Progress Report for 2007
Weed and other pest control systems for cranberries

Project No: Continuing 13C-4167-1215

Title: Weed and other pest control systems for cranberries

Year Initiated: 1991 **Current Year:** 2007 **Terminating Year:** 2010

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Justification:
Weeds, insects and disease are major problems facing cranberry growers in Washington. The registration of new pesticides for use in the PNW on cranberries is critical to the survival of the industry. Research to help the registration of new pesticides and improve the efficacy of current registration is needed to help solve these major pest problems in the industry.

Objectives:
1) Screen and evaluate new herbicides for their effectiveness in controlling perennial weeds in established cranberry bogs.

2) Evaluate alternative controls for blackvine weevil and cranberry girdler.

3) Evaluate biorational insecticides for control of blackheaded fireworm and tipworm:

4) Implement new cranberry disease management alternatives for domestic and export

Procedures:
Objective 1: Screen and evaluate new herbicides for their effectiveness in controlling perennial weeds in established cranberry bogs.

New herbicides: Several herbicides were screened for efficacy and phytotoxicity. Yellow loosestrife was used as a target weed. These herbicides were selected based on being new reduced-risk products or from previous years' research results. Replicated trials across several sites were conducted at several grower sites. Summary data of efficacy and crop safety are provided in Table 1. Several herbicides caused severe crop damage and are not suitable for cranberries; others had no damage or efficacy. Four potential chemistries include KSU 12800, quinclorac, rimsulfuron and flumiclorac. Based on recent conversations with registrants, an IR4 trail with quinclorac is scheduled for 2008.

Table 1. Summary of herbicide screening for control of yellow loosestrife and general crop phytotoxicity.

Treatment	Timing	% Control	Crop damage
Flumioxazin	Pre	None	None
Isoxaflutole	Pre	None	None
Penoxsulam	Early post	100	Dead
Quinclorac	Early post, two applications	80 to 90	None
Quinclorac	Mid to late post, two application	None	None
Sulfosulfuron	Early post	100	Dead
Flumiclorac	Early post	50 to 80	None to slight
Topramezone	Early post	20	None
KSU 12800	Early post, one application	0 to 100, rate dependent	None to dead
Rimsulfuron	Early post, two applications	50 to 80	None
Mesotrione	Early post, two applications	10 to 20, slight reduction in height	None

Ranunculus, *Rubus and Rumex* control*:*

A management strategy for *Rumex cetosella* was assessed by focusing on a combination of dormant season Stinger applications followed by summer Callisto applications. Replicated plots of these treatments were put out at numerous grower sites. Dormant Stinger, if applied post-harvest with additional follow-up applications, appears to provide good control of Rumex (Table 2).

Table 2. Effect of Stinger and Callisto for management of *Rumex cetosella* (sour dock) at four cranberry beds in Long Beach, Washington in 2007

Herbicide and application date(s)	% control			
	Site 1	Site 2	Site 3	Site 4
Stinger 10/20 + 1/30		76		
Stinger 10/20 + 1/30 + 3/13	92		91	85
Stinger 10/20 + 1/30 + 3/13; Callisto 4/3 + 5/18	91			88
Stinger 3/12; Callisto 4/6 + 5/18				16
Callisto 4/3 + 5/18 + 6/22	2	56		22
Control	0	0	0	0
Treatment Prob (F)	0.001	0.001	0.001	0.001

A management strategy for using Classic for creeping buttercup (*Ranunculus repens*) control was assessed. Classic was applied in February for mature plant control with subsequent Callisto and Devrinol for seedling control. Although Classic showed excellent efficacy on mature plants (Table 3) without seedling control with either a pre-emergent herbicide (Devrinol) or post-emergent herbicide (Callisto), overall control was lost by the end of the season.

Table 3. Buttercup control using Classic for mature plants and Callisto and Devrinol for seedlings in cranberry beds in Long Beach Washington in 2007.

	% Control		
	Site 1	Site two	
Treatment	8/14/2007	6/22/2007	7/23/2007
Control	0	0	0
Classic @ 0.5oz/ac on 2/22/07	47	70	37
Classic @ 0.5oz/ac on 2/22/07 +Callisto @ 8oz/ac on 6/22/07 & 8/3/07	98	63	80
Classic @ 0.5oz/ac on 2/22/07 + Devrinol 60lb/ac 6/14/07 + Callisto @ 8oz/ac 8/3/07	73	83	93
LSD (P=.05)	62	35	30
Treatment Prob(F)	0.0382	0.0047	0.001

LSD= least significant difference value between treatments.

A management strategy for three species of blackberry was assessed using multiple spot treatments of Callisto. Replicated patches of blackberry were treated three times during the season and rated for recovery. All species responded about the same, with Himalayan having slightly more regrowth than cutleaf or creeping blackberry (Table 4). These treatments will continue for several years to determine the length of time required to kill them with Callisto.

Table 4. Effect of three Callisto applications on the recovery of blackberry species in cranberry beds in Long Beach Washington in 2007.*

Blackberry species	% regrowth	% bleaching	% control
Cutleaf blackberry (*R. laciniatus*)	14	18	74
Creeping dewberry (*R. ursinus*)	10	18	66
Himalayan blackberry (*R. discolor*)	32	23	67

* Callisto applied 6/7/07, 7/16/07 & 8/9/07 @ 100 gpa spray volume. Plots rated September/October.

<u>Improving the efficacy of Callisto</u>: Callisto lacks efficacy on several recalcitrant weed species, including yellow loosestrife, *Lysimachia terrestris*. Our research in 2006 suggested that it is likely that the cuticle structure of these species prevents herbicide uptake, and that certain surfactants and use of highly concentrated herbicide solutions (ultra-low spray volumes) improve efficacy. We assessed the efficacy of one, two and three applications of Callisto using various high-end surfactants: invert emulsion (Thinvert), silicon hybrid (Kinetic), and a methylated seed oil with ammonium sulfate (Hasten). Treatments were applied 4/18, 5/19 and 6/18. Only Hasten

+ ammonium sulfate at three applications was partially effective (Table 5). At least for loosestrife, there doesn't appear to be an easy way to enhance efficacy of Callisto by alternating surfactants.

Table 5. Yellowweed control with various surfactants and multiple timings in a cranberry bed in Long Beach Washington in 2007					
	% control			Plant height (in)	% flowering
Treatment	5/25/2007	7/23/2007	8/20/2007	7/23/2007	7/23/2007
Thinvert (99%) 1 application	0	0	0	24	100
Thinvert (99%) 2 applications	5	0	0	17	100
Thinvert (99%) 3 applications	7	3	7	15	50
Kinetic 2 qt/ac 1 application	7	0	0	13	90
Kinetic 2 qt/ac 2 applications	8	10	7	10	0
Kinetic 2 qt/ac 3 applications	18	13	35	10	25
Hasten 2 qt/ac + ammonium sulfate 1 application	22	8	13	13	40
Hasten 2 qt/ac + ammonium sulfate 2 applications	15	3	3	11	23
Hasten 2 qt/ac + ammonium sulfate 3 applications	23	45	68	9	2
LSD (P=.05)	9	17	15	4	28
Treatment Prob(F)	0.0004	0.0022	0.0001	0.0001	0.0001

LSD= least significant difference value between treatments.

<u>Effective herbicides and delivery systems for annual weeds and late season grasses.</u> The efficacy of Select herbicide for late season management of barnyard grass, perennial ryegrass and creeping bentgrass was assessed using different surfactants and spray volumes. The differences between Select and Select Max were subtle and not consistent between sites or grass species (Table 6). Similarly, the effects of surfactants were subtle. Adding ammonium sulfate (Kicker plus) to a crop oil (Agridex) increased phytotoxicity. A nonionic surfactant (R11 or X77) didn't appear to be any less phytotoxic than a crop oil to improve efficacy. More than one application was needed to control perennial grasses treated mid-season. Treating perennial ryegrass with Select @ 12 gpa or 100 gpa did not result in any difference in treatment efficacy (data not shown).

Table 6. Efficacy and phytotoxicity of grass herbicides in cranberry beds in Long Beach WA in 2007.*

		Creeping bentgrass		Perennial ryegrass		Barnyard grass	Cranberry	
		Control rating 1=none, 5=good		% control	Control rating 1=none 5=good	Burndown rating 1=none; 5=100%	Phytotoxicity rating 1=none; 5=dead	
		Number of Applications					One application	Two applications
		One	Two	One	Two		Site one	Site two
Treatment	Rate							
Control		1	1	0	1	1	1	1
Select Max X77	16 fl oz/a 0.25 % v/v	1	5	56.7	4	2.8	1	1
Select Max R11	16 fl oz/a 0.25 % v/v	1	4	48.3	4	2.8	1	1.7
Select Max Agridex	16 fl oz/a 1 % v/v	1	4	55	4	3.8	1.07	1.3
Select Max Agridex Kicker Plus	16 fl oz/a 1 % v/v 1 qt/a	1	4.3	72	3		1.67	1
Select Agridex	8 fl oz/a 1 % v/v	1	3	46.7	3.3	3.3	1.17	1.3
Select X77	8 fl oz/a 0.25 % v/v	1	1.3	39.8	4.3	3.5	1.17	1
Select X77 Kicker Plus	8 fl oz/a 0.25 % v/v 1 qt/a	1	4	67.3	4		2.1	1
Select Agridex	8 fl oz/a 0.5 % v/v	1	5	39.8	4	3.5	1.17	1
LSD (P=.05)			1.1	34.9	17	1	0.2	0.6
Treatment Prob(F)		ns	0.001	0.026	0.0001	0.0001	0.0001	0.1544

*Treatments were applied in early August with 100 gpa spray volume and evaluated in 30+ days after treatment.
LSD= least significant difference value between treatments.

Objective 2: Evaluate biorational insecticides for control of blackvine weevil and cranberry girdler: In 2007 we focused on three main insecticides: rynaxypyr, clothianidin, and metaflumizone. We assessed these insecticides for their efficacy as an adulticide and larvicide. Additional comparisons were made with nematodes treatments and weevil baits. Girdler research focused on nematodes.

Blackvine Weevil: Numerous insecticides (imidacloprid, clothianidin, dinotefuran, chlorantraniliprole, flubendiamide and metaflumizone) and nematodes *(Steinernema kraussei)* were evaluated in growers' fields for larvicidal efficacy on blackvine weevil *(*BVW*)* (*Otiorhynchus sulcatus).* Imidacloprid, clothianidin, metaflumizone and *Steinernema kraussei* were all reasonably effective. The most extensive data set has been obtained for the neonicotinoid insecticide, imidacloprid, which has been registered for use for that effect. Although effective, this treatment lacks adequate efficacy to permanently suppress weevil populations. Research on methods (timing and application methods) to enhance its efficacy has not been too successful. Based on limited data, *Steinernema kraussei* is one of the most effective treatments overall.

Numerous insecticides (thiamethoxam, dinotefuran, clothianidin, chlorantraniliprole and metaflumizone) and sodium silicofluoride-based baits mixed in apple or sugar beet press cake were evaluated in growers' fields for adulticide efficacy on BVW. All products had adulticide activity. Based on one-year of efficacy, metaflumizone was slightly better than other broadcast-applied insecticides. Both apple and beet press cake silicofluoride baits showed efficacy equal to or much better than the commercial Cryolite bait. A combination of bait and broadcast insecticides was required to achieve superlative adult control. From a grower's perspective, use of a larvicide or adulticide alone was not adequate by itself for a control program.

Objective 3: *Evaluate biorational insecticides for control of blackheaded fireworm and tipworm:* Fireworm: Trials on fireworm were conducted in growers' fields to assess the efficacy of flubendiamide, metaflumizone, and rynaxypyr on second generation fireworm larvae. An untreated control and Diazinon treatment were used as comparisons. Treatments will be applied in early July using simulated chemigation (450 gpa application volume followed by 225 gpa rinse) to 6 replicated plots (10' x 10') in abandoned grower beds with high adult moth activity. Efficacy data was based on sweeping beds for larvae, and the amount of feeding damage on foliage. All the new chemistries had reasonable efficacy when applied with high-volume broadcast methods; none have the level of control of Diazinon when applied via chemigation (Table 7). These results are discouraging since efficacy via chemigation is required for an insecticide to be considered a true replacement for an organophosphate. We replicated this study on several other farms, but fireworm populations were never adequate to make inferences. Research on chemigation efficacy will have to be done in subsequent years on additional chemistries. Other trials were conducted with just broadcast application assessing the efficacy of novaluron on second generation fireworm. It was very effective, but needs to be assessed using chemigation.

Table 7. Efficacy of various insecticides for first generation fireworm control at a farm in Long Beach, Washington, in 2007. *									
				# Live larvae from 15 sweeps					
				Small larvae	Medium larvae	Large larvae	Total live & dead larvae from 15 sweeps		
Treatment	Rate		Application method	2 DAT	2 DAT	2 DAT	7 DAT	7 DAT	All dates
DPX-E2Y45	0.066	lb ai/a	Chemigation	5	4	0	13	2	15
BAS320	18.3	fl oz/a	Chemigation	2	5	3	11	13	24
NNI-480	4	oz/a	Chemigation	6	4	0	15	6	22
DIAZINON AG600	2	qt/a	Chemigation	2	1	0	3	3	5
DPX-E2Y45	0.066	lb ai/a	Broadcast	2	2	0	6	5	12
BAS320	18.3	fl oz/a	Broadcast	1	1	2	2	4	7
NNI-480	4	oz/a	Broadcast	1	1	0	3	1	4
DIAZINON AG600	2	qt/a	Broadcast	1	0	0	0	1	2
CONTROL				4	6	4	15	4	20
LSD (P=.05)				2.2	2.5	2.0	8.3	5.0	10.1
Treatment Prob (F)				0.0001	0.0002	0.002	0.0002	0.0013	0.0004
* Broadcast applied @ 280 gpa with no washoff, chemigation applied @ 280 gpa followed by 680 gpa washoff. Four replications of 10' by 12' plots. Treatments applied 5/9/07. LSD= least significant difference value between treatments.									

Tipworm: Trials on tipworm were conducted at two replicated sites (6'x'6' plots, 4 replications) in Grayland, comparing the efficacies of rynaxypyr (DPX-E2Y45), flubendiamide (NNI-480), metaflumizone (BAS320), Spirotetramat (Movento), and *Bacillus thuringiensis* Berliner subsp. *israelensis* (*Bti*) (Gnatrol). An untreated control and Diazinon treatment were used as comparisons. Four applications (10 to 14 days apart) were made, starting with first generation hatch, and continued to mid-July. Efficacy was measured based on the level of undamaged terminals, and larvae and pupae found in tips. By the end of the spray season, all the control data had lost significance because of excessive pressure from surrounding untreated plots. The best efficacy data was collected earlier and is shown in Table 8. Diazinon provided the best control at both sites. Movento had good control at site 1, but was less impressive at site 2. None of the other products provided consistent significant control on par with Diazinon. At the end of the spray season Movento plots had some phytotoxicity in the form of leaf burning. Overall, these results are discouraging; no one product has comparative efficacy to Diazinon. However additional trials with Movento and DPX are warranted.

Table 8. Tipworm control in two farms in Grayland Washington in 2007.								
			Site one			Site two		
			% cupped tips	% terminal buds with foraging damage	% tip with tipworm pupae	% cupped tips	% terminal buds with foraging damage	% tip with tipworm pupae
Treatment	Rate		6/27/2007	6/27/2007	6/27/2007	7/5/2007	7/5/2007	7/5/2007
CONTROL			17	17	9	27	19	12
DPX-E2Y45	0.066	lb ai/a	27	20	5	22	17	12
BAS320	18.3	fl oz/a	17	13	10	29	19	13
GNATROL	128	oz/100 gal	39	33	17	32	29	17
NNI-480	4	oz/a	42	37	17	25	19	10
MOVENTO	16	oz/a	12	5	0	27	15	12
DIAZINON AG600	2	qt/a	5	3	2	12	2	0
LSD (P=.05)			14	11	8	10	11	9
Treatment Prob(F)			0.0001	0.0001	0.0016	0.0136	0.0082	0.0403

* Treatments applied 5/10/2007, 5/24/2007, 6/13/2007, and 6/27/2007 on 4 replicated plots per site. Data collected from 15 uprights per plot. Data collected included larvae, pupae, and damage assessments every two weeks. Only the significant data are shown.
LSD= least significant difference value between treatments.

Objective 4: Evaluate alternative fungicides for control of fruit rots and keeping quality of fresh cranberries: Research in 2007 assessed fruit rot management strategies. Traditional fungicide applications (Bravo at fruit set followed by Maneb in 14 days) were compared with against earlier and more aggressive applications of Echo, Indar, and Abound. All treatments were split with normal or extra N to increased rot. Nitrogen effect on rot and yield didn't show up until year 2, and as expected extra N increase rot, but there was no interaction with fungicide treatment (Tables 9 -14). None of the early fungicide treatment affected fruit rot at harvest or during storage in 2006, but did in 2007. A single extra fungicide applied mid-bloom did not usually reduced fruit rot, while an extra Echo at 50% bloom + Abound 10 days after 50% bloom did consistently reduced fruit rot, especially rot at harvest. Extra fungicide during bloom did not reduced or increase yield. There were several other interesting findings from these studies. At one site with Pilgrim there was an interaction with N rate and fungicide. For total fruit rot (storage + harvest both years) Indar treatment with low N had 21% rot while with high N it has 55% rot. Monkey facing also seemed to be affected by fungicide treatment. There was usually significantly higher monkey facing with the traditional grower fungicide treatment and lower incidence with a mid-bloom Indar treatment was added. Other new fungicides (Omega, Pristine, Cabrio) did not appear to provide any better fruit rot control than Echo or the untreated control (Table 15). Overall, the effects of extra mid-bloom fungicides are subtle and it appears that more than one application may be needed to suppress fruit rot. Observations with monkey facing are interesting in that it suggests that fungicide or fungi might play a role in its development.

Table 9. Comparison of fungicide treatments timings on percent of fruit rot of Pilgrim at harvest at two farms in 2006 & 2007.

Treatment	% Fruit rot @ harvest			
	McPhail 2006	McPhail 2007	Gray 2006	Gray 2007
Normal N	1.6	5	3.0	4.2
Extra N (21-0-0 3x @ 10 lbs N/ac)	2.2	10	3.8	8.4
LSD for N treatment	0.8	2.1	1.1	1.5
Grower treatment: (Echo @ set + Dithane @ 14 days post-set)	2.2	7.6	3.2	7.3
Grower treatment + Abound @ 50% bloom	2.5	7.4	3.3	6.3
Grower treatment + Echo @ 50% bloom	1.6	8.7	3.6	5.7
Grower treatment + Echo @ 50% bloom + Abound @ 10 days after 50% bloom	0.9	4.2	2.8	4.0
Grower treatment + Indar @ 50% bloom	2.5	8.9	4.0	7.9
LSD for fungicide treatment	1.3	3.1	1.8	2.5

LSD= least significant difference value between treatments.

Table 10. Comparison of fungicide treatments timings on % fruit rot six weeks after harvest at two farms in 2006 and 2007.

Treatment	% Fruit rot @ 6 wks after harvest			
	McPhail 2006	McPhail 2007	Gray 2006	Gray 2007
Normal N	1.6	1.7	1.8	12.4
Extra N (21-0-0 3x @ 10 lbs N/ac)	2.3	4.9	2.4	20.5
LSD for N treatment	1.3	1.7	1.0	2.4
Grower treatment: (Echo @ set + Dithane @ 14 days post-set)	2.6	4.1	2.8	16.8
Grower treatment + Abound @ 50% bloom	2.3	4.1	1.7	17.3
Grower treatment + Echo @ 50% bloom	1.7	3.5	2.2	18.2
Grower treatment + Echo @ 50% bloom + Abound @ 10 days after 50% bloom	1.3	1.5	2.0	14.5
Grower treatment + Indar @ 50% bloom	1.9	3.4	1.9	15.5
LSD for fungicide treatment	2.0	2.8	1.8	3.9

LSD= least significant difference value between treatments

Table 11. Comparison of fungicide treatment timings on yield at two farms in 2006 & 2007.

Treatment	Yield (bbl/ac)			
	McPhail 2006	McPhail 2007	Gray 2006	Gray 2007
Normal N	138	277	107	323
Extra N (21-0-0 3x @ 10 lbs N/ac)	144	277	125	338
LSD for N treatment	17	31	14	33
Grower treatment: (Echo @ set + Dithane @ 14 days post-set)	133	253	118	324
Grower treatment + Abound @ 50% bloom	136	258	126	338
Grower treatment + Echo @ 50% bloom	135	299	112	339
Grower treatment + Echo @ 50% bloom + Abound @ 10 days after 50% bloom	137	281	99	300
Grower treatment + Indar @ 50% bloom	163	293	123	350
LSD for fungicide treatment	27	49	22	52

LSD= least significant difference value between treatments

Table 12. Comparison of fungicide treatment timings on % fruit rot on Stevens and Pilgrim at PCCRF farm in 2006 and 2007

Treatment	% fruit rot @ harvest			
	Stevens-2006	Stevens- 2007	Pilgrim-2006	Pilgrim-2007
Normal N	1.8	3.3	3.9	15
Extra N (21-0-0 3x @ 10 lbs N/ac)	1.4	8.5	3.9	25
LSD for N treatment	1.5	2.0	1.1	4
Echo @ set + Dithane @ 14 days post-set	2	6.1	4.5	16
Echo @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	0.9	5.1	3.3	24
Abound @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	1.2	5.7	3.2	22
Indar@ 50% bloom + Echo @ set + Dithane @ 14 days post-set	1.3	5.1	3.5	21
Untreated control	2.6	7.3	5.2	17
LSD for fungicide treatment	1	3.3	2.1	6

LSD= least significant difference value between treatments.

Table 13. Comparison of fungicide treatment timings on % storage rot on Stevens and Pilgrim at PCCRF farm in 2006 and 2007

Treatment	% Fruit rot @ 6 wks after harvest			
	Stevens-2006	Stevens- 2007	Pilgrim-2006	Pilgrim-2007
Normal N	1.6	3.5	0.7	8.2
Extra N (21-0-0 3x @ 10 lbs N/ac)	0.6	5.6	1.3	14
LSD for N treatment	2	1.8	0.6	3.5
Echo @ set + Dithane @ 14 days post-set	0.6	3.3	1	9.6
Echo @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	0.6	4.5	1.5	12.7
Abound @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	1.3	4.3	1	12.1
Indar@ 50% bloom + Echo @ set + Dithane @ 14 days post-set	1.7	4.2	1	11.7
Untreated control	1.0	6.3	0.6	9.6
LSD for fungicide treatment	3.0	2.9	0.6	5.6

LSD= least significant difference value between treatments.

Table 14. Comparison of fungicide treatment timings on yield and % fruit rot on Stevens and Pilgrim at PCCRF farm in 2006 and 2007

Treatment	Yield (bbl/ac)			
	Stevens-2006	Stevens- 2007	Pilgrim-2006	Pilgrim-2007
Normal N	113	169	133	347
Extra N (21-0-0 3x @ 10 lbs N/ac)	129	176	112	384
LSD for N treatment	13	24	17	41
Echo @ set + Dithane @ 14 days post-set	110	159	123	379
Echo @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	108	161	111	359
Abound @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	128	179	138	366
Indar @ 50% bloom + Echo @ set + Dithane @ 14 days post-set	138	183	131	381
Untreated control	122	181	106	344
LSD for fungicide treatment	20	39	27	65

LSD= least significant difference value between treatments.

Table 15 . Fruit rot control with new fungicides on a Pilgrim bed in 2006 and 2007**.**

Treatment	Bbl/ac 2006 + 2007	% Harvest + storage rot 2007	% harvest rot 2006 + 2007	% total harvest + storage rot 2006 + 2007
Echo @ 50% bloom, 50% fruit set & 2 week after 50% fruit set.	497	4	5	9
Pristine @ 50% bloom, 50% fruit set & 2 week after 50% fruit set.	546	12	8	16
Cabrio @ 50% bloom, 50% fruit set & 2 week after 50% fruit set.	564	11	8	18
Omega @ 50% bloom, 50% fruit set & 2 week after 50% fruit set	577	9	5	12
Untreated control	577	6	4	10
LSD for fungicide treatment	106	5	4	7

LSD= least significant difference value between treatments.