Evaluation of methods to improve weed control for organic cranberry production

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Executive Summary

Effective weed control options are needed to support organic cranberry production. Horticultural vinegar (acetic acid) is not currently registered for use in cranberries and questions remain about how to use this product effectively for weed control. We tested to two aspects of application technique - frequency and method - that could affect the efficacy of weed control with horticultural vinegar in cranberries. Frequency was tested with weekly or twice-weekly applications with a 4% acetic acid solution. Application methods tested were Foliar application, Basal application (solution applied to the root zone) and a combination of Basal + Foliar application. Our trial plots were located in a commercial cranberry field that was not slated for harvest in 2010. The predominant weed in the trial area was horsetail (80%) along with a mixture of annual and perennial broadleaf weeds. We found that treating weeds weekly or twice weekly with horticultural vinegar did not make a difference in terms of weed control but twice weekly applications did cause a slight increase in cranberry vine damage. However, cranberry vines recovered from this damage seven-weeks after the last spray. All three application methods caused significant damage to weeds during the weekly spray programs, however once spraying ceased weeds - especially horsetail - recovered within two-weeks. Of the three application methods the Basal + Foliar and Foliar caused the highest levels of weed damage, but also high levels of cranberry vine damage - although damage to vines was not permanent. The Basal method maybe a safer method for achieving adequate weed control but also minimizing vine damage. Overall our result suggest that horticultural vinegar does not provide long term suppression of weeds (especially difficult to control perennials like horsetail) in cranberries. A more directed injection (going below the soil surface) and with a higher concentration of acetic acid may improve control of perennial weeds. However, it will be important to ensure that cranberry vines can recover from any damage caused by higher rates of acetic acid.

Introduction

Lack of weed control options is an important barrier to organic production of cranberries in British Columbia. Both annual and perennial weeds are problems in cranberries. Weeds can affect yield, vine growth, vine establishment and harvest efficacy (AAFC 2007). While conventional growers have access to a number of herbicides for controlling weed issues there are no organic options for weed control in cranberries currently registered in Canada.

Horticultural vinegars (acetic acid) are currently registered as herbicides in Canada for both the domestic market (home owners) and for landscape and industrial (e.g. right-of-way) uses. Under the Canadian Organic Standards horticultural vinegars are permitted provided the vinegar is derived from a non-synthetic source and cultural control measures are insufficient to control the weeds (CGSB 2006). In cranberries, cultural control measures can be effective against some types of weeds (e.g. annuals) during the initial phases of cranberry bed establishment. Cultural controls are less effective in established fields and against perennial weeds (AAFC 2007). For perennial weeds additional post-emergent herbicide treatments are used in conventional production with spot and wiper application (AAFC 2007). Being able to use horticultural vinegar in a similar manner would be useful for those growers already producing organically or wanting to transition established fields to organic production.

Horticultural vinegar is a contact herbicide that causes tissue desiccation (Webber and Shrefler 2006). Several factors including weed species, size of weeds, application method and number of applications influence the efficacy of vinegar-based herbicides (Stein and Rumsey 2008, Webber and Shrefler 2006, Chinery 2002). Work on cranberries in Washington State has indicated that spring applications of 3-4% acetic acid resulted in 89-97% control of false lily-of-the-valley (Patten 2007). Experience from Quebec has shown that acetic acid injection into the collar of perennial weeds is effective (Painchaud 2010). Locally, preliminary trials have demonstrated that a 4% acetic acid solution can cause significant damage to some perennial weeds like plantain spp. (E.S. Cropconsult Ltd. unpublished data). However, acetic acid is a broad spectrum herbicide and there is the risk of damaging cranberry vines. Moderate levels of cranberry vine damage have been documented in trials using a 3-4% acetic acid solution (Patten 2007). Targeted applications to weed plant roots (via basal drenches or injections) may help to minimize cranberry vine damage (Zeldin 2008, Painchaud 2010).

The objective of this study was to examine the impact of application method (basal drenches alone or in combination with foliar applications) and frequency (once or twice a week) on the efficacy of horticultural vinegar herbicides for weed control in cranberries.

Material and Methods

Field location and plot description – The trial was conducted in a commercial cranberry field in Delta B.C. from which berries were not due to be harvested in 2010. The field was located in North West Delta and is currently not organic, but the long term plan is to

transition to organic production. Soil composition in the field was 17.2% sand, 61.6% silt and clay, and 21.2% organic matter. Horsetail (*Equisetum arvense*) was the main weed found throughout the trial area accounting for 60 to 80% of the weed cover in each plot (Fig. 1). A mixture of broadleaf weeds including plantain (*Plantago major*), stork's bill (*Erodium cicutarium*), blackberry (*Rubus discolor*), pineapple weed (*Matricaria matricarioides*) and perennial sow thistle (*Sonchus arvensis*) made up the remainder of the weed community in the trial area. At the start of the trial weeds ranged in size from 0.5 cm to 40 cm tall. The location of the trial, within the field, was chosen based on the presence of weeds (mixture of species), healthy cranberry vines and the advice of the grower. The area available for the trial was big enough to accommodate six replicates of all eight treatments (48 plots in total). Individual plots measured $1m^2$ and treatments were randomly assigned to each plot (completely randomized design).

Figure 1. Weed cover in Control plots. Note that the dominant weed in the study area was horsetail.

Treatments and application protocol – The study consisted of an evaluation of the effect of application method and frequency on the efficacy of vinegar-based herbicides; thus the study design was a two-way (Method X Frequency) repeated-measures MANOVA. Four types of application methods were evaluated at two different application frequencies for a total of eight treatments. The eight treatments were:

1) Control (Water) application (1x/week)
2) Control (Water) application (2x/week)
3) Foliar vinegar application (1x/week)
4) Foliar vinegar application (2x/week)
5) Basal vinegar drench (1x/week)
6) Basal vinegar drench (2x/week)
7) Basal vinegar drench + Foliar vinegar application (1x/week)
8) Basal vinegar drench + Foliar vinegar application (2x/week).

Initially our plan was to use GroTek Elimaweed (Green Star Plant Products) for this study, as preliminary trials in 2009 indicated that this product was a promising candidate for weed control in cranberries (E.S. Cropconsult Ltd. unpublished data). However, we were unable to obtain a sufficient supply of the product for the present study and instead switched to EcoClear (Ecoval Corporation). Although this formulation is not OMRI approved, it is a non-synthetic source of horticultural vinegar and has Canadian registration for use in industrial areas. The EcoClear formulation is 25% acetic acid. All horticultural vinegar treatments and water for the Control treatments were applied using SOLO backpack sprayers with cone type nozzles. The concentration of acetic acid used for this trial was 4% solution as per Patten (2007). For each plot this concentration of acetic acid was made by adding 45 ml of EcoClear (25% acetic acid) to 235 ml of water. For Control plots 280 ml of water was applied to plots.

Basal applications were made by directing the nozzle at the soil at the base of each weed plant and spraying for five seconds. Foliar applications were sprayed onto weed foliage to the point of run-off. In the combined Basal + Foliar application plots the basal portion was directed at the base of the plant for three seconds and then the weed foliage was lightly misted. Plots were first sprayed on April 19, 2010 and were treated for 9 weeks, to June 14 (Table 1). In some weeks a group of plots weren't treated as per the schedule and this decision was made whenever the level of damage on cranberry vines was very high, and there was concern about killing vines or when there were no weeds to treat in a set of plots. This occurred during Weeks 5 and 6 for the Basal + Foliar treatment and again during Week 10 for all plots (Table 1).

Assessment – Damage to weeds and cranberry vines was assessed in all plots seven times: prior to the first application and then three times during the course of the nine weeks of spraying and three times following the end of the spray program (Table 2). Weed damage was measured using a 1-5 scale described by Patten (2007) where

1 = no control.
2= 1-30% tissue damage
3= 31-60% tissue damage
4= 61-99% tissue damage
5 = 100% dead or dying (all foliage and stems to ground level).

Damage to cranberry vines was also assessed using a 1-5 scale (Patten, 2007), where

1 = healthy - no vine damage
2= 1-30% vine damage
3= 31-60% vine damage
4= 61-99% vine damage
5 = 100% vines dead.

Table 1. Summary of weekly and twice-weekly application dates of vinegar-based herbicides to cranberry plots over the course of 10 weeks.

Week	1X/week application	2X/week application	Notes
1	April 19	April 19 April 22	
2	April 26	April 26 April 28	
3	May 3	May 3 May 5	
4	May 10	May 10 May 12	
5	May 17	May 17 May 19	No Basal + Foliar treatment
6	May 25	May 25 May 28	No Basal + Foliar treatment
7	May 31	May 31 June 2	
8	June 7	June 7 June 9	
9	June 14	June 14 June 17	
10			No sprays on week 10 because of concerns regarding vine damage

Table 2. Summary of assessment dates for evaluation of vinegar-based herbicides for weed control in cranberries

Week	Date	Assessment
1	April 19	Pre-spray assessment
4	May 10	3-weeks post start of spraying on April 19
6	May 25	6-weeks post start of spraying on April 19
8	June 7	8-weeks post start of spraying on April 19
11	June 28	1st end of trial assessment (2 week post last spray June 14)
13	July 13	2nd end of trial assessment (4 weeks post last spray June 14)
16	Aug 5	3rd end of trial assessment (7 weeks post last spray June 14)

Data analysis –The combined effect of application method and frequency on weed control and cranberry vine damage was examined using two-way repeated-measures MANOVA. Post-hoc profile analyses were done using one-way ANOVA and means comparison using Tukey-Kramer HSD ($\alpha = 0.05$). All data were analyzed using JMP-In Version 5.1 (SAS Institute Chicago, IL).

Results

Weed Control – Application method had a significant impact on weed damage in cranberry plots but application frequency did not (Table 3). In addition to a significant effect of Method on weed damage we also observed a significant interaction of Time X Method (Table 3). Prior to treatment there was no difference among plots in terms of weed damage, low levels of damage observed in plots prior to the beginning of our trial are attributed to a single herbicide application made to the area 1 month prior to our study. After 3 weeks of spraying, all three methods of application provide significantly better weed control than the Control - with Basal + Foliar causing the most damage (Fig. 2). All three application methods continued to provide effective weed control after 6 and 8 weeks of spraying (Fig. 2). We found this pattern of weed control held for 2-weeks following the last vinegar application (Fig. 2) but we also saw overall weed damage ratings fall across all treatments - with Basal + Foliar still providing the highest levels of control. However 4 and 7 weeks following the last vinegar application weed damage levels in all of the treated plots were not any better than in the Control plots. In fact, weed damage was slightly and significantly higher in Control plots compared to the vinegar treated plots during the final two post-treatment assessments (Fig. 2). This was likely because all remaining weeds in the study area were treated, by the grower, with a conventional herbicide on Week 12.

Table 3. Effect of application method and frequency on the efficacy of horticultural vinegar on weeds and cranberry vines - data were analyzed using 2-way repeated measures MANOVA.

	Weed Damage	Cranberry Vine Damage
Method	**F = 41.45, df = 3, 40** **P < 0.001**	**F = 31.47, df = 3, 40** **P < 0.001**
Frequency	F = 3.04, df = 1, 40 P =0.09	**F = 6.68, df = 1,40** **P = 0.01**
Method X Frequency	F = 0.87, df = 3, 40 P = 0.47	F = 0.46, df = 3, 40 P =0.71
Time	**F = 80.37, df = 6, 35** **P < 0.001**	**F = 59.81, df = 6, 35** **P < 0.001**
Time X Method	**F = 7.81, df = 18, 99** **P < 0.001**	**F = 5.02, df = 18, 99** **P < 0.001**
Time X Frequency	F = 0.95, df = 6,35 P = 0.47	F = 1.90, df = 6, 35 P = 0.11
Time X Method X Frequency	F = 0.81, df = 18, 99 P = 0.68	F = 0.81, df = 18, 99 P = 0.68

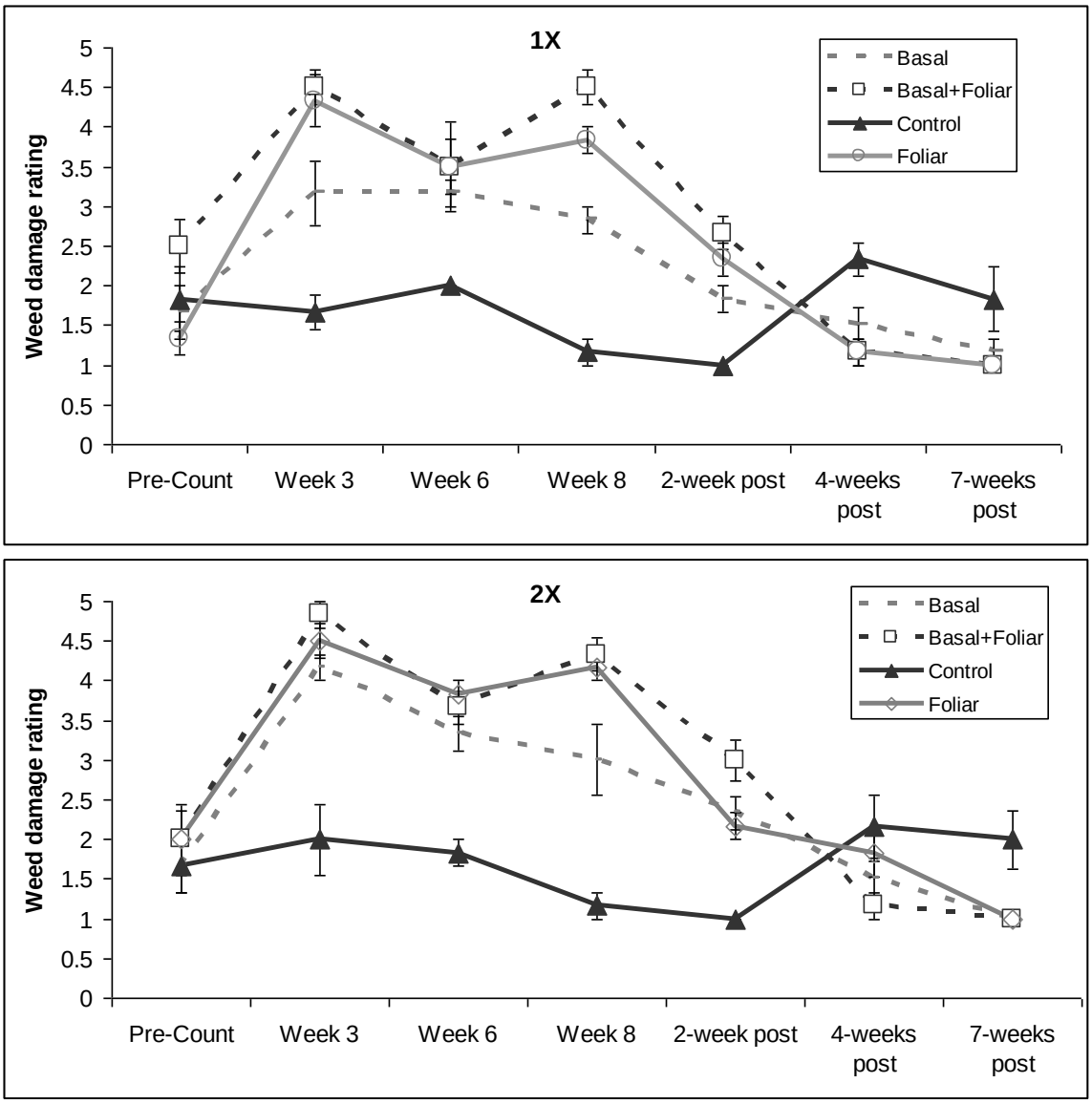

Figure 2. Effect of application method of a 4% acetic acid solution on weed damage in cranberry fields. Plots were treated once a week (top graph) or twice a week (bottom graph). Each point represents the mean ± s.e. of six replicates/treatment/assessment date. Weed damage was assessed prior to treatment and three times during the nine week treatment period and then three times post-treatment.

Cranberry vine damage – Overall, we saw an increase in cranberry vine damage in treated plots during the first 9 weeks of the trial when vinegar was being applied. However, in the 7 weeks post-treatment vines recovered to pre-treatment levels, this lead to an overall significant Time effect (Table 3). Both application Method and Frequency caused significant levels of cranberry vine damage (Table 3). In terms of frequency, applying vinegar twice a week caused slightly higher levels of damage during the first nine weeks when sprays were actively applied. For application method, there was a significant interaction with time (Method X Time) which followed a similar pattern that was observed for weed damage. During the nine weeks of spraying vine damage was

significantly higher in all treated plots than Control plots (Fig. 3). Among the three application methods, vine damage was lower overall for the Basal treatment and significantly different from the Basal + Foliar and Foliar treatments at the Week 8 and 2-week post treatment assessments (Fig. 3). However, 4 and 7-weeks post the last application of acetic acid all treated vines recovered and damage levels were similar to those in the Control plots.

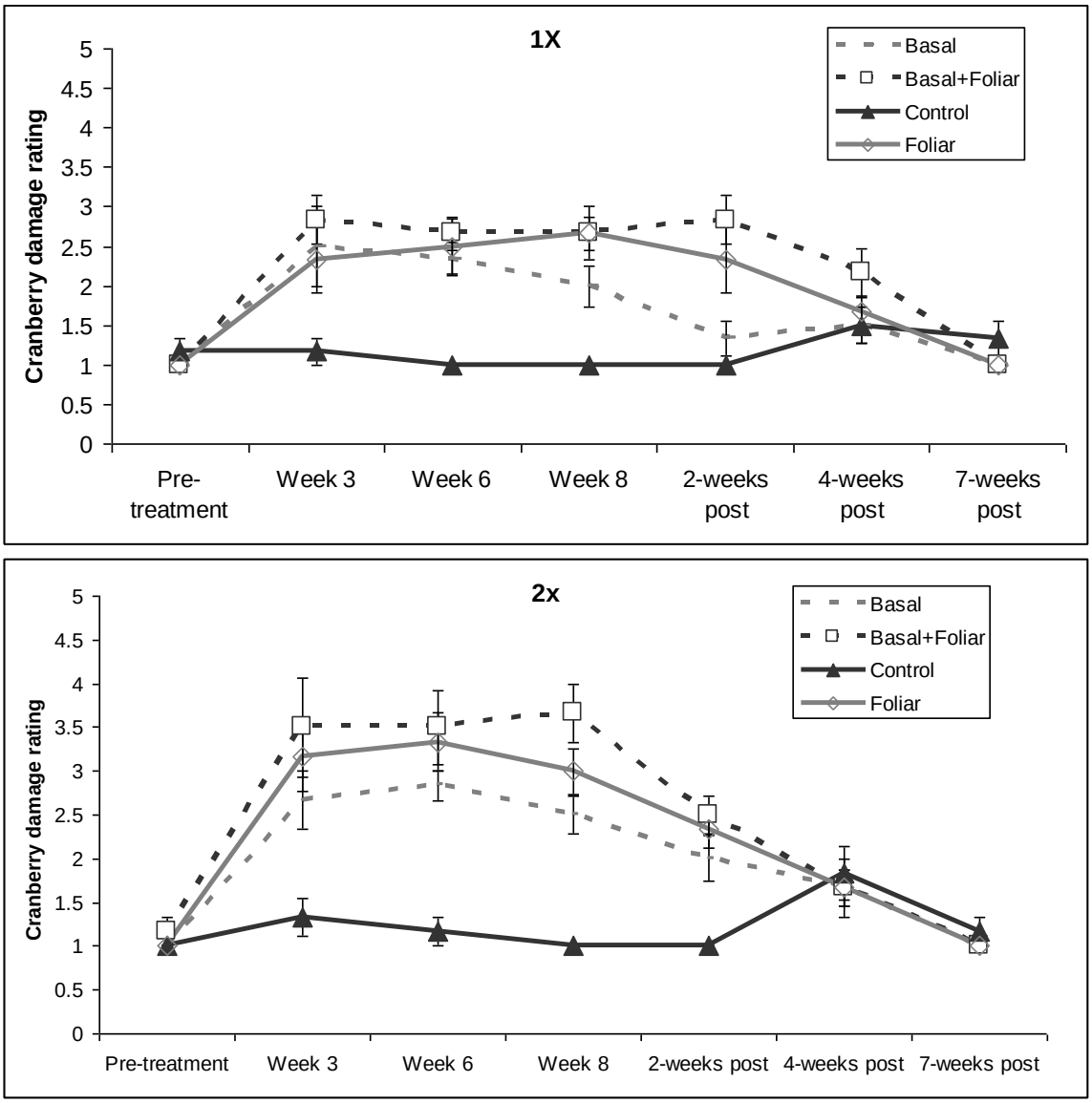

Figure 3. Effect of application method of a 4% acetic acid solution on cranberry vine damage in cranberry fields. Plots were treated once a week (top graph) or twice a week (bottom graph). Each point represents the mean ± s.e. of six replicates/treatment/ assessment date. Cranberry vine damage was assessed prior to treatment and three times during the nine week treatment period and then three times post-treatment.

Discussion The efficacy of horticultural vinegar for post-emergent weed control needs to be better understood in order to support growers wanting to pursue organic cranberry production (Zedlin 2008, AAFC 2007). In this study we examined if modifications to the current practice of herbicide spot application with a backpack sprayer could improve weed control with horticultural vinegar in cranberries. Our study showed that applying vinegar to the base of weeds and targeting the root zone (Basal) caused levels of weed control that were generally at the same level as the Foliar and Basal + Foliar application, but caused overall less damage to cranberry vines than the other two application methods. Additionally we did not find that doubling the frequency of applications from once a week to twice a week increased the level of weed control. Twice weekly applications caused slightly more damage to cranberry vines though, but all vines recovered seven weeks after the last vinegar application. As a pre-caution we did not apply Basal + Foliar treatments during Weeks 5 and 6, and we stopped all sprays at week 10 because visually vine damage looked heavy and we had high levels of weed control in the Basal + Foliar plots. Thus the potential damage to vines from the Basal + Foliar treatment is underestimated in this study because continual weekly spraying for 9 or 10 weeks may have resulted in permanent vine damage.

Although all three application methods resulted in weed control, control was not sustained in any of our plots four and seven weeks after weekly sprays ceased (Fig. 2 and Fig. 4). This was mostly due to the recovery of horsetail. Our findings suggest then that horticultural vinegar on it's own can provide short-term suppression of tough perennial weeds like horsetail but only with an aggressive weekly program. Once there is suppression of horsetail additional approaches to management should be used, e.g. physical removal of re-growth. Horticultural vinegar can damage the foliage of cranberry plants, although plants appear to recover once application ceases (Fig. 2). Our study plots were treated for nine weeks and with a fairly dilute concentration of acetic acid (4%) which has been used in other studies (e.g. Patten 2007). Longer treatment periods may be more effective at providing more permanent control of perennial weeds. However, with longer treatment regimens there is the risk that damage to cranberry vines is permanent and labour costs will also be higher.

Figure 4. Weed control in a representative plot at Week 9 (left) and at 7-weeks post treatment. Note the complete recovery of horsetails.

Another option to improve efficacy of acetic acid for weed control may be to use a higher rate. For example, based on studies in Quebec Painchaud (2010) recommends 9 to 12% acetic acid solution and injection volume of 40ml right into the root zone of perennial weed bunches (6.5 cm deep). Further, the recommendation is for only two treatments using this method. Painchaud (2010) also recommends using acetic acid soil injections when soil humidity is greater than 40% to minimize damage to vine. This type of program may be more effective against perennial weeds here in B.C. however it is important to monitor the duration of control, to ensure that difficult to control perennials - like horsetail - do not re-grow after the initial burn-down. Also different varieties and ages of cranberry vines may be more susceptible to higher concentrations of acetic acid, so caution should be taken when increasing rates to ensure that permanent vine damage does not occur.

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References

Agriculture and Agri-Food Canada (AAFC). 2007. Crop profile for cranberry in Canada. 57 pp.

Canadian General Standards Board (CGSB). 2006. Organic production systems: Permitted Substances List. CAN/CGSB-32.311-2006. 31pp.

Chinery, D. 2002. Using acetic acid (vinegar) as a broad-spectrum herbicide. Cornell University Cooperative Extension Rensselaer County Fact Sheet 7.011

Painchaud, J. 2010. Organic cranberry production. Presented a the Atlantic Cranberry Management Course, Halifax, N.S. March 10 to 12, 2010. http://www.atlanticcranberry.ca/Presentations/PAINCHAUD%20Organic%20Cranberry%20Production%20in%20Quebec.pdf (First accessed August 1, 2010)

Patten, K. 2007. Management of tough perennial and annual weeds. Presentation to BC Cranberry Commission. http://longbeach.wsu.edu/cranberries/ documents/ bccranberrygrowerswinterworkshop-weedcontrol2007.pdf (First Accessed March 1, 2008)

Stein, D. and Rumsey, K. 2008. Vinegar as an herbicide – A new "natural" weed control tool. http://www.pesticide.org/pubs/alts/weeds/vinegarinherbicides.html

Webber III, C.L., Shrefler, J.W., 2006. Vinegar as a burn-down herbicide: Acetic acid concentrations, application volumes, and adjuvants. 2005 Vegetable Weed Control Studies, Oklahoma State University, Division of Agricultural Sciences and Natural Resources, Department of Horticulture and Landscape Architecture. Stillwater, OK. MP-162, 29-30.

Zeldin, E. 2008. Overview of organic cranberry production.http://www.cias.wisc.edu/wp-content/uploads/2008/07/orgcran.pdf (First Accessed September 1, 2008).