2022 Research Project Report

Assessing an herbicide layering strategy in newly renovated and established cranberry fields

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Introduction

Perennial weed management in cranberries remains a challenge because the majority of conventional herbicides registered for use are primarily useful for annual weed management, and provide little control of perennial weeds arising from deep and extensive root and shoot systems. Unlike annual weeds, perennial weeds usually have a larger starting capital and a longer growth period due to their reserves in their storage organs, including rhizomes, stolons, tubers and roots. Although herbicides damage or even kill their leaves and stems, perennial weeds have enough energy stored in the storage organs to regrow a new set of leaves and stems until the nutrient reserves run out (Sandler 2008). Additionally, perennial weed species are seldom controlled by a single herbicide application due to their extensive, and often very deep, underground root and shoot systems. Therefore, a successful perennial weed management must involve forcing weeds to deplete the nutrient reserves by killing the storage organs and by forcing growth of leaves and stems without opportunity to photosynthesize and replenish nutrient reserves (Chicouene 2007; Melander et al. 2012) through an herbicide layering strategy composed of both single and multiple applications of pre-emergence (PRE), post-emergence (POST) and/or post-harvest herbicides (POST-H).

In a region with relatively mild winters such as the southern coast of British Columbia, the period after harvest in winter is the optimal time to treat perennial weeds with post-harvest herbicides. This timeframe goes largely unexploited by cranberry growers for herbicide applications, with little reported use in BC. Like most plants that go dormant in winter, during this period of growth, perennial weeds begin to translocate carbohydrate reserves from the leaves and stems to the overwintering organs from which new plants will originate the following spring (Rashid et al. 2017). Post-harvest herbicides are absorbed into the plant through its leaves and translocated with the carbohydrates to the storage organs, where they can prevent new spring growth from occurring. In the following spring, an application of pre-emergence herbicide at lower label rate can control perennial weed species arising from seeds while minimizing cranberry root injuries. Some herbicides applied post-harvest can have residual effects that can carry into spring, so the pre-emergence herbicide application may not be necessary to control seed germination of perennial weed species. Follow-up with post-emergence herbicides can damage/kill perennial weed plants and thus prevent them from photosynthesizing and replenishing nutrient reserves. Although spot and wipe-on applications of post-emergence herbicides are widely used in cranberries, these practices are slow, labor-intensive and ineffective against the problematic creeping perennial weed species (i.e., field horsetail, sheep sorrel, creeping buttercup and vetch) due to their extensive vegetative structures. Furthermore, while perennial weeds contacted by the wicking apparatus are controlled, those growing lower than the wicking height may escape the treatment. Continuous use of wipe-on application may generate selection pressure that positively selects short-statured weed phenotype. Therefore, it is important to identify a broadcast post-emergence herbicide application strategy (i.e., optimal rate and timing) that can improve perennial weed management and minimize phytotoxicity. The present study aims to identify and evaluate an effective and safe herbicide layering strategy composed of broadcast applications of pre-emergence, post-emergence and/or post-harvest herbicides in order to manage problematic perennial weed species in newly renovated and established cranberry beds.

Materials and Methods

The field experiments were conducted at the Field 5 of the BC Cranberry Research Farm in Delta, BC (49°06'06.1"N, 123°01'36.5"W; hereafter, BCCRF) and the cranberry farm in Pitt Meadows, BC (49°18'23.1"N 122°38'37.7"W; hereafter the Pitt Meadows) in order to evaluate the efficacy of layering post-harvest, pre-emergence and/or post-emergence herbicides on the prevalent perennial weed species in newly renovated and established cranberry fields. The field experiment focusing on weed management in recently renovated cranberry beds was set up at the BCCRF. The field was planted in Spring 2020 with plugs of two-year-old plants, which are still establishing in the field. The field experiment on weed management in established cranberry beds was set up at the Pitt Meadows. The field is well established and is at least 5 years old. Both fields were planted with Rutgers varieties (New Brunswick, New Jersey). The site at the BCCRF was planted with an unreleased numbered variety called "98-11" and the site at the Pitt Meadows was planted with a variety called Mullica Queen®.

In the BCCRF field, weed distribution and density were spatially and temporally heterogeneous throughout the field; therefore, the areas that had uniformly high pressure of sheep sorrel (*Rumex acetosella*) was identified and experimental plots were set up in those selected areas. Each 4 m x 2 m plot was composed of two 2 m x 2 m subplots with one subplot serving as the treated plot while the other as the untreated weedy check plot. The field experiment was designed as a randomized complete design with four replications. In the BCCRF field, woody plants (i.e., blackberry, maple and birch) became dominant throughout the field sites (remnant forest seedbank or any blown in from the surrounding forests) and thus hand-weeding of the established woody plants within the experimental plots were performed. The Pitt Meadow site is highly infested with field horsetail (*Equisetum arvense*). Eighteen weed species were present, but their distribution was heterogeneous and density was very low (less than 15%). Field horsetail (*Equisetum arvense*) is the most prevalent weed species in all the experimental plots (ranged from 60 to 90% density). The field experiment was designed as a randomized complete block design with four replications. The plots were 4 m x 2 m with two-meter buffers between plots on all sides. These buffers were used as weedy-check plots (vs. the adjacent treated plots).

The herbicide types and treatments used in the current study are listed in Table 1, 2 and 3. The post-harvest herbicide treatment was applied on January 26, 2022. As a granular herbicide (i.e., Casoron G4), the post-harvest herbicide treatment was applied using hand-held applicator (Spread-Rite G, PBI Gordon Corp). The pre-emergence herbicide treatments were applied on March 31, 2022. The first and second post-emergence herbicide treatments were applied on April 21 and June 7, 2022, respectively. Both the pre- and post-emergence herbicide treatments were applied using a CO_2-pressurized backpack sprayer equipped with a four-nozzle boom fitted with 8002VS flat-fan nozzles (TeeJet Technologies, Wheaton, IL) spaced 50 cm apart and calibrated to deliver 200 L ha^{-1} at 207 kPa. Following the second post-emergence herbicide treatment application at the hook stage, weed assessment was conducted bi-weekly until harvest. The weed coverage (%) of the target weed species present within each plot was visually scored on a 0% (no coverage) to 100% (complete coverage) scale. The treated plots were compared to the untreated buffers adjacent to each plot to account for the inconsistent weed distribution and cranberry establishment throughout the study sites.

Table 1. Herbicide types and application rates used in the present study.

Trade Name	Active Ingredient	Application rate	Surfactant (if needed)
Devrinol 2XT	Napropamide	4500 g ai ha^{-1}	
Authority 480	Sulfentrazone	140.16 g ai ha^{-1}	
Lontrel XC	Clopyralid	102 g ai ha^{-1}	
Callisto 480SC	Mesotrione	100.8 g ai ha^{-1}	Agral 90 (0.2% v/v.)
Poast Ultra	Sethoxydim	495 g ai ha^{-1}	Merge (1L ha^{-1})
Casoron G-4	Dichlobenil	4400 g ai ha^{-1}	

Table 2. Timing of treatment applications with phenological stages of the cranberry plant in the BC Cranberry Research Farm study site.

Treatment	Phenological stage of cranberry			
	Post-harvest	Pre-bud break	Bud break	Hook
1	-	Sulfentrazone	Clopyralid	Mesotrione + Sethoxydim
2	-	Sulfentrazone	Mesotrione	Mesotrione + Sethoxydim
3	Dichlobenil	-	Clopyralid	Mesotrione + Sethoxydim
4	Dichlobenil	-	Mesotrione	Mesotrione + Sethoxydim
5	Dichlobenil	Sulfentrazone	Clopyralid	Mesotrione + Sethoxydim
6	Dichlobenil	Sulfentrazone	Mesotrione	Mesotrione + Sethoxydim

Table 3. Timing of treatment applications with phenological stages of the cranberry plant in the Pitt Meadows study site.

Treatment	Phenological stage of cranberry			
	Post-harvest	Pre-bud break	Bud break	Hook
1	-	Napropamide	Clopyralid	Mesotrione + Sethoxydim
2	-	Napropamide	Mesotrione	Mesotrione + Sethoxydim
3	-	Sulfentrazone	Clopyralid	Mesotrione + Sethoxydim
4	-	Sulfentrazone	Mesotrione	Mesotrione + Sethoxydim
5	Dichlobenil	-	Clopyralid	Mesotrione + Sethoxydim
6	Dichlobenil	-	Mesotrione	Mesotrione + Sethoxydim
7	Dichlobenil	Napropamide	Clopyralid	Mesotrione + Sethoxydim
8	Dichlobenil	Napropamide	Mesotrione	Mesotrione + Sethoxydim
9	Dichlobenil	Sulfentrazone	Clopyralid	Mesotrione + Sethoxydim
10	Dichlobenil	Sulfentrazone	Mesotrione	Mesotrione + Sethoxydim

Following the second post-emergence herbicide treatment application at the hook stage, phytotoxicity assessment was preformed bi-weekly. Cranberry tolerance to the herbicide treatments have been assessed by visually scoring the crop for overall injury on a 0% (no injury) to 100% (complete crop loss) scale. As the BCCRF experimental plots are the newly renovated fields, evaluating the effect of the herbicide layering program on crop yield/safety assessments was not appropriate. At the Pitt Meadows plots, ripened berries were harvested (hand-picked) on from two 0.25 m^2 areas randomly selected within each plot. Crop residue analysis has been conducted and the result will be available in late January 2023.

Results and Discussion

Weed control efficacy evaluation

In the BCCRF study site, there was no significant effect of the herbicide treatment on sheep sorrel control (Table 4): 14 DAT ($p=0.294$); 28 DAT ($p=0.528$) and 56 DAT ($p=0.555$).

Table 4. Sheep sorrel (*Rumex acetosella*) control compared to the untreated check after the herbicide layering application.

Treatment	14DAT* (June 21, 2022)	28DAT (July 5, 2022)	56DAT (August 5, 2022)
1	65 ± 22% a**	0 % a	10 ± 14% b
2	66 ± 23% a	22 ± 22% a	23 ± 22% b
3	28 ± 19% a	9 ± 9% a	20 ± 11% b
4	23 ± 23% a	36 ± 22% a	28 ± 21% b
5	80 ± 11% a	0% a	17 ± 18% a
6	65 ± 22% a	20 ± 20% a	0 % a

* DAT = days after the second post-emergence herbicide treatment.

** Means followed by the same letter do not differ significantly within columns (p=0.05)

In the Pitt Meadows study site, percent field horsetail control compared to the untreated checks after the herbicide layering treatments is shown in Table 5. Excellent field horsetail control (>95% control) was maintained until the harvest (September 29, 2022) when the post-harvest application of dichlobenil was included in the herbicide layering (the treatment #5 to #10; Table 5). Correlating with the carbohydrate cycles in perennial plants in temperate climates, our results indicate that dichlobenil applied in winter may be absorbed by field horsetail plants and translocated with carbohydrates to their rhizomes where the herbicide can damage or kill the rhizomes and thus prevent new spring growth from occurring. The present study suggests that the pre-emergence herbicide application may not be necessary for field horsetail control when dichlobenil applied in winter is included in the herbicide program (Table 5). Further study should examine whether the post-harvest application of dichlobenil can eliminate the need for post-emergence herbicides while providing excellent (>95%) season-long field horsetail control.

Table 5. Field horsetail (*Equisetum arvense* L.) control compared to the untreated check after the herbicide layering application.

Treatment	14 DAT* (June 21, 2022)	28 DAT (July 5, 2022)	56 DAT (August 4, 2022)	Harvest (September 29, 2022)
1	6 ± 5% a**	1 ± 1% a	26 ± 13% a	18 ± 11% c
2	13 ± 9% ab	7 ± 7 % ab	11 ± 7% a	17 ± 15% c
3	45 ± 21% b	44 ± 20% bc	38 ± 19% a	29 ± 23% bc
4	50 ± 18% b	49 ± 12% c	47 ± 11% a	44 ± 6% a
5	**97 ± 1% c**	**95 ± 2% d**	**95 ± 2% b**	**97 ± 1% abc**
6	**97 ± 2% c**	**99 ± 1% d**	**97 ± 2% b**	**98 ± 1% abc**
7	**98 ± 1% c**	**99 ± 1% d**	**95 ± 9% b**	**94 ± 5% c**
8	**99 ± 1% c**	**99 ± 1% d**	**90 ± 9% b**	79 ± 18% c
9	**98 ± 1% c**	**99 ± 1% d**	**97 ± 1% b**	**97 ± 1% abc**
10	**98 ± 2% c**	**97 ± 1% d**	**97 ± 1% b**	**97 ± 2% ab**

* DAT = days after the second post-emergence herbicide treatment.

** Means followed by the same letter do not differ significantly within columns (p=0.05)

Crop phytotoxicity assessment

At both BCCRF and Pitt Meadows sites, the curling/cupping of cranberry leaves and the curling of vines were observed in the plots where clopyralid was applied at bud break stage. However, the plants recovered subsequently from phytotoxicity (approximately 2-3 weeks after the application), and no apparent effect on growth stage progression was observed as the plants started reaching the hook stage. Crop residue analysis has been conducted and the result will be available in late January 2023.

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