CHEMICAL CHARACTERISTICS OF CRANBERRY WATER SOURCES

Eric Hanson
Department of Horticulture
Michigan State University

Introduction

Irrigation water quality is particularly important in cranberry production since up to up to 8 feet of water may be applied annually for irrigation and flooding. Several characteristics of water can be of concern. High total salts (electrical conductivity) can stress plants by impeding water uptake and inducing nutrient deficiencies. High sodium concentrations relative to other ions can result in sodic soils where drainage is impeded. High alkalinity levels can increase soil pH above desired levels. Lastly, some specific ions can be toxic to plants (eg. boron). There is often some confusion regarding the definitions of several of these terms.

Alkalinity is the total concentration of bases, expressed in ppm calcium carbonate ($CaCO_3$) equivalent. Alkalinity levels tell how easily water can be neutralize by acids. Water high in alkalinity resists pH changes when acid is added. Total alkalinity includes carbonate, bicarbonate, and hydroxide alkalinity. Labs may analyze for these components separately, or report total alkalinity.

Carbonates: Inorganic carbon may be present in water in the form of free carbon dioxide (CO_2), bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}). Free CO_2 is the dominant form when pH is below 6.4, and HCO_3^- dominates at pH 6.5 to 10. Water contains little CO_3^{-2} unless the pH is greater than 10. The carbonate system (CO_2 - HCO_3^- - CO_3^{-2}) contributes most of the alkalinity and buffering capacity to natural water.

Hardness is the concentration of multi-valent cations, primary calcium (Ca^{+2}) magnesium (Mg^{+2}). Hardness is not the same as alkalinity, though they are often similar because the carbonates in water usually are derived from calcium and magnesium carbonates.

pH is a measure of acidity expressed as the negative log of the H^+ ion concentration. pH values below 7.0 are acidic, 7.0 is neutral, and values above 7.0 are alkaline. A change of one unit (5.0 to 6.0) represents a 10 -fold difference in H^+ concentration.

In cranberries, alkalinity was a recognized concern several decades ago. The diversion of alkaline water for use on cranberry beds appeared to have increased soil pH and rendered a successful cranberry production area in Wisconsin nonprofitable (Stevens, 1946a; Stevens et al., 1940). Very low carbonate (alkalinity) levels may increase the risk of oxygen deficiencies when plants are flooded (Stevens and Thompson, 1942). Cranberry injury from saline water (high soluble salts) was observed when hurricanes contaminated Massachusetts cranberry beds with sea water (Chandler and DeMoranville, 1959).

Until recently, commercial cranberry culture had been confined to acidic, hydric soils in Massachusetts, New Jersey, Oregon, Washington, Wisconsin, and the Canadian province of British Columbia. Surveys in the 1940's indicated that water used on Massachusetts cranberry plantings was very low in alkalinity (1 to 6 ppm bound CO_2) and acidic to neutral in pH, whereas water from Wisconsin operations was usually higher in alkalinity (5 to 80 mg/l bound CO_2) and pH (Stevens, 1946b). Water from New Jersey cranberry farms was very low in alkalinity (Stevens et al., 1940).

The recent strong demand for cranberries has resulted in the construction of cranberry plantings in new regions such as Maine, Michigan, Minnesota and New York in the United State, the Canadian Provinces of Quebec, Nova Scotia., and New Brunswick, and in Chile. Some recent plantings are situated on the traditional acidic, hydric soils, but where these soils are limited or protected from development by regulations, plantings have been built on upland sites (Roper and Planer, 1993). As a whole, new plantings may represent more diverse soil and water characteristics than were associated with the traditional production regions. In 1998, we surveyed the chemical properties of water sources being used for cranberry production in order to aid individuals evaluating the potential of sites and water sources for cranberry production.

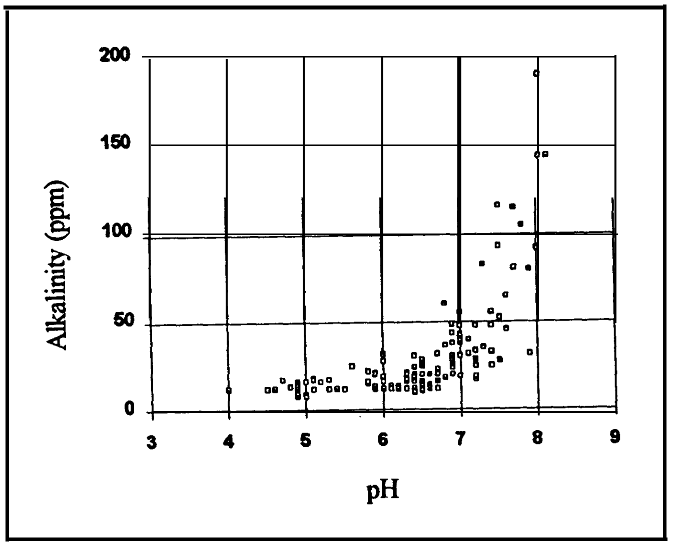
Methods

Samples were collected between March and November from streams and rivers above or below cranberry operations, and ponds, lakes and reservoirs that served as water sources for cranberry operations (Table 1). Samples from Chile, British Columbia, Quebec, Washington, and Wisconsin were provided by Benjamin Little (Cran Chile), David McArthur (University of British Columbia), Jacques Painchaud (Conseiller Regional en Horticulture), Kim Patten (Washington State University), and Teryl Roper (University of Wisconsin), respectively. Carolyn DeMoranville (University of Massachusetts), David Yarborough (University of Maine), and Nicholi Vorsa (Rutgers University) assisted with collections from their respective states. Water was placed in polyethylene or glass bottles, and sent to Michigan for analyses. Some samples were sent fresh and processed immediately, whereas others were frozen until processed.

Results

The mean and range of various chemical characteristics of water from the different regions are illustrated in Table 2. Mean pH was relatively low in New Jersey (5.2) and Massachusetts (6.1) and high in Michigan (7.7), Chile (7.4) and Washington (7.4). The range and mean pH levels for Massachusetts and Wisconsin samples (Table 2) are similar to those reported previously (Stevens, 1946b). Mean alkalinity levels were lowest in New Jersey (14 ppm) and Massachusetts (18) and highest in Michigan (105). Alkalinity data reported here are consistent with a previous survey (Stevens, 1946b), where water from Wisconsin cranberries exhibited higher mean alkalinity, and a wider range, than samples from Massachusetts.

The hazard from alkaline water is that soil pH may increase above desired levels. It is important to recognize that soil pH is affected by the alkalinity, not pH, of water. The impact on soil pH depends on the use rate and alkalinity levels of the water, and the buffering capacity of the soil. A useful rule of thumb is that an acre-foot of water with an alkalinity levels of 100 ppm $CaCO_3$ contains about 270 lb of lime. This quantity may not affect the pH of a highly buffered organic soil; but could increase the pH of a clean sand. About 86 lb sulfur would be needed to neutralize 270 lb of lime, so the annual S requirement to counteract the lime added by 100 ppm alkalinity water could represent a significant long term cost.



Based on samples from this survey, alkalinity levels can be assumed to be low (<50 ppm) when pH is <6.8 (see figure). However, when pH is above 6.8, alkalinity levels varied enormously. In other words, water sources with a pH <6.8 likely contain safe alkalinity levels, whereas water with pH >6.8 may or may not contain problematic alkalinity levels.

The tolerance of cranberries to salinity (soluble salts), sodium (Na) and chloride (Cl) has not been clearly defined. In general agriculture, water containing <0.75 mmho salinity (USDA, 1954) and less than 40 ppm Na and 60 ppm Cl (Biernbaum and Versluys, 1998), is suitable for irrigation uses. In our survey, salinity levels rarely approached 0.75 mmho. The highest salinity was found in the most alkaline samples. Samples seldom contained more than 40 ppm Na or 60 ppm Cl. The exceptions to this were several samples from British Columbia. These samples were collected at the end of a very dry summer, and suggest that some intrusion of sea water into ditches has occurred.

Some caution is advised in comparing water characteristics between regions or states. Samples from each region were taken at different times of the year. Chemical characteristics would likely differ somewhat if samples were collected during different years or months. Samples were also handled somewhat differently. Some were refrigerated and analyzed within a few days of collection, whereas others were frozen until analysis. To test the stability of samples over time, a set of 15 samples were analyzed immediately after collection and again after 4-6 weeks storage at room temperature. The only measurement that changed significantly over the storage period was soluble salts (tended to increase with time. This suggests that differences in sample handing did not alter analytical results to a large extend.

Literature Cited

Biernbaum, J.A., and N.B. Versluys. 1998. Water management. Hort Technology 8:504-509.

Davenport, J.R., and C.J. DeMoranville. 1993. A survey of several soil physical characteristics of cultivated cranberry bog soils in North America. Commun. Soil Sci. Plant Anal. 24: 1768-1773.

Roper, T.R., and T.D. Planer. 1993. Upland cranberry plantings in Wisconsin, thoughts on creating the appropriate agronomic conditions. Cranberries Magazine. August pp. 4, 18.

Stevens, N.E. 1946a. Further observations on alkaline flooding water in cranberry growing. Trans. Wisc. Acad. Sci. 36:395-398.

Stevens, N.E. 1946b. Observations on flooding water used in cranberry culture. Mass. Expt. Sta. Bull. 433. P. 37-48.

Stevens, N.E., N.F. Thompson. 1942. Factors influencing injury to cranberry plants during flooding. Trans. Wisc. Acad. Sci. 34:73-81.

Stevens, N.E., L.M. Rogers, and H.F. Bain. 1940. Alkaline flooding water in cranberry growing. Trans. Wisc. Acad. Sci. 32:351-360.

United States Department of Agriculture. 1954. Quality of irrigation water. In: Diagnosis and Improvement of Saline and Alkali Soils. U.S.D.A Handbook 60. pp 69-82.

Table 1. Water source locations and sampling times.

Location	Time	Sources
British Columbia	Sept	Reservoirs in Delta, East and West Richmond, Fort Langley, Langley, and Pitt Meadows.
Chile	Sept	Properties of Cran Chile near Valdevia.
Maine	Aug	Adroscoggin County stream. Reservoirs in Kennebec, Lincoln, and Washington Counties.
Massachusetts	March to Aug	Plymouth and Barnstable County streams, rivers, ponds and reservoirs.
Michigan	Aug to Oct	Reservoirs in Allegan, Cheboygan, Chipewa, Ottawa, and VanBuren Counties.
New Jersey	July	Atlantic County stream. Burlington County streams, rivers, drain, and lake. Camden County river. Ocean County streams and rivers.
Quebec	Aug	Irrigation canal, reservoirs, and rivers near St-Louis-de-Blandford and Notre-Dame-de-Lourdes.
Washington	Oct to Nov	Reservoirs and ponds in Grayland, Long Beach, and North Beach.
Wisconsin	May to Aug	Various sources in Adams, Jackson, Juneau, Monroe, Oneida, Portage, Vilas, and Wood counties.

Sample number (n), and mean and range (parentheses) of selected chemical properties of cranberry water samples.

				ppm				
	n	pH	Soluble salts (mmho)	Ca	Mg	Na	Cl	Alkalinity
British Columbia	11	6.9 (6.5-7.3)	0.28 (.11-1.05)	36 (0-160)	7 (3-21)	42 (5-162)	83 (17-354)	40 (16-61)
Chile	5	7.4 (7.2-7.9)	0.05 (.02-.07)	27 (21-32)	2 (0-2)	5 (5-7)	13 (5-19)	26 (17-32)
ME	14	7.0 (5.3-7.4)	0.13 (.03-.34)	11 (0-40)	1 (0-9)	10 (5-24)	14 (3-48)	31 (17-56)
MA	50	6.1 (4.0-6.9)	0.12 (.05-.34)	16 (9-67)	2 (0-3)	12 (0-46)	21 (0-80)	18 (9-44)
MI	8	7.7 (7.0-8.1)	0.32 (.11-.58)	66 (20-133)	11 (1-20)	4 (0-8)	16 (0-38)	105 (32-190)
NJ	19	5.2 (4.5-7.1)	0.05 (.03-.12)	2 (0-18)	0 (0-1)	6 (4-13)	6 (2-22)	14 (8-40)
Quebec	11	7.0 (4.9-7.6)	0.15 (.02-.31)	34 (10-57)	1 (0-3)	0 (0-0)	0 (0-0)	46 (16-116)
WA	12	7.4 (6.8-7.9)	0.20 (.07-.33)	10 (0-50)	5 (0-14)	18 (4-49)	36 (14-80)	53 (18-116)
WI	28	7.0 (6.2-8.0)	0.14 (.02-.46)	15 (0-0-80)	3 (1-20)	10 (2-69)	22 (3-126)	40 (16-128)