p.65). The differences between the bound carbon dioxide content of surface and bottom waters varied from zero to 13.3 parts per million. Bound carbon dioxide thus constitutes a somewhat less variable characteristic by which differences may be measured, but from the above information it is evident that a cranberry grower who is interested in obtaining reliable information regarding the nature of his water supply should not be satisfied with a single test if he finds the water near the border line, but should obtain a series of readings at intervals. In general, however, fluctuations are least in early spring and late fall, which are thus the most favorable times for comparing one water source with another.

The water used in flooding Wisconsin cranberry marshes ranges from pH 5.2 to pH 8.6, and from less than 8 to more than 60 parts per million of bound carbon dioxide. The greater number of marshes, more than 50 of them, are found in the group having water with pH 7 or less, that is neutral or somewhat acid
water. This includes all those in the Mather and Cranmoor districts, as well as a number of those in the northern part of the state.

There is a small number of marshes in the northern part of the state with flooding water from 7.2 to almost 8.2, and a still smaller group, chiefly in the southeastern quarter of the state, with flooding water which at times may test as high as pH 8.4 or even pH 8.6.

**Specific Cultural Problems Possibly Related to the Use of Alkaline Water**

The following observations relate specifically to the three or four marshes in the state which are known to have flooding water which sometimes tests as alkaline as pH 8.4 or 8.6. These marshes have been observed closely over a period of ten or twelve years and have never during this time produced a really satisfactory crop of fruit, even though they have had adequate frost protection and no unusual losses from insects and disease. As already stated, we have no proof that this condition is due to the alkalinity of the flooding water, but there are certain pathological conditions which are observed on these marshes, not often found on those with acid water.

In general, the effect one gets from observing such a marsh is that the vines are constantly over-fertilized and over-stimulated. Vegetative growth is much too abundant and many of the berries actually produced are abnormally large. Growth in the spring is unusually vigorous and rapid and is frequently associated with a condition that we have come to call 'flower bud absorption'. This is a condition in which uprights develop from fruit buds on which the blossom buds have aborted and fail to grow away from enclosing bud scales, although growth of the upright proceeds normally in other respects. The general appearance suggests frost injury, but repeated observations have convinced us it is not due to frost in these cases and may be associated with water. At any rate, this condition is much more common on marshes with alkaline water.

On such marshes in the fall fruit buds tend to overgrow, that is, develop beyond the point normal for the resting period, and are thus more subject to injury, frequently to complete killing, during the winter submergence. In addition to this killing of
flower buds, other types of winter injury, the wellknown 'leaf drop' and even death of vines is more common and more difficult to control on marshes having extremely alkaline water.

Whether the abnormalities noted are due to alkaline water or soil is, of course, not proved, but they are certainly associated with it. One theory is that they are, at least in part, the result of excess nitrogen due to the action of bacteria which grow best in alkaline soil. Weed problems appear to be somewhat different and indeed to be somewhat aggravated on these marshes with alkaline water as compared to the usual marsh. Some species of weeds not serious on the more acid marshes cause difficulty on them, and in addition they have their share of many troublesome cranberry weed species. The general impression one gets here, as in the case of the cranberry vines themselves, is that the soil is extremely fertile and favorable to plant growth.

While such extreme conditions as those noted above are not to be found on marshes with slightly alkaline water (pH 7.2-7.8), and some of these under good management produce good crops and pay good dividends, the general management problems seem to be aggravated even here.

**History of the Industry of Relation to Flooding Water**

In spite of some inevitable conflict in statements as to the exact dates, areas and yields, it is possible from the publications of the Wisconsin State Horticultural Society and the Wisconsin Cranberry Growers Association to reconstruct a fairly consistent and adequate history of the cranberry industry in the state. Some knowledge of this history seems necessary to an understanding of the general problem here discussed.

Unquestionably cranberries were picked and sold in large quantities from wild vines before there was any attempt at cultivation. The earliest record of actual cultivation found thus far is in connection with a paper on cranberry culture presented before the Horticultural Society in 1876 by Mr. H. Floyd of Berlin. In discussing this paper a Mr. Peffer is quoted (5 p.145) as saying that "he had cultivated cranberries since 1853; found that they grew readily from cuttings, even on clay soil; had found difficulty in the frost heaving the ground and covering the vines with muck where he scalped the marshes." How extensive Mr. Peffer's plantings were is not known, but there is little doubt
that the earliest general improvement of marshes was in the region of which Berlin was the commercial and shipping center. E. W. Daniels, writing in 1878 (5 p.140) states that in 1860 he purchased land near Auroraville for cranberry growing, but soon abandoned it to the state. A few years later (1865 seems to be the most probable date) H. S. Sackett purchased a tract of land two miles from Berlin and built dams for flooding the marsh. Sackett is reported to have had a very profitable crop in 1868 and the Carey Brothers a large and profitable one in 1872. The earliest report (1878) of the 1872 crop states that it was over 6000 barrels for the Carey marsh itself and 14,400 for the Berlin area, with a maximum price in Berlin of $11.00 a barrel. Later accounts naturally indicate a somewhat larger yield.

Independent accounts by Hitchcock in 1875 (p. 126-128) and Daniels in 1878 (p. 140-143) are in substantial agreement that there were in the Berlin area at this time over 1000 acres of more or less improved marshes under the ownership of the Careys, Sackett, Walters, Rounds, and Company, and Mason (later Spencer) and others. These marshes, while containing only wild vines, were not unimproved. Mr. Sackett had no canals but held the water from rainfall and spring fresheets. Rounds and Company had 10 miles of ditches and Spencer 8 miles. The Carey's had “fifteen miles of ditch” and a canal one and one-fourth miles long from their mill-pond at Auroraville built at a cost of $7,800.

The importance of an adequate water supply and of adequate control of the water for winter protection and insect control is emphasized in detail by H. Floyd of Berlin 1876 (p. 64-68), and C. S. Whittier of Camp Douglas in 1877 (p. 53-59).

It was undoubtedly the large profits made during the early 1870's in the Berlin area that led to the expansion of the industry in Wisconsin and particularly to the establishment of marshes in Wood County and the Mather-Warrens district, estimated in 1875 (p. 126) to comprise 2500 acres of newly improved marshes. It is probably unnecessary to add that an acre of cranberries at that time did not mean what it does today, but merely wild vines with more or less improvement in the way of ditches and dikes.

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6 Throughout this portion of the paper, page references are to the publications of the Wisconsin State Horticultural Society for the years indicated.
The present importance of the Wood County and the Mather-Warrens Districts in Wisconsin is evident from the fact that they still comprise 75 per cent of the total acreage. Here are located most of the oldest marshes in the state, many of them in successful operation under the direct descendants of the men who first improved them.

In the Berlin area, on the other hand, at the present time there is but one commercial marsh. The decline of the Berlin area has, of course, not been continuous. There were some good crops in this area within the last thirty-five years.

While there may be many factors concerned with the decline of cranberry growing in the Berlin area and its persistence on a profitable basis in Wood, Juneau, and Monroe counties, in spite of such hazards as the drought and fires of 1894 and 1895, and the great drought and winter killing of 1932 and 1934, it is certainly true that the water used in constantly increasing amounts to supplement that held from the rain came in Wood County and those west and south from such streams as Hemlock Creek, the Lemonweir River and later from the Wisconsin River, all somewhat acid, whereas the sources of flooding water in Waushara county, such as the Fox River and Willow Creek, are decidedly alkaline.

It seems highly probable that a casual relation exists between the type of flooding water used and the success of the industry in the Wood County area, and its decline in the Berlin area. It is not, however, necessary to assume such a relation in order to recognize the possibility that present methods of cranberry culture may be unsuited to marshes using alkaline water. Present cultural methods have been developed from the experience of growers in the areas longest occupied and it is a fact that during the intensive development of the industry from 1900 until the present time, the successful growers in the central area have had no experience with the use of alkaline water in flooding. Neither have those in Massachusetts or New Jersey since so far as can be learned no alkaline water is used for flooding in either of these states.

Naturally, the more widely scattered marshes in the northern part of Wisconsin have yielded as yet much less information on this problem. For one thing they are all young compared to

*The water in this pond tests at various seasons from pH 7.6 to pH 8.6*
those further south, few if any are over 30 years old, and if alkaline flooding water has any effect, it is probably cumulative. Moreover, they do not represent a single type of water, but a wide range of types. It is, however, true that those northern Wisconsin marshes, which during the past decade have proved so outstandingly prolific, have used for flooding, water derived from what Birge and Juday designate as “seepage lakes” characterized by very soft water.

**SIGNIFICANCE OF THE ABOVE OBSERVATIONS**

For the immediate future it seems clear that in planting commercial cranberry marshes, those locations having only alkaline flooding water should be avoided. It is, of course, entirely possible that the correlation above described is not casual. Yet the chances of its being important are so great that it seems unwise for any individual to risk the large investment usually necessary for starting a new marsh in the face of this additional possible handicap.

It is admitted that we have not even observational evidence bearing on the question of the possibility of growing cranberries with alkaline flooding water on the highly acid peat soil associated with native stands of “brown bush” *chamaedaphne calyculata* (L) Moench. The experiment might well succeed, at least for a time, but on the other hand, might be expensive for any individual to attempt. Obviously, when time and facilities can be made available, this whole subject should be studied experimentally, though adequate experiments might take many years.

It is probably unnecessary to add that many factors other than a suitable water supply must be considered in selecting a suitable location for a cranberry marsh. This factor is emphasized here because in the past it has been so largely neglected.