WSDA SPECIALTY CROP BLOCK GRANT PROGRAM
FINAL PERFORMANCE REPORT

Grant Agreement Number: **WSDA Contract No. K282**

Report Submitted By: Timothy W. Miller, Washington State University, Northwestern Washington Research and Extension Center, Mount Vernon, WA 98273 twmiller@wsu.edu, (360) 848-6138

Project Summary

1. Provide a background for the initial purpose of your project. Include the specific issue, problem, or need that was addressed by the project.

Cane burning, chemically removing the first primocanes produced by red raspberry in the spring, is commonly practiced in the Pacific Northwest. The practice was first described by scientists in Washington and Oregon in the early 1970's, and was developed to aid in the machine harvest of the predominant raspberry cultivar at the time ('Willamette') using the herbicide dinoseb. This practice is now used on approximately 95% of raspberries in Washington. The goal of this research was to determine whether cane burning current Pacific Northwest red raspberry cultivars with currently available herbicides improves berry yield as dramatically as cane burning did when it was first developed. Our research hypothesis was that that cane burning is not as important as it was during its development and may be dropped from current raspberry production practices without resulting in lost yield or unacceptable losses in weed control.

This project measured the effects of cane burning herbicides in two older and three newer red raspberry cultivars ('Meeker' and 'Coho' and 'Cascade Bounty', 'Chemainus', and 'Saanich', respectively). Data generated included (1) effectiveness of five herbicides for managing primocanes; (2) injury to floricanes, including visual symptoms and berry yield; and (3) weed control. Treatments included a residual herbicide (terbacil, Sinbar) applied to dormant raspberries or cane burning products (carfentrazone (Aim), oxyfluorfen (Goal), pyraflufen (Vida), glufosinate (Rely), and saflufenacil (Treevix)) applied to emerging primocanes. In off-station trials, weed control and primocane growth were monitored and those plots were machine harvested each season. In on-station trials, weed control, yield, and primocane growth were monitored as well as herbicide effects on floricane fruiting laterals (counts of flowers, fruiting sites). At the end of the season, final primocane measurements were collected and time required for pruning and training was recorded. The project was conducted from 2010 to 2012, with the same plots receiving the same treatment each year.

2. Establish the motivation for your project by presenting the importance and timeliness of the project.

An estimated 95% of red raspberry producers in Washington cane burn at least once per season, depending on the health and vigor of their raspberry planting. Herbicide cost alone ranges from $30 to $50/acre to cane burn, translating to an estimated $475,000 on the 9,500 acres of red raspberries harvested each year. Over a ten-year lifespan for a raspberry planting, Washington growers may spend as much as $4.5 million on this practice. Since this project could confirm the hypothesis that cane burning certain PNW red raspberries does not significantly improve berry yield, growers of those cultivars might be able to reduce their use of these cane burning herbicides, potentially saving growers the cost of the products as well as their cost of application. Because this project also evaluated the effect of cane burning on weed control, we could also gauge the necessity of replacing the cane burning herbicide application with a different residual product, potentially off-setting some of those savings. Consequently, it was anticipated that this project would better identify the value of the cane burning practice for red raspberry producers and result in more profitable raspberry growing enterprises.

3. If the project built on a previously funded SCBGP project, describe how this project complimented and enhanced the previously completed work.

This was a new project.

Project Approach

4. Briefly summarize the activities performed and tasks achieved during the project period. Whenever possible, describe the work accomplished in both quantitative and qualitative terms. Include the significant results, accomplishments, conclusions and recommendations. Describe favorable and unusual developments.

A Master of Science student, Yushan Duan, began on assistantship on the project in January, 2010. She attended classes at WSU in Pullman during spring and fall semester, 2010, and was at the WSU Mount Vernon Northwestern Washington Research and Extension Center (NWREC) in the summers of 2010 and 2011. She completed her MS in fall, 2011, but continued on the project through 2012 and, with the exception of final pruning and training, has completed the field work for Field experiments #1 and #3 during the third and final year of the project.

Field Trial #1. This trial was designed for large-plot primocane management comparisons. Two red raspberry cultivars were tested in 2010 ('Meeker' and 'Coho'), both fields owned and managed by Sakuma Brothers Farms near Burlington, WA. Plots measured at least 300 feet long (one row per plot). A third site with similar plot sizes was added for 2011 and 2012, a 'Cascade Bounty' field near Lynden, WA (Truman Sterk, Cooperator). 'Meeker' plots were tested from 2010-2012; 'Coho' plots were inadvertently oversprayed by the cooperator in 2011, so that trial was dropped in 2011. Treatments in 'Meeker' and 'Coho' were Aim alone, Goal alone, Sinbar alone, Aim + Sinbar, Goal + Sinbar, and a nontreated check, replicated three times. In 'Cascade Bounty', treatments were Aim, Goal, and Sinbar each used alone, and a nontreated check, replicated three times. Herbicides were applied in April of each year when primocanes were about 6 inches tall. Primocane re-growth (diameter and height) and weed control were measured biweekly through each summer. Berries were machine-harvested approximately every three days by the cooperator during July and August of each year, and berry weight from each harvest was recorded. Primocane growth data from 2010 and 2011 were provided in earlier reports, so we will present only 2012 measurements in this report.

Berry yield. In all Field Trial #1 treatments, only applications to 'Meeker' resulted in significantly increased yield (Table 1). No treatments improved 'Meeker' total berry yield in 2010, while all treatments except Sinbar alone increased yield in 2011 and 2012 compared to nontreated 'Meeker'. Berry yield in the three year average followed the same pattern, except even Sinbar alone improved yield compared the nontreated raspberry, although Sinbar alone resulted in similar berry yield as did Aim applied alone. Given that treatment with Aim + Sinbar and Goal + Sinbar yielded more berries than did Sinbar alone, the lower yield from Sinbar alone was probably due to poorer weed control (discussed below) or reduced primocane growth during fruiting rather than herbicide injury.

Neither 'Coho' in 2010 nor 'Cascade Bounty' in either 2011 or 2012 produced significantly more berries than did nontreated raspberries, nor did they produce more fruit than raspberries treated with Sinbar alone (Table 1). The trend in the data, however, was toward that same conclusion in both cultivars; that is, cane burning resulted in nonsignificant numerical increases in berry production.

Primocane growth rate. 'Meeker' primocane growth rate was reduced by all treatments until 68 days after treatment (DAT) in 2012 (Figure 1). Growth rate of primocanes treated with Sinbar alone was greater than when applied in sequence cane burning herbicides, or by cane burning herbicides alone. By 87 DAT, primocanes in all herbicide treated plots were growing as quickly as nontreated primocanes. 'Meeker' primocanes in 2012 responded to cane burning herbicides in a similar manner as in previous years (growth reduction until 78 DAT in 2010 and 80 DAT in 2011, data not shown). Differential growth from Aim or Goal in 2012 was not as pronounced as in previous years, however. 'Cascade Bounty' primocane growth rate was

reduced by Goal for the entire season, although the difference was slight by about 77 DAT (Figure 2). Aim also reduced primocane growth rate from 54 DAT through the rest of the season. Primocanes treated with Sinbar grew similarly to nontreated primocanes until the last measurement at 109 DAT, at which time growth rate slowed slightly. In 2011, 'Cascade Bounty' primocane growth rate was reduced by Goal until 80 DAT, and by Aim and Sinbar until 48 DAT (data not shown).

Weed control. In 'Meeker' (2010-12) and 'Coho' (2010), Sinbar applied with or without caneburning herbicides gave the best August weed control, exceeding 84% (Table 2). There were subtle differences between Aim and Goal in 'Meeker' over time. Weed control with Goal initially was superior to Aim (2010), but by 2012, weed control with Goal alone was only 16% compared to 46% with Aim alone. This result was primarily due to poor control of common chickweed (*Stellaria media*) by Goal over the three years, although the combination treatment of Goal + Sinbar was poorer than Aim + Sinbar by 2012 (84 and 96%, respectively). In 'Cascade Bounty', initial weed populations were very low, resulting in no significant treatment effect in 2012 (85 to 93% among treatments). It appears, then, that under conditions of low weed pressure, that cane burning herbicides can provide adequate weed control even when used alone. Under higher weed pressure, however, residual herbicides are necessary to maintain acceptable weed control, and that combination/sequential applications of cane burning herbicides with a residual product may be superior to residual products alone.

Table 1. Total berry yield (kg/ha) in the first trial (2010-2012).

Treatment	Application Rate	2010	2011	2012	Average
Meeker		kg/ha	kg/ha	kg/ha	kg/ha
Aim	0.09 kg ai/ha	7716	8579 a	7,057 ab	7784 ab
Goal	0.47 kg ai/ha	9373	9450 a	7,052 ab	8625 a
Sinbar	1.34 kg ai/ha	8007	7940 ab	6,205 bc	7384 b
Aim + Sinbar	0.09 kg ai/ha+ 1.34 kg ai/ha	9310	9135 a	8,132 a	8859 a
Goal + Sinbar	0.47 kg ai/ha+ 1.34 kg ai/ha	8744	9166 a	7,892 a	8601 a
Non-treated	-	6758	6250 b	5,121 c	6043 c
Coho					
Aim	0.09 kg ai/ha	4,099	---	---	4,099
Goal	0.47 kg ai/ha	4,921	---	---	4,921
Sinbar	1.34 kg ai/ha	4,638	---	---	4,638
Aim + Sinbar	0.09 kg ai/ha+ 1.34 kg ai/ha	4,449	---	---	4,449
Goal + Sinbar	0.47 kg ai/ha+ 1.34 kg ai/ha	4,887	---	---	4,887
Non-treated	-	3,646	---	---	3,646
Cascade Bounty					
Aim	0.09 kg ai/ha	---	10,163	8,261	9,212
Goal	0.47 kg ai/ha	---	11,135	8,396	9,766
Sinbar	1.34 kg ai/ha	---	10,755	7,618	9,187
Non-treated	-	---	9,794	7,154	8,474

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method ($P < 0.05$).

Table 2. Weed control (%) in August in Meeker and Cascade Bounty (2010-12).

Cultivar	Treatment	Weed control		
		2010	2011	2012
Meeker	Aim	60 c	55 b	46 c
	Goal	70 b	47 b	16 d
	Sinbar	92 a	91 a	82 b
	Aim + Sinbar	89 a	96 a	96 a
	Goal + Sinbar	95 a	96 a	84 b
Coho	Aim	51 b	---	---
	Goal	52 b	---	---
	Sinbar	95 a	---	---
	Aim + Sinbar	95 a	---	---
	Goal + Sinbar	97 a	---	---
Cascade Bounty	Aim	---	96 b	93
	Goal	---	98 ab	85
	Sinbar	---	100 a	91

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

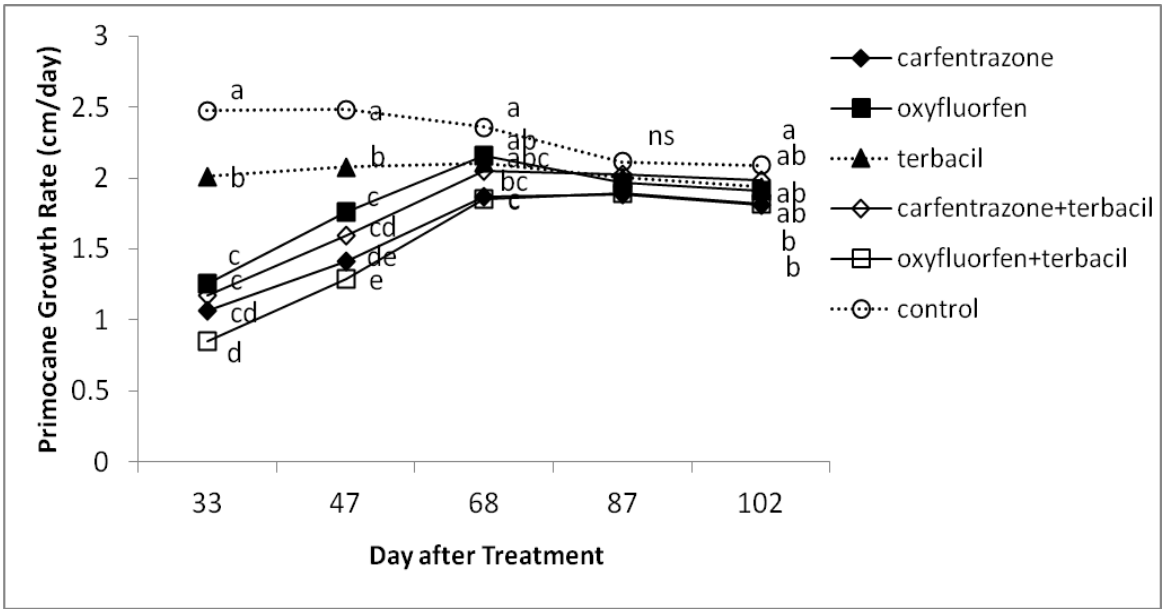

Figure 1. Meeker primocane growth rate (cm/day) in the off-station trial (2012). Products tested were Aim (carfentrazone), Goal (oxyfluorfen) and Sinbar (terbacil). Means at each date followed by the same letter are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

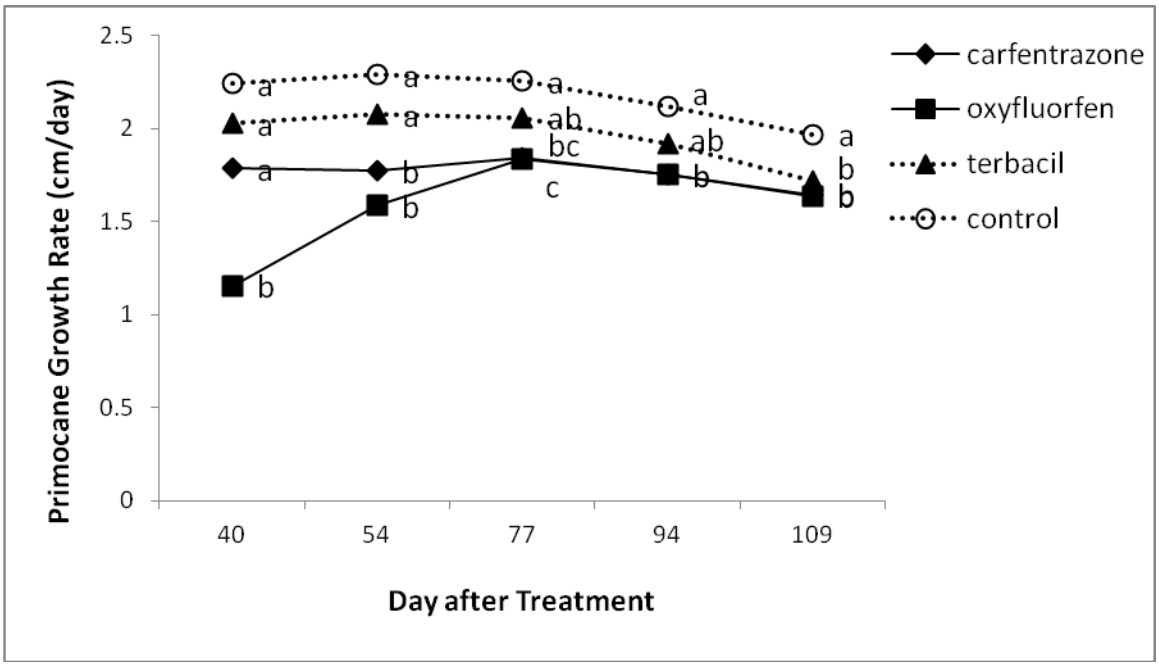

Figure 2. Cascade Bounty primocane growth rate (cm/day) in the off-station trial (2012). Products tested were Aim (carfentrazone), Goal (oxyfluorfen), and Sinbar (terbacil). Means at each date followed by the same letter are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

Field Trial #2. This trial was designed for small-plot primocane management comparisons between 'Meeker' and 'Cascade Bounty' raspberries established in 2006 at WSU NWREC. Plots measured 30 feet long (one row per plot), replicated five times. Treatments were Aim, Goal, or a nontreated check and the same plots were used in all years. Cane burning herbicides were applied in April of each year, when primocanes were about 6 inches tall. Primocane re-growth (diameter and height) was measured biweekly through each summer. Berries were machine-harvested during July and August of each year, and berry weight from each harvest was recorded. Following harvest, two floricanes were randomly selected per plot for vegetative and reproductive measurements (height, diameter, lateral length, fruiting site counts). Also, the time it took to prune and train these cultivars was recorded during the first two winters of the trial to determine cane burning affects to this aspect of raspberry production; pruning and training time will be recorded later in 2012 for the third and final year of this project. Primocane growth data from 2010 and 2011 were provided in earlier reports, so we will present only 2012 measurements in this report.

Berry yield. Yield was significantly affected by cane burning treatment and between cultivars in two of three years; the interaction between these effects was not significant in any year nor in the 3-year average. Treatment with Goal increased raspberry yield in 2010 and 2011, but not in 2012 nor in the 3-year average (Table 3); treatment with Aim increased berry yield only in 2011. Although not statistically significant, the trend in the data was for higher yield from cane burning in all three years, however. 'Meeker' produced more berries than 'Cascade Bounty' in 2010 and 2011, and the 3-year average production of 'Meeker' was 28% greater than 'Cascade Bounty'. Even in 2012, when fruit yield did not differ by cultivar, the trend was for more fruit from 'Meeker'. As in Field Trial #1, the lack of interaction between cane burning herbicide and cultivar indicates that although neither cultivar responded individually to cane burning, cane burning increased berry yield when the two cultivars were averaged together.

Primocane growth rate. Cane burning herbicides slowed primocane growth in 'Meeker' until 67 DAT (Figure 3). Suppression by Goal continued until 82 DAT, after which treated primocanes grew similarly to nontreated primocanes. 'Cascade Bounty' primocane growth was suppressed essentially season-long by cane burning, although growth following treatment with Goal was similar to nontreated primocane growth by 115

DAT. In previous years, cane burning reduced primocane growth rate of 'Meeker' until about 68 DAT, while cane burning reduced primocane growth rate of 'Cascade Bounty' until about 98 DAT. 'Meeker' primocane growth rate did not greatly differ whether treated by Aim and Goal in any year, but Goal suppressed 'Cascade Bounty' primocane growth about 14 days longer than Aim in 2010 and 2011.

Nontreated 'Cascade Bounty' primocanes initially grew faster than 'Meeker' primocanes in 2012, although growth was similar between the two cultivars from 52 to 97 DAT (Figure 3). By 115 DAT, nontreated 'Meeker' primocane growth was greater than for 'Cascade Bounty'. This pattern was similar to primocane growth observed in previous years, so it appears that 'Cascade Bounty' primocanes grow more quickly early in the season then gradually slow, while 'Meeker' primocanes grow more quickly from mid-season on. This may help to explain some of the differential weed control from the two sites in Field Trial #1, as early-season 'Cascade Bounty' primocane growth may result in quicker bed shading and therefore greater competition to weeds.

Dormant Season. In 2010-11, pruning and training 'Meeker' took 20% longer than 'Cascade Bounty', equivalent to about 36 additional hr/ha (Table 4). Total time spent on 'Meeker' was reduced by an average of 45 hr/ha (18%) by cane burning. Both Aim and Goal were equally effective for reducing training time of 'Meeker'. Training time for 'Cascade Bounty' was not improved by cane burning, although there was a trend toward reduced training time after treatment with Goal. In 2011-12, pruning and training time was not reduced by cane burning for either cultivar. Similar to the previous year, 'Meeker' took 22% longer to prune/train than did 'Cascade Bounty'

In general, pruned primocane biomass was not significantly different between cultivars after cane burning in 2010-11, although 'Meeker' produced less biomass than 'Cascade Bounty' when not cane burned (Table 5). Furthermore, pruned primocane weight from plots treated with Goal was 49 and 58% less with both 'Meeker' and 'Cascade Bounty', respectively, than for nontreated plots. Pruned primocane weight of 'Meeker' following Aim treatment was similar to that of nontreated 'Meeker', but Aim reduced 'Cascade Bounty' primocane biomass by 43% compared to nontreated 'Cascade Bounty'. Primocane weight was generally greater in 2011-12 than in the previous year, but response to cane burning herbicides was similar. Goal reduced pruned 'Cascade Bounty' and 'Meeker' primocane biomass by 44 and 33%, respectively, compared to nontreated raspberries, while Aim reduced pruned primocane biomass by 26 and 21%, respectively. Pruned primocane biomass of 'Meeker' was 39% less than 'Cascade Bounty in 2010-11 and 29% less in 2011-12.

Table 3. Total berry yield (kg/ha) in the second trial (2010-2012).

Treatment	Rate	2010	2011	2012	Average
		kg/ha	kg/ha	kg/ha	kg/ha
Aim	0.09 kg ai/ha	7309 ab	5483 a	6792	6528
Goal	0.47 kg ai/ha	8015 a	6018 a	6729	6921
Nontreated	-	6155 b	4063 b	5815	5344
Cultivar					
Cascade Bounty	---	6203 b	4692 b	6027	5640 b
Meeker	---	8116 a	5685 a	6864	6888 a

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method ($P < 0.05$).

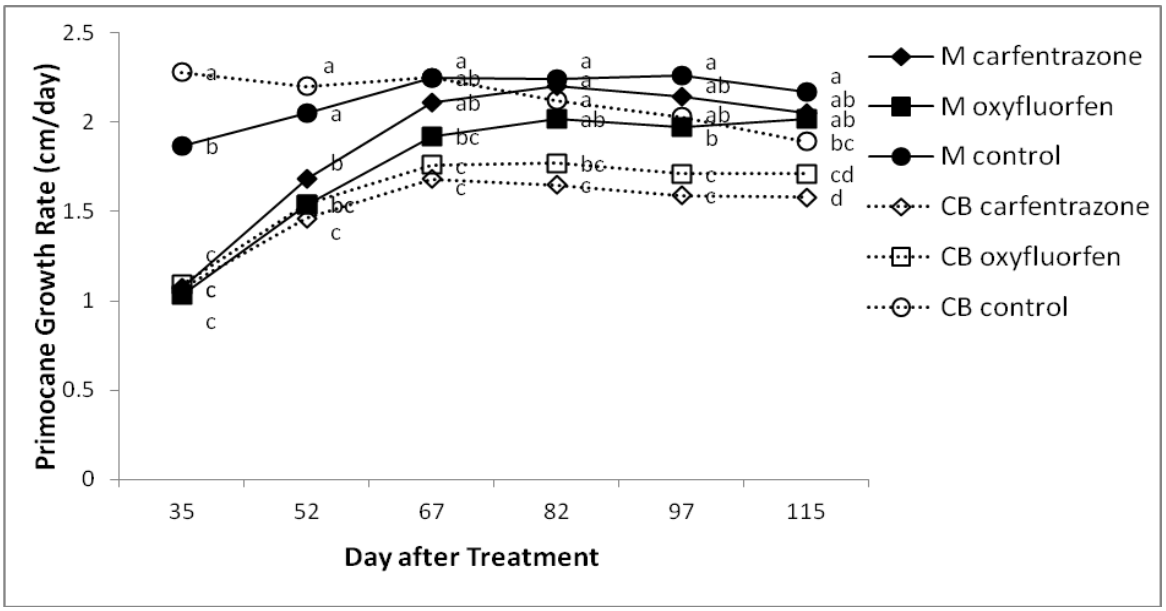

Figure 3. 'Meeker' and 'Cascade Bounty' primocane growth rate (cm/day) in on-station trials (2012). Products tested were Aim (carfentrazone), Goal (oxyfluorfen). Means in each date followed by the same letter are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

Table 4. Total dormant-season training time (hr/person/ha).

Treatment	Cultivar		Treatment mean
	Meeker	Cascade Bounty	
2010-11			
Aim	204 b	186 a	196 B
Goal	207 b	168 a	186 B
Non-treated	250 a	189 a	218 A
Cultivar mean	218 A	182 B	
2011-12			
Aim	100	82	91
Goal	97	85	91
Non-treated	106	81	94
Cultivar mean	101 A	83 B	

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

Table 5. Weight (kg/ha) of primocanes pruned off the bed.

Treatment	Cultivar		Treatment mean
	Meeker	Cascade Bounty	
2010-11			
Aim	1396 bc	1946 b	1671 B
Goal	925 c	1411 bc	1168 B
Non-treated	1829 b	3389 a	2609 A
Cultivar mean	1383 B	2249 A	
2011-12			
Aim	2491 a	3857 ab	3174 AB
Goal	2234 a	3201 b	2628 B
Non-treated	3351 a	4853 a	4103 A
Cultivar mean	2759 A	3910 B	

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

Field Trial #3: The red raspberry cultivars 'Meeker', 'Chemainus', 'Saanich', and 'Cascade Bounty' were transplanted into a new block at WSU NWREC in 2010. Cane burning was conducted on these raspberries using the nonregistered herbicides Vida (pyraflufen), Treevix (saflufenacil), and Rely (glufosinate) in April of 2011 and 2012. Berries were picked by hand three times in 2011 and by three machine harvests in 2012.

Berry yield. Total fruit yield differed by herbicide application in 2012 and also by cultivar, but there was no interaction between those two main effects. Berry yield was improved 25 to 30% by Treevix, compared to the other two cane burning herbicides or to nontreated raspberries (Table 6). Berry yield was higher in 'Saanich' than in either 'Cascade Bounty' or 'Meeker', while 'Chemainus' yielded similarly to both 'Cascade Bounty' and 'Meeker'. Lack of interaction between herbicide and cultivar indicates that cane burning was not a consistent factor in yield among these cultivars, at least in two- or three-year old raspberries.

Table 6. Total fruit yield after application of cane burning herbicides (2011-12).

Treatment	Rate	2011	2012
	product/a	lb/acre	lb/acre
By herbicide			
Vida	5.5 fl.oz	1486	1047 b
Treevix	1 oz	1714	1500 a
Rely	77 fl.oz	1667	1027 b
Non-treated	---	1454	1146 b
By cultivar			
Cascade Bounty	---	2947 a	1061 b
Chemainus	---	768 c	1232 ab
Meeker	---	328 d	924 b
Saanich	---	2278 b	1503 a

Means in each column followed by the same letter, or not followed by a letter, are not significantly different based on Tukey's Honestly Significant Difference method (P< 0.05).

5. Describe the significant contributions and roles of project partners.

Grower cooperators were excellent to work and invaluable for completion of this project. Obtaining yield data on grower fields and using their harvest equipment added credibility and insured that other growers could

easily believe the results and likely see a similar response on their own fields. Both cooperators were excited about the research, and very interested in seeing the results on their own farm.

Goals and Outcomes Achieved

6. Describe the activities that were completed in order to achieve the performance goals and Expected Measurable Outcomes for the project.

Completed activities included off-station tests with 'Meeker' (three years), 'Cascade Bounty' (two years), and 'Coho' (one year) and two on-station tests: one with 'Meeker' and 'Cascade Bounty' (three years) and a second with 'Meeker', 'Cascade Bounty', 'Chemainus', and 'Saanich' (two years). A survey of Washington red raspberry producers provided baseline information about grower attitudes about cane burning prior to reporting on project findings. Portions of the project still remaining to be accomplished include the effects of cane burning on pruning and training (two years have been collected and the third year will be completed in November-December, 2012) and the final survey of grower attitudes (to be conducted after training (Lynden, December 2012) and completion of fact sheet reporting on these results).

7. If any Expected Measurable Outcomes were long term, summarize the progress that has been made towards their achievement.

Only short- and mid-term outcomes were expected from this project.

8. Provide a comparison of the activities and goals established for the project with the actual accomplishments.

The project experimentation was very successful, with most of the anticipated work actually occurring. A few tasks were, however, not successfully accomplished. First, not as much field data was obtained as was hoped in Field Trial #1. Only three cultivars were tested, primarily because the new raspberry cultivars we were interested in including in our trial were either not available for long-term testing on grower fields, or not as large as we needed for a minimum level of testing (treatments of Aim, Goal, Sinbar, and nontreated was considered to be the minimum level). This shortcoming was alleviated through testing of four cultivars in Field Trial #3, including the cultivars in which the primary interest lay ('Meeker', 'Cascade Bounty', 'Saanich', and 'Chemainus'). Goal setting may have also been too ambitious in the desire to have measureable results by the end of the project. While this portion of the project will be successfully completed, it will not occur for several months.

Despite these shortcomings, good data were generated that indicate that cane burning may not always be necessary in PNW raspberries. Conclusions from this research are as follows:

Berry Yield. Cane burning increased berry yield of 'Meeker' in two years of three, averaging 29 to 47% greater yield in treated plots over three years. At least some of this increase resulted from weed control, as residual herbicide alone increased yield by 22%. Conversely, 'Cascade Bounty', 'Coho', 'Saanich', and 'Chemainus' berry yield was not significantly increased by cane burning. There was a trend in the data suggesting that yield was marginally better in treated plots, but the numerical increase was within the margin of error for each trial. Although yield of individual cultivars was not greater with cane burning, when 'Meeker' and 'Cascade Bounty' yields were averaged together, raspberry yield was increased by treatment with either Goal or Aim during two of three years. Treevix also increased berry yield when yields of two- or three-year-old 'Meeker', 'Cascade Bounty', 'Saanich', and 'Chemainus' was averaged together.

Primocane Growth. Primocane growth rate was slowed by use of cane burning products for about 70 to 80 days. Goal slowed growth rate slightly longer than did Aim in both 'Meeker' and 'Cascade Bounty'. Biomass of pruned primocanes that had to be removed during the dormant-season did not differ between Goal and Aim treatments, although pruned primocane biomass tended to be marginally greater with Aim than with Goal.

Product Choice. There did not appear to be much difference between Aim and Goal in the cultivars used in this trial when applied at the tested rates. Goal slowed primocane growth longer than did Aim, but yield was not statistically increased. These products were generally inadequate for weed control unless a residual product was also used. This was particularly true in fields were weed pressure was higher, in particular when common chickweed was present, where Goal performed more poorly than Aim. Of single applications of the three nonregistered products, Treevix was more effective than Vida or Rely, significantly increasing berry yield of three-year-old raspberries.

Cultivar Choice. In side-by-side comparisons, 'Meeker' produced 18% more fruit than did 'Cascade Bounty'. 'Cascade Bounty' also produced about 30 to 40% more primocane biomass that had to be removed during dormant-season pruning. Despite this, 'Meeker' required significantly more time to prune and train than 'Cascade Bounty', about 20% longer in both years. In their first two harvests, 'Saanich' and 'Cascade Bounty' produced more fruit than 'Chemainus' or 'Meeker'. This is an indication of the relative precociousness of these cultivars, although it may also be partly due to more winter injury suffered by 'Meeker' than other cultivars.

9. Clearly convey the achievement of your Expected Measurable Outcomes by describing the baseline data that was gathered and the achievement (or progress toward achievement) of your set targets.

Some of the more pertinent results from the baseline survey include:

(1) 80% of survey responders (24 growers) grow 'Meeker' raspberry, and 92% of those growers practice cane burning on that cultivar. 'Chemainus', 'Saanich', and 'Cascade Bounty' account for a combined 27% of growers (8 growers), and 100% of those varieties are cane burned each year.

(2) At least 70% of growers cane burn to increase yield, to provide weed control, or to improve harvest efficiency.

(3) 89% of growers use Aim to cane burn, followed by 59% who use Gramoxone (paraquat), 30% who use Goal, and 19% who use a combination of herbicides.

(4) 67% of these growers would consider modifying their primocane management programs based on data from this project, while 30% said "maybe" and 4% said they wouldn't consider changing.

Our goal was to increase the knowledge of red raspberry producers about the benefits and risks of cane burning as a primocane management strategy. Our target was that by 2013, one third of surveyed red raspberry growers will test a primocane management program that does not include cane burning. As the field portion of this research was conducted, preliminary results were reported at grower meetings (such as the Western Washington Small Fruit Workshop in Lynden, WA and WSU Extension/Whatcom Farmers/Skagit Farmers/Wilbur-Ellis grower meetings) and growers were informed of year-to-year progress toward confirmation of the research hypothesis. At the end of these grower meetings (the last is scheduled for early December, 2012) and following production of the final cane burning fact sheet (March, 2013), growers will be asked about their beliefs and thoughts about cane burning and, if they currently practice cane burning, whether they may consider changing their program in response to this new information. This will provide data as to whether our target outcome is being achieved.

Beneficiaries

10. Describe those who have benefited from the completion of your project and its accomplishments.

Raspberry producers in the PNW will clearly benefit from the results of this research project. Showing that the raspberry cultivars 'Cascade Bounty', 'Chemainus', 'Coho', and 'Saanich' did not produce significantly more berries in response to cane burning will give producers of those cultivars an additional data to consider when deciding whether to cane burn or not in future years. It will also bring home in a tangible way the benefit of cane burning to reduce pruning and training costs in 'Meeker' during the dormant season (one year of two) as contrasted with 'Cascade Bounty', where cane burning did not significantly affect pruning and training time in either of the first two years.

11. Clearly state the quantitative data that concerns the beneficiaries of the project and/or that describes the economic impact of the project.

Based on these data, it appears that 'Meeker' raspberry generally responds favorably to cane burning, showing an increase in three-year average berry yield and reduced dormant-season training and pruning time. 'Cascade Bounty' benefits less from cane burning than does 'Meeker', with cane burned plants producing a similar berry yield and requiring a similar amount of time for pruning and training as did nontreated plants. Since 'Meeker' is by far the most widely planted raspberry cultivar in Washington, we do not generally recommend dropping the practice for most producers. Producers of other cultivars, in particular 'Cascade Bounty', 'Chemainus', and 'Saanich', should experiment with not cane burning every year to determine whether cane burning is a net benefit to their raspberry production systems.

Lessons Learned

12. Offer insights into the lessons learned by project staff as a result of completing this project. Include the positive and negative results and conclusions of the project.

This was a project with a graduate student, so she was unquestionably the staff member who learned the most from this project. She learned how to apply treatments, manage field portions of the project, prune and train PNW red raspberries, and methodically collect data, as well gaining insight into the physiology of raspberry as it responds to cane burning treatments. She has presented findings in scholarly meetings as well during as her final defense seminar with WSU. She currently is enrolled in a PhD program, based in large part on her successful completion of the tasks in this project.

All project staff learned which raspberry measurements were of greater importance than others. For example, the number of primocanes measured for growth parameters in year one was substantially reduced in subsequent years, given that variability between canes and cane loss due to harvest damage were both lower than anticipated. This will be useful for project staff when designing future raspberry trials.

13. Describe any unexpected outcomes or results that were an effect of implementing your project.

Although not completely unexpected, I believe the two grower cooperators learned much about how to establish and conduct statistically sound research. It is often surprising to first-time cooperators how replication of treatments is required for investigators to generate meaningful data. Perhaps the largest benefit they gain, apart from the results generated on their land, is when they want to test other management practices on their own fields after the experiment is done.

14. If activities, goals or Expected Measurable Outcomes were not achieved, identify and share your lessons learned to help others expedite problem-solving.

The incomplete level of outcome achievements in this trial has more to do with time than to results not matching expectations. I expect we can meet our goal of one third of raspberry growers re-evaluating their cane burning practices in light of these data, but that outcome will not be realized until we complete the extension portion of this project. In retrospect, this project was too ambitious in scope in that data analysis and reporting on the findings really couldn't be done in the prescribed timeline. Therefore, future projects need to allow more time for this aspect of project completion.

Additional Information

15. Provide the total level of cash or in-kind matching donations utilized for your project. Describe the amounts, sources and ways in which the donations were utilized.

In-kind donations by the grower-cooperators were documented in 2010 and 2011 as targeted ($10,000/ac/year of the trial was targeted; actual in-kind costs were 10,260/ac for 2011 and 2012). In-kind

donations are at a similar level in 2012 (data will not be available until after pruning and training is completed during winter 2012-13). The expected donation will therefore total about $31,000. These in-kind donations included crop husbandry at the Field Trial #1 sites (pruning and training, fertility, irrigation, pest management (except herbicides), and particularly, the cost of harvesting the berries).

16. Provide any additional information available (i.e. publications, websites, photographs) that was not applicable to any of the prior sections.

Scholarly publications:

1. Duan, Y. and T.W. Miller. 2011. Determining the effects of cane burning to red raspberry in the Pacific Northwest. Weed Science Society of America, Portland, OR, WSSA Abstracts, CD.
2. Duan, Y., T. Miller, and T. Walters. To burn or not to burn, that's the question. VI International Weed Science Congress, Hangzhou, China (*in press*).

Presentations:

1. An update on cane burning in red raspberry. December 7, 2010. WSU Western Washington Small Fruit Workshop, Lynden, WA.
2. Weed research update. January 13, 2011. North Willamette Horticulture Society, Canby, OR.
3. Weed management in raspberries. December 9, 2011. WSU Washington Small Fruit Conference, Lynden, WA.
4. Weed research update. January 12, 2012. North Willamette Horticulture Society, Canby, OR
5. Raspberry spawn control: what we know and what we need to find out. July 19, 2012. Fruit For the Future, Invergowrie, Scotland, UK.