ORGANIC FARMING RESEARCH FOUNDATION

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Controlling weeds using propane generated flame and steam treatments in crop and non croplands

FINAL REPORT

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Project locations: Berry Patch Farms, Brighton, CO (Trials 1-6, certified organic)**;** Edna Chase Farm near Bennett, Colorado (Trial 7, non-organic)

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Note: This project report includes one trial in alfalfa in a conventional farming system that includes herbicide and insecticide treatments.

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Introduction to Research Projects

Organic agriculture producers face many challenges in growing crops along the Colorado Front Range. Of all pests, weeds continue to rank number one with growers. Weeds compete with row crops for water, nutrients, sunlight and physical space. Weeds, especially noxious weeds, have become such a problem that, in 1990, the Colorado State Legislature enacted the Colorado Noxious Weed Management Act. This act requires all landowners to manage noxious weeds on their property.

Weed control presents further problems for the organic farmer since the use of herbicides is prohibited. Presently, organic producers use plastic mulch, mechanical weeding, cover crops and hand weeding to control weeds. The introduction of thermal weeding offers significant advantages to help manage weeds in crop and non-cropland areas of the farm. Many crop fields along the Front Range are becoming closer in proximity to encroaching home developments, making flaming applications more difficult and less desirable.

Thermal weed control techniques (flaming and steam) typically apply heat directly to the weed, quickly raising the temperature of the moisture in the plant's cambium cells. The rapid expansion of this moisture causes the cell structure to rupture, preventing nutrients and water from entering the stalk and leaves, with dieback resulting in most plant species.

Using steam instead of conventional flame has some significant advantages. Steam treatments allow one to eliminate fire risks and flame damage to sensitive environments. This system could be used along with numerous mulches, without the danger of burning or destroying the crop beds. Also, no smoke is produced when weeds are steamed rather than flamed. The use of steam could be used throughout the growing season to eliminate weeds along mulched beds, service rows, and ditch banks. The steam method is especially appealing because of the air pollution concerns and the burning bans frequently experienced along the Colorado Front Range.

Through the use of the thermal weed control system, labor costs could be reduced, labor could be reallocated to other areas of the farm, and weeds could be controlled in any type of weather and environment.

Because of the different application methods and types of crops that thermal weed control would be applied to, five separate reports will be included in this final report.

Objective Statement

The purpose of this study is to examine if thermal treatment of weeds will provide effective control on an established certified organic farm and whether steam treatment of crops and field borders in the spring, summer and fall can reduce annual, biennial and perennial weeds common along the Colorado Front Range. A flame treatment will be compared to a steam treatment efficacy for the control of weeds and insects in alfalfa. Also, steam treatment weed control will be investigated for use in non-cropland applications such as irrigation ditch banks, irrigation pipes, and walkways between beds, edges of the beds, and roadsides. Following are the main objectives of this study:

1. Research the effectiveness of timing of steam or flame treatments for annual, biennial and perennial weed control in organic crops.
2. Research the effectiveness of timing of steam and flame treatments for annual, biennial and perennial weed control in non-cropland areas.
3. Determine the economics of flame and steam applications.

4. Produce a video, brochure, web site and field day to assist with technical transfer of this research-based information to organic farmers and growers interested in making the transition to organic production systems.

Timing of steam treatments of weeds in horticulture and agronomic crops needs to be evaluated along the Front Range of Colorado to determine optimum effectiveness in controlling a number of different weed species. Also, steam treatments need to be evaluated on non-cropland to determine efficacy. If successful, field day demonstrations and news releases will be utilized to encourage adoption by area farmers. This would include mailing test results to organic growers in Colorado.

Applications of steam treatments of weeds on annual weeds in organically grown crops will be made in the summer of 2002. Non-cropland applications will be made throughout the growing season. The flame or steam treatments of weeds may provide comparable pest control to some herbicide treatments. Another possible objective will be to monitor the propane flame and steam treatments on the control of insects and disease organisms. However, the primary objective of our research is to determine impact of this system on weeds that infest organically grown crops.

Weeds are a chronic problem in organic production along the Colorado Front Range. Mechanical cultivation and hand weeding (hoeing) typically are used to control these weeds; however, there is a danger of damaging the above ground plant parts and the feeder roots when using mechanical cultivation. The turning or disturbing of soil creates a favorable environment for more weeds to invade. Also, the use of thermal weed control systems such as steam or flame addresses a growing trend towards identifying effective, economical alternatives to herbicides for controlling weeds. The use of either steam or flame to control weeds could have broad applications in organic farming operations.

Trial 1. *Weed control using the Sioux Weed Blaster Steamer, Atarus Ranger Propane Flamer and mechanical cultivation in a peach orchard*

Summary

Weeds are a chronic problem in organic peach production along the Colorado Front Range. Mechanical cultivation and hand weeding (hoeing) typically are used to control these weeds; however, there is a danger of damaging the tree trunks, branches and the feeder roots when using mechanical cultivation. The purpose of this study was to examine whether steam or flame treatments in the late spring could reduce weed populations in an organic peach orchard without damaging trees. After three weed control applications of steam, flame and mechanical cultivations, the following was observed: The mechanical cultivation treatment gave 92 and 93% control of common rye and volunteer alfalfa, respectively. Both kochia and netseed lambsquarter control dropped to 50% for the mechanical cultivation treatment. Flaming gave 72 and 80% control of common rye and volunteer alfalfa, respectively. Both kochia and netseed lambsquarter were controlled at 65%. Steaming weeds with three applications using the Sioux Weed Blaster Steamer weed control device gave 6% control of common rye, 8% control of volunteer alfalfa, 13% control of kochia, and 2% control of netseed lambsquarter. Just one or two applications of steam was not effective in controlling weeds in this study. Based on the cost of operation and weed control performance of the Sioux Weed Blaster during our study, it was not cost efficient to control weeds on farm with this machine. In addition, the Origin Ranger flamer cost of operation and weed control performance was only cost efficient in the control of weeds for spot application treatment. After three applications, a statewide burning ban prevented further flame or steam treatments. Drought conditions could have played a major role in thermal weed control efficacy and possibly reduced the benefit of steam and flame applications.

Materials and Methods

The field research test site was located at Berry Patch Farms near Brighton, Colorado. Berry Patch Farms is a certified organic operation. The treatments selected for this experiment were:

1. One steam application
2. Two steam applications
3. Three steam applications
4. Three flame applications
5. Three mechanical Cultivation applications
6. Untreated check

Each weed control treatment application was replicated 3 times. Each plot was 4 feet wide by 15 feet (60 square feet). Weeds were steamed using the Sioux Weed Blaster Steamer furnished by A-J Sales and Service Company of Commerce City, Colorado. The Sioux Weed Blaster Steamer uses diesel as a fuel source and applies 2 gallons of water per minute, which produces 350 degree F saturated steam at 250 psi. This machine holds 125 gallons of water, which allows about one hour of steaming operation. The flamed treatment involved using the handheld Atarus Ranger Thermal weed control device. The Atarus Ranger uses propane as the fuel source and provides about 45 minutes of flaming per 3 kg tank of propane when used at the high flame setting. Successful flaming requires only a blanching of weed tissue without allowing the fire point to be reached (The fire point is the temperature at which the flame becomes self-sustained so as to continue burning). Mechanical cultivation control consisted of using a gas powered Stihl trimmer.

The first steam, flame and mechanical cultivation treatments were applied on April 30, 2002, when weeds were 1 to 6 inches tall and required 60 seconds of steaming, flaming or mechanical cultivation to treat all weeds during the first application. The temperature at the time of application was 67 degrees F, wind 2 mph and humidity 13%. The second set of applications was applied on May 4, 2002, for a duration of 90 seconds. At the time of the second set of applications, the weeds were between 2 and 8 inches tall. The temperature was 68 degrees F, wind 7 mph and humidity 28%. The third and final set of treatments occurred on May 20, 2002, for a duration of 120 seconds. The temperature at the time of application was 52 degrees F, wind 9 mph and humidity 62%. Treatment time durations were increased to compensate for the increase in plant biomass encountered through the growing season.

The weeds encountered in this study were kochia (*Kochia scoparia*), netseed lambsquarter (*Chenopodium berlandieri*), common rye (*Secale cereale*) and volunteer alfalfa (*Medicago sativa*).

Treatments were evaluated for effects on weeds on May 4, 14, 20, 29, and June 14, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Analysis of Variance with Least Significant Differences mean separation.

Results

Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on 0-100% scale.

Date 5/4/02 (12 days after 1st application)

	Average Percent Control			
Treatment	Kochia	Lambsquater	Rye	Alfalfa
1 Steam application	0 a	0 a	0 a	0 a
2 Steam applications	0 a	0 a	0 a	0 a
3 Steam applications	0 a	0 a	0 a	0 a
Flame application	81.7 b	85.0 b	30.0 b	40.0 b
Mechanical Cultivation	83.3 b	85.0 b	81.7 c	91.7 c
Untreated Check	0 a	0 a	0 a	0 a
LSD Values	2.8765	7.527 7.365	9.1969	

Date 5/14/02 (10 days after 2nd application)

	Average Percent Control			
Treatment	Kochia	Lambsquater	Rye	Alfalfa
1 Steam application	0 a	0 a	0 a	0 a
2 Steam applications	1.7 a	1.7 a	3.3 a	8.3 a
3 Steam applications	1.7 a	1.7 a	3.3 a	8.3 a
Flame application	88.3 b	90.0 b	75.0 b	43.3 b
Mechanical Cultivation	85.0 b	88.3 b	90.0 c	50.0 b
Untreated Check	0 a	0 a	0 a	0 a
LSD Values	4.5984	3.9534	5.6726	14.823

Date 5/20/02 (16 days after 2nd application)

	Average Percent Control			
Treatment	Kochia	Lambsquater	Rye	Alfalfa
1 Steam application	0 a	0 a	0 a	0 a
2 Steam applications	0 a	0 a	0 a	1.7 a
3 Steam applications	0 a	0 a	0 a	1.7 a
Flame application	71.7 b	96.0 b	70.0 b	50.0 b
Mechanical Cultivation	68.3 b	86.7 b	90.0 c	63.3 c
Untreated Check	0 a	0a	0 a	0 a
LSD Values	9.9645	18.091	7.4271	9.3629

Date 5/29/02 (9 days after 3rd application)

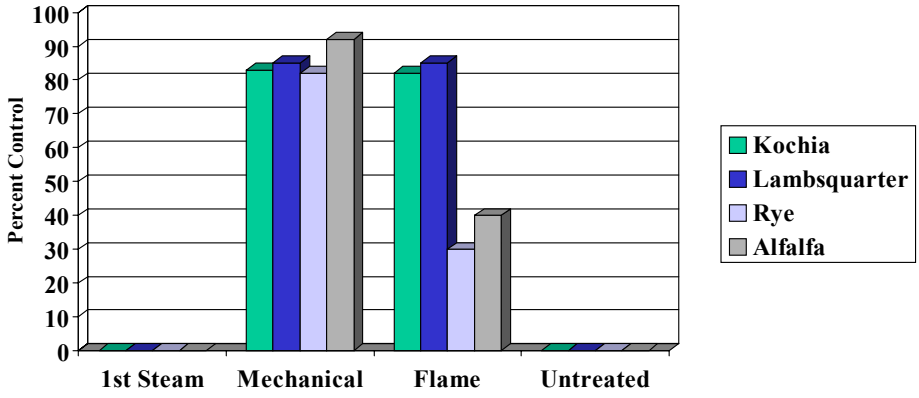
	Average Percent Control			
Treatment	Kochia	Lambsquater	Rye	Alfalfa
1 Steam application	0 a	0 a	0 a	0 a
2 Steam applications	0 a	0 a	0 a	0 a
3 Steam applications	6.7 b	2.3 b	6.3 b	8.0 b
Flame application	97.0 d	98.0 d	83.3 c	94.3 c
Mechanical Cultivation	90.0 c	91.7 c	93.3 d	90.0 d
Untreated Check	0 a	0 a	0 a	0 a
LSD Values	2.3875	3.3215	4.6382	12.974

Date 6/14/02 (25 days after 3rd application)

	Average Percent Control			
Treatment	Kochia	Lambsquater	Rye	Alfalfa
1 Steam application	0 a	0 a	0 a	0 a
2 Steam applications	0 a	0 a	0 a	0 a
3 Steam applications	15.0 b	10.0 b	11.7 b	13.3 b
Flame application	65.0 d	65.0 d	71.7 c	80.0 c
Mechanical Cultivation	50.0 c	50.0 c	91.7 d	93.3 d
Untreated Check	0 a	0 a	0 a	0 a
LSD Values	8.7354	7.9647	7.4271	7.7303

Effect of One Treatment Application on Weeds in a Peach Orchard

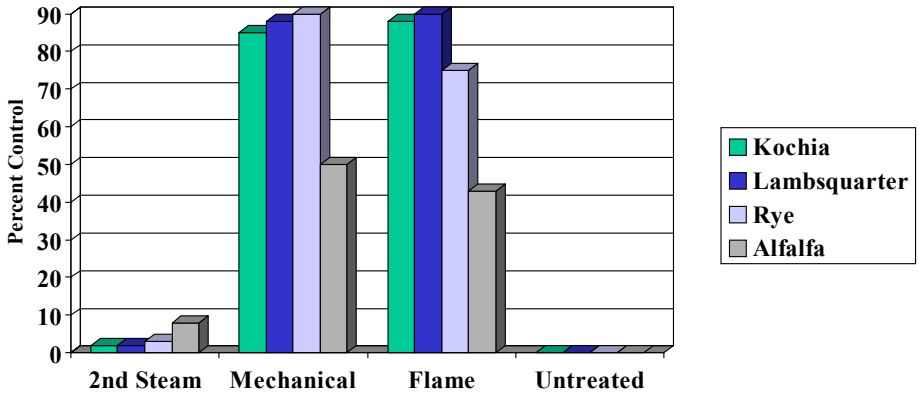
12 Days After the First Application (5/4/02)



12

Effect of Two Treatment Applications on Weeds in a Peach Orchard

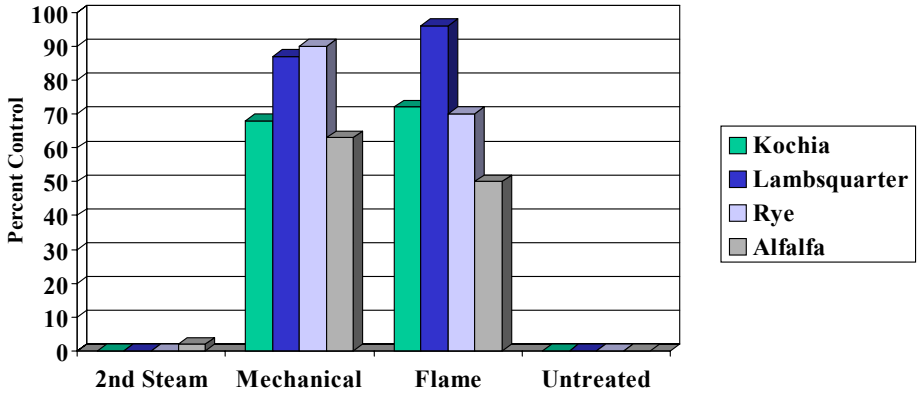
10 Days After the Second Application (5/14/02)



13

Effect of Two Treatment Applications on Weeds in a Peach Orchard

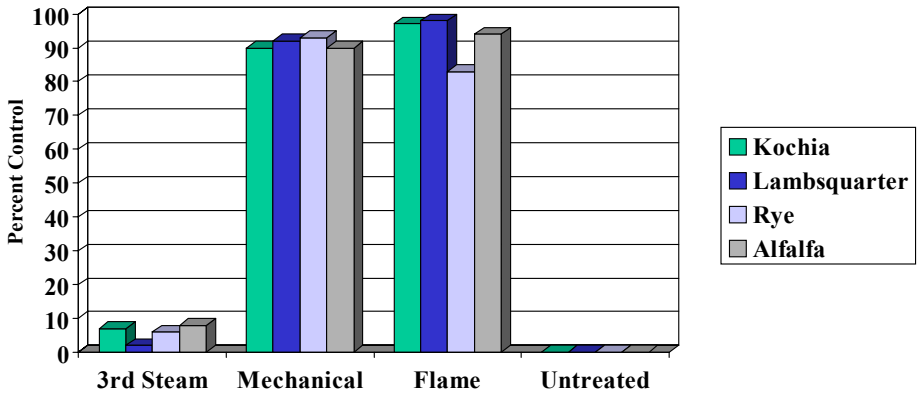
16 Days After the Second Application (5/20/02)



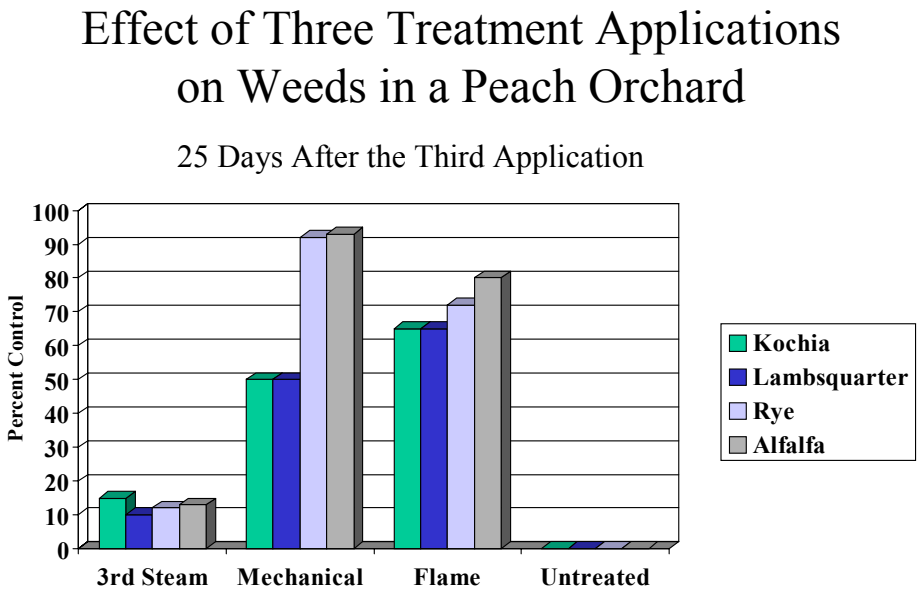
14

Effect of Three Treatment Applications on Weeds in a Peach Orchard

9 Days After the Third Application (5/29/02)



15



16

Discussion and Conclusion

Evaluations taken twelve days after the first treatment of steam found no detrimental effect on any weed species when compared to the untreated check. The flame treatment showed 82 and 85% control of kochia and netseed lambsquarter respectively. Common rye and volunteer alfalfa showed only 30 and 40% control, respectively, following the first flame application. Mechanical cultivation had the greatest effect on kochia, netseed lambsquarter, common rye and volunteer alfalfa, with at least 81% control of each weed species.

Ten days after the second treatment of steam, less than 2% injury of kochia and lambsquarter was seen when compared to the untreated check. Two applications of steam gave 3.3% and 8.3% control of annual rye and alfalfa, respectively. The one application of steam treatment showed no effect on any weed species at this time. The flame treatment showed 88.3% and 90% control of kochia and netseed lambsquarter respectively. Common rye and volunteer alfalfa showed 75% and 43.3% control, respectively, following the second flame application. Mechanical cultivation had the greatest effect on kochia, netseed lambsquarter, and common rye, with at least 85% control of each weed species. Mechanical cultivation only gave 50% control of volunteer alfalfa.

On May 20, 2002, sixteen days after the second treatment of steam, less than 2% injury of any weed was seen when compared to the untreated check. The one application of steam treatment showed no effect on any weed species at this time. The flame treatment showed 71.7% and 96% control of kochia and netseed lambsquarter respectively. Common rye and volunteer alfalfa showed 70% and 50% control, respectively, following the second flame application. Mechanical cultivation showed 68% control of kochia, 87% control of netseed lambsquarter, 90% control of common rye, with at least 63% control of volunteer alfalfa.

On May 29, 2002, nine days after the third treatment of steam, up to 8% injury of volunteer alfalfa, and 6.7, 2.3% and 6.3% injury of kochia, netseed lambsquarter and common rye, respectively. The one and two applications of steam treatment showed no effect on any weed species at this time. The flame treatment showed 97% and 98% control of kochia and netseed lambsquarter respectively. Common rye and volunteer alfalfa showed 83.3% and 94.3% control, respectively, following the second flame application. Mechanical cultivation showed 90% control of kochia, 91.7% control of netseed lambsquarter, 93.3% control of common rye, and 90% control of volunteer alfalfa.

Twenty-five days after the third and final treatment applications, the mechanical cultivation treatment gave 91.7% and 93.3% control of common rye and volunteer alfalfa, respectively. Both kochia and netseed lambsquarter control dropped to 50% for the mechanical cultivation treatment. Flaming gave 71.7% and 80% control of common rye and volunteer alfalfa, respectively. Both kochia and netseed lambsquarter were controlled at 65%. Steaming weeds three times using the Sioux Weed Blaster Steamer weed control device gave 11.7% control of common rye, 13.3% control of volunteer alfalfa, 15% control of kochia, and 10% control of netseed lambsquarter. The one and two application treatments of steam did not have a lasting effect on any weed species.

After three applications, a statewide burning ban prevented further flame or steam treatments. Based on results experienced in this study, the steam treatment using the Sioux Weed Blaster Steamer weed control device provided only slight injury, less than 14% control of any weed species tested. This level of weed control was only achieved after three applications of steam. Fewer than three applications yielded even less control of weeds. This level of control would not be acceptable to the commercial growers. The Atarus Ranger flame device generally provided weed control levels comparable to mechanical cultivation. The use of flame technology does reduce the turning or disturbing of soil and mimics no-till farming. Mechanical cultivation achieved fair to good weed control, depending on the weed species tested. Drought conditions could have played a major role in thermal weed control, both steam and flame treatment efficacy and could have possibly reduced the benefit of steam and flame applications.

The costs of operating the Sioux Weed Blaster and the Origin Ranger during the 2002 summer season are broken down in the two tables below. The estimated cost of the Sioux Weed Blaster is $8900.00. The machine can treat weeds for approximately one hour before the water tank needs to be refilled. During this time, 125 gallons of water is used and 3600 square feet of weeds are treated. Approximately 6 gallons of diesel and 4 gallons of gasoline are used during this one-hour of operation.

To treat one acre of weeds the cost of operating the Sioux Weed Blaster (Steam Unit)

Item	Amount per acre	Cost per acre
Water	1512.5 gallons	$1.25
Diesel for Boiler	72 gallons	$104.40 ($1.45 per gallon)
Gasoline for generator	48 gallons	$72.00 ($1.50 per gallon)
Labor	12 hours	$84.00 ($7 per hour)
Total		$ 261.65 per acre

Based on the cost of operation and weed control performance of the Sioux Weed Blaster during our study, it was not cost efficient to control weeds on farm with this machine.

The estimated cost of the Origin Ranger flamer is $995.00. The machine can treat weeds for approximately 45 minutes before the propane tank needs to be refilled.

To treat one acre of weeds the cost of operating the Origin Ranger Flamer

Item	Amount per acre	Cost per acre
Propane	105.6 pounds of propane	$96.00
Labor	12 hours	$84.00 ($7 per hour)
Total		$180.00 per acre

Based on the cost of operation and weed control performance of the Origin Ranger flamer during our study, it is only cost efficient to control weeds for spot application weed control problems (around tree trucks where mechanical cultivation could possibly damage the tree) and not for large area weed problems. The Red Dragon Flamer manufactured by Flame Engineering, Inc. is designed for large-scale weed control areas (alfalfa and corn fields) and would be more cost efficient than the Origin Ranger would.

Video of the Atarus Stinger thermal weed control device in action is available at our web site: www.adamscountyextension.org

Trial 2. *Weed control using the Sioux Weed Blaster Steamer and mechanical cultivation in plastic culture strawberries*

Summary

Weeds are a chronic problem associated with organic strawberry production in Colorado. Plastic mulch helps reduce weeds within the beds of strawberries; however, the greatest weed threat comes from weeds growing at the edge of the plastic beds. Soil typically holds the plastic mulch in place and is prone to weed infestations. The purpose of this study was to examine whether steam treatments in the late spring could reduce the occurrence of weed populations spreading under the edge of plastic mulch of strawberry beds. Weeds were steamed using the trailer mounted Sioux Weed Blaster Steamer weed control device. Mechanical cultivation control involved using a gas powered Stihl trimmer. Hand weeding (hoeing) was also employed along the plastic mulch edge. After three weed control applications of either steam, mechanical cultivation and hand weeding, the following was observed: The hand weeded treatment gave the best control of weeds with at least 80% control of all weed species tested. Mechanical cultivation gave 80% control of kochia, 45% control of dandelion and 70% control of downy brome. Steaming weeds using the Sioux Weed Blaster Steamer weed control device gave little to no control of kochia. Steam treatments gave poor control (50%) of dandelion but surprisingly, steam treatments gave 85% control of downy brome. Applications of steam did not appear to damage the plastic mulch. The Sioux Weed Blaster Steamer weed control device tested in this experiment did not control weeds at a level required by commercial growers. Based on the cost of operation and weed control performance of the Sioux Weed Blaster during our study, it was not cost efficient to control on farm weeds with this machine. After three applications, a statewide burning ban prevented further steam treatments. Drought conditions could have played a major role in steam weed control efficacy and possibly reduced the benefit of the steam applications. Further testing is planned for the upcoming years looking at the recently acquired Atarus Stinger steam generating system.

Materials and Methods

The field research test site was located at Berry Patch Farms, near Brighton, Colorado. Berry Patch Farms is a certified organic operation. The treatments selected for this experiment were:

7. One steam application
8. Two steam applications
9. Three steam applications
10. Three mechanical cultivation applications
11. Three hand weedings
12. Untreated check

Each weed control treatment was replicated 3 times. Each plot was 2 feet wide by 15 feet (30 square feet). Weeds were steamed using the Sioux Weed Blaster Steamer furnished by A-J Sales and Service Company of Commerce City, Colorado. The Sioux Weed Blaster Steamer uses diesel as a fuel source and applies 2 gallons of water per minute, which produces 350 degrees F saturated steam at 250 psi. This machine holds 125 gallons of water, which allows about one hour of steaming operation. Mechanical cultivation control consisted of using a gas powered Stihl trimmer. Hand weeding was performed by using a long handled hoe.

The first steam, mechanical cultivation and hand weeding treatments were applied on April 30, 2002, when broadleaf weeds were 1 to 2 inches tall and grass weeds 4 to 6 inches tall. Each plot was 30

square feet and required 60 seconds of steaming, mechanical cultivation or hand weeding to treat all weeds during the first treatment. The second set of applications was applied on May 4, 2002, for a duration of 90 seconds. The temperature was 67 degrees Fahrenheit, humidity 13% and wind less than 2 mph. At the time of the second set of applications on May 4, 2002, the weeds were between 4 and 8 inches tall. The temperature was 68 degrees Fahrenheit, humidity 28% and wind out of the west at 7 mph. The steam was applied for 90 seconds and mechanical cultivation and hand weeding each took 60 seconds to treat. The third and final set of treatments occurred on May 20, 2002, with the steam treatment receiving a 120 second application. The mechanical cultivation and hand weeding treatment only required 45-second applications. The temperature was 52 degrees Fahrenheit, humidity 62% and wind out of the south at 9 mph. Weeds were between 5 and 9 inches tall in the untreated check. Treatment time durations were increased to compensate for the increase in plant biomass encountered through the growing season.

The weeds encountered in this study were kochia (*Kochia scoparia*), dandelion (*Taraxacum* spp.), and downy brome (*Bromus tectorum*).

Treatments were evaluated for effects on weeds on May 4, 15, 20, 29, and June 14, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Analysis of Variance with Least Significant Difference mean separation.

Results

Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on 0-100% scale.

Date 5/4/02 (12 days after 1st application)

	Average Percent Control		
Treatment	Kochia	Dandelion	Downy Brome
1 Steam application	0 a	0 a	0 a
2 Steam applications	0 a	0 a	0 a
3 Steam applications	0 a	0 a	0 a
Hand Weeded	97.7 c	90.0 c	94.3 c
Mechanical Cultivation	93.3 b	43.3 b	60.0 b
Untreated Check	0 a	0 a	0 a
LSD	2.8765	15.191	3.0016

Date 5/15/02 (11 days after 2nd application)

	Average Percent Control		
Treatment	Kochia	Dandelion	Downy Brome
1 Steam application	0 a	0 a	0 a
2 Steam applications	0 a	33.0 a	66.7 b
3 Steam applications	0 a	33.0 a	66.7 b
Hand Weeded	99.0 b	71.7 b	96.7 c
Mechanical Cultivation	96.7 b	76.7 b	71.7 b
Untreated Check	0 a	0 a	0 a
LSD	4.2232	37.762	20.985

Date 5/20/02 (16 days after 2nd application)

	Average Percent Control		
Treatment	Kochia	Dandelion	Downy Brome
1 Steam application	0 a	0 a	0 a
2 Steam applications	0 a	49.3 b	56.7 b
3 Steam applications	0 a	50.0 b	60.0 bc
Hand Weeded	100.0 b	90.0 d	78.3 d
Mechanical Cultivation	100.0 b	60.0 c	66.7 c
Untreated Check	0 a	0 a	0 a
LSD	1.065	7.6587	9.9183

Date 5/29/02 (9 days after 3rd application)

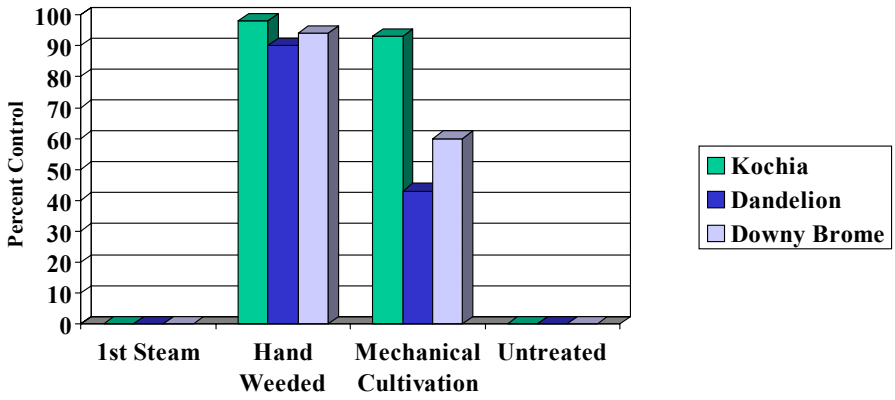
	Average Percent Control		
Treatment	Kochia	Dandelion	Downy Brome
1 Steam application	0 a	0 a	0 a
2 Steam applications	1.7 a	38.3 b	60.0 b
3 Steam applications	3.3 a	55.0 c	91.7 cd
Hand Weeded	95.0 b	90.0 e	96.7 d
Mechanical Cultivation	96.7 b	75.0 d	85.0 c
Untreated Check	0 a	0 a	0 a
LSD	4.2881	12.828	11.586

Date 6/14/02 (25 days after 3rd application)

	Average Percent Control		
Treatment	Kochia	Dandelion	Downy Brome
1 Steam application	0 a	0 a	0 a
2 Steam applications	2.0 a	30.0 b	55.0 b
3 Steam applications	15.0 b	50.0 c	85.0 d
Hand Weeded	86.7 c	80.0 d	90.0 d
Mechanical Cultivation	83.3 c	45.0 c	70.0 c
Untreated Check	0 a	0 a	0 a
LSD	7.8250	10.634	10.371

Effect of One Treatment Application on Weeds Bordering Strawberry Beds

12 Days After the First Application (5/4/02)



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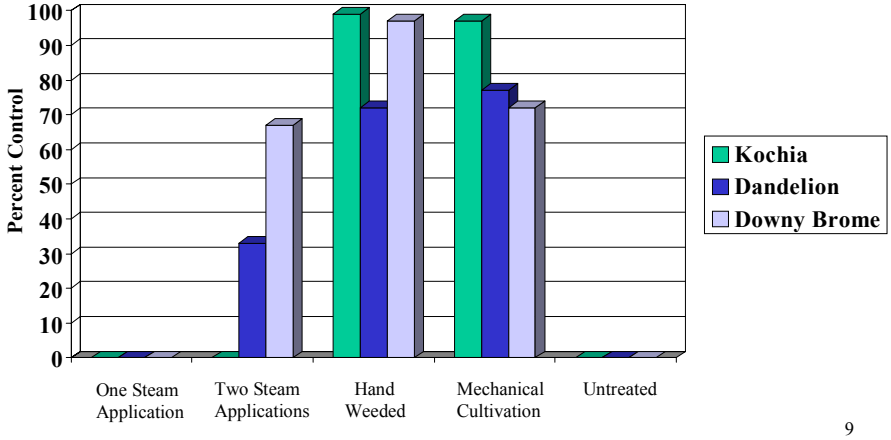
Effect of Two Treatment Applications on Weeds Bordering Strawberry Beds

11 Days After the Second Application (5/15/02)



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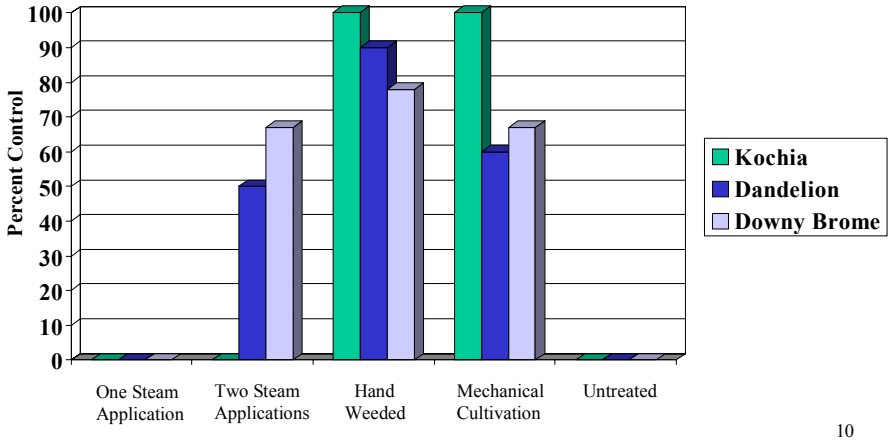
Effect of Two Treatment Applications on Weeds Bordering Strawberry Beds

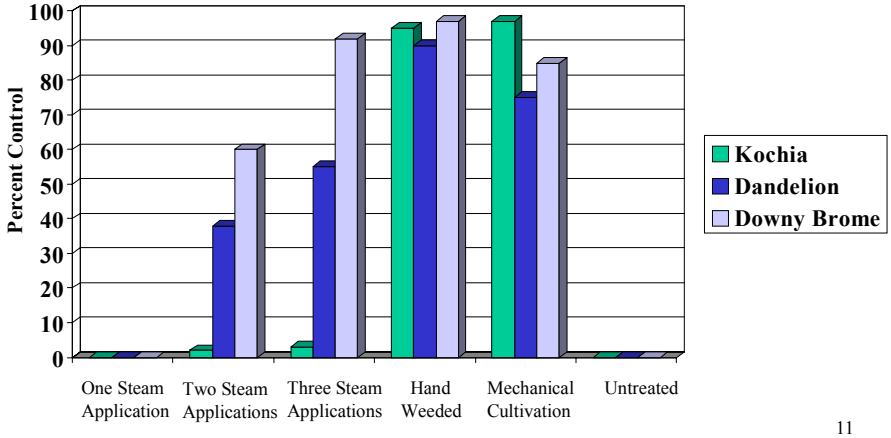
16 Days After the Second Application (5/20/02)



10

Effect of Three Treatment Applications on Weeds Bordering Strawberry Beds

9 Days After the Third Application (5/29/02)



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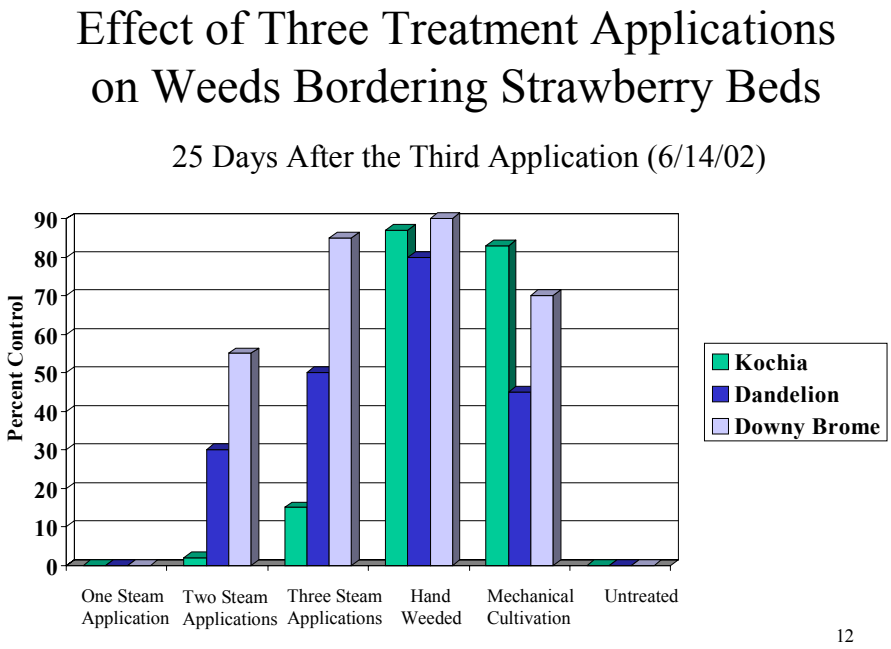


Discussion and Conclusion

Evaluations taken twelve days after the first treatment of steam found no detrimental effect on any weed species when compared to the untreated check. The high pressure from the Sioux Weed Blaster Steamer caused soil and mulch to be displaced. The hand weeded treatment provided at least 90% control of all weed species. The mechanical cultivation gave 93% control of kochia. However, mechanical cultivation gave only 43% and 60% control of dandelion and downy brome, respectively.

Eleven days after the second application of steam, no control of kochia was observed. Steam plots showed 33% control of dandelion and 67% control of downy brome. The second hand weeded treatment provided over 96% control of kochia and downy brome. Hand weeding gave 72% control of dandelion. The mechanical cultivation gave good control (93%) of kochia. Mechanical cultivation gave only 77% and 72% control of dandelion and downy brome, respectively.

Sixteen days after the second application of steam, no control of kochia was observed. Steam plots showed 49% control of dandelion and 57% control of downy brome. The hand weeded treatment provided 100% control of kochia and 78% of downy brome. Hand weeding gave 90% control of dandelion. The mechanical cultivation treatment gave compete control (100%) of kochia. Mechanical cultivation gave only 60% and 67% control of dandelion and downy brome, respectively.

On May 29, the two applications of steam treatment gave 2%, 38% and 60% control of kochia, dandelion and downy brome, respectively. Nine days after the third and final steam treatment, kochia control averaged only 3%. Dandelion and downy brome were controlled at the 55% and 92% level, respectively. The hand weeded treatment showed at least 90% control of all weed species tested. Mechanical cultivation gave 97% control of kochia. Mechanical cultivation gave only 75% and 85% control of dandelion and downy brome, respectively.

On June 14, the two applications of steam treatment gave 2%, 30% and 55% control of kochia, dandelion and downy brome, respectively. Twenty-five days after the third and final steam treatment, kochia control averaged 15%. Dandelion and downy brome were controlled at the 50% and 85% level, respectively. The hand weeded treatment showed 87%, 80% and 90% control of kochia, dandelion and downy brome, respectively. Mechanical cultivation gave 83% control of kochia. Mechanical cultivation gave only 45% and 70% control of dandelion and downy brome, respectively.

After three applications, a statewide burning ban prevented further steam treatments. Based on results experienced in this study, the steam treatment using the Sioux Weed Blaster Steamer weed control device provided erratic activity, about 15% control of kochia, 50% of dandelion and 85% of downy brome. Only the downy brome was adequately managed with the Sioux Weed Blaster. This level of weed control was only achieved after three applications of steam. Fewer than three applications yielded even less control of weeds of tested weed species. Hand weeding generally provided good to excellent weed control. Mechanical cultivation gave good control of kochia, poor control of dandelion and fair control of downy brome. Drought conditions could have played a major role in steam weed control efficacy and possibly reduced the benefit of steam.

The cost of operating the Sioux Weed Blaster during the 2002 summer season is broken down in the table below. The estimated cost of the Sioux Weed Blaster is $8900.00. The machine can treat weeds for approximately one hour before the water tank needs to be refilled. During this time, 125 gallons of water is used and 1800 square feet of weeds are treated. Approximately 6 gallons of diesel and 4 gallons of gasoline are used during this one-hour of operation.

To treat one acre of weeds the cost of operating the Sioux Weed Blaster

Item	Amount per acre	Cost per acre
Water	3025 gallons	$2.5
Diesel for Boiler	144 gallons	$208.00 ($1.45 per gallon)
Gasoline for generator	96 gallons	$144.00 ($1.50 per gallon)
Labor	24 hours	$168.00 ($7 per hour)
Total		$ 522.5 per acre

Based on the cost of operation and weed control performance of the Sioux Weed Blaster during our study, it was not cost efficient to control on farm weeds with this machine.

Further testing is planned for the upcoming years, which will include evaluating the Atarus Stinger steam generation system. The Atarus Stinger produces higher temperatures of steam than the Sioux Weed Blaster and could increase weed control efficacy.

Trial 3. *Annual weed control using The Atarus Ranger Propane Flamer in a non-cropland environment*

Summary

Annual weeds commonly infest non-cropland areas such as ditch banks and fencerows along the Front Range of Colorado. The purpose of this study was to examine whether propane flaming treatments of non-cropland (ditch banks) in the early spring could effectively reduce kochia populations. Weeds were flamed using the handheld Atarus Ranger Thermal Weed Control Device. Two flame applications were used during this experiment. Flaming occurred when kochia was ¼ to ¾ inch tall or about the size of a penny in diameter. Eight days after the first flame application, 93.5% kochia control was achieved. A 93% level of kochia control was achieved 68 days following the 2nd flame application. The lack of rainfall during this test helped prevent new seedlings from emerging and helps to explain the long period of weed control achieved with the flame treatment. Flaming weeds using the Atarus Ranger effectively controlled the annual weed kochia after just two applications and provided commercially acceptable weed control.

Materials and Methods

The field research test site was located at Berry Patch Farms, near Brighton, Colorado. Berry Patch Farms is a certified organic operation. The treatments selected for this experiment were:

1. Two Flame applications
2. Untreated Check

The annual weed examined in this study was kochia (*Kochia scoparia)*. Each weed control treatment was replicated 3 times. Each plot was 4 feet by 4 feet (16 square feet). Weeds were flamed using the handheld Atarus Ranger Thermal Weed Control Device. This device uses propane as the fuel source and provides about 45 minutes of flaming per 3 kg tank of propane when used at high flame setting. Two flame applications were used during this experiment, with the first applied on April 8, 2002. Temperature at time of 1st flame application was 42 degrees Fahrenheit, humidity 66% and wind from the north at 9 mph. The second flame application was applied on April 17, 2002. Temperature at time of 2nd flame application was 63 degrees Fahrenheit, humidity 20% and wind from the north at 8 mph.

Flaming occurred when kochia was ¼ to ¾ inch tall or about the size of a penny in diameter. Kochia populations averaged about one plant per square inch. Each plot was 16 square feet and required 30 seconds of flaming to treat all weeds. Successful flaming requires only a blanching of weed tissue without allowing the fire point to be reached (The fire point is the temperature at which the flame becomes self-sustained so as to continue burning).

Treatments were evaluated for effects on weeds on April 10, 16, 22, 24, 30, May 4, 14, 20, 29 and June 14, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Tukey's Least Significant Difference method.

Results

Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on 0-100% scale.

Days After Treatment	Flame Application % Control	Untreated Check % Control
2 DAT of 1st Application	92.5%	0
8 DAT of 1st Application	93.25%	0
5 DAT of 2nd Application	95.75%	0
7 DAT of 2nd Application	98.75%	0
13 DAT of 2nd Application	99.5%	0
17 DAT of 2nd Application	98.0%	0
27 DAT of 2nd Application	98.5%	0
43 DAT of 2nd Application	98%	0
52 DAT of 2nd Application	93.75%	0
68 DAT of 2nd Application	93.0%	0

Discussion and Conclusion

Evaluations taken two and eight days after the 1st flame application showed excellent activity with greater than 92% control of kochia in the flamed plots. Evaluations taken 5, 7, 13, 17, 27,43, 52 68 days after the 2nd flame application again showed excellent activity with greater than 93% control of kochia in the flamed plots. Drought conditions could have played a major role in flame weed control efficacy and possibly increased the benefit of flame treatments. Lack of rainfall throughout the duration of this experiment allowed little to no new emergence of seedling kochia. Because flaming doesn't stir or disturb the soil, this also decreased new weed seedling emergence. However, stinging nettle started to invade the flamed and untreated plots and could have suppressed new kochia emergence.

After two applications, a statewide burning ban prevented further flame treatments. Based on results experienced in this study, two flame treatments using the Atarus Ranger flamer weed control device provided excellent control of kochia throughout the duration of this study. The Atarus Ranger allowed the flame applications to be applied quickly and easily. This device is a well-designed weed management tool. Based on our experience in the field this summer with the Atarus Ranger, this device should provide years of reliable service for those who want to adopt weed flaming technology.

Trial 4. *Perennial weed control using The Atarus Ranger Propane Flamer in a non-cropland environment*

Summary

Perennial weeds are common pests of non-cropland areas such as ditch banks, fencerows and irrigation canals along the Front Range of Colorado. The perennial weeds encountered in this study were stinging nettle (*Urtica dioica);* scouringrush (*Equisetum hyemale);* and poison hemlock (*Conium maculatum)*. The purpose of this study was to examine whether propane flaming treatments of non-cropland (ditch banks) in the early spring could reduce perennial weed populations. Weeds were flamed using the handheld Atarus Ranger Thermal Weed Control Device. Flame treatments were applied on April 8, April 17, May 5 and May 20, 2002. Flame treatments occurred when the stinging nettle, scouringrush and poison hemlock were 1 to 4 inches tall. All weed species plant densities averaged about 5 plants per square foot. Observation made after each flame application found excellent control of stinging nettle and hemlock and good control of scouringrush. A statewide burning ban prevented further flame treatments after the fourth application. Flaming weeds using the Atarus Ranger effectively managed the perennial weeds stinging nettle, poison hemlock and scouringrush after four flame applications. The Atarus Ranger provided commercially acceptable weed control during the course of this study.

Materials and Methods

The field research test site was located at Berry Patch Farms, near Brighton, Colorado. Berry Patch Farms is a certified organic operation. The treatments selected for this experiment were:

1. Four flame applications
2. Untreated check

Each weed control treatment was replicated 3 times. Each plot was 4 feet wide by 4 feet (16 square feet). Weeds were flamed using the handheld Atarus Ranger Thermal Weed Control Device. This device uses propane as the fuel source and provides about 45 minutes of flaming per 3 kg tank of propane when used at high flame setting. Four flame applications were used during this experiment, with the first applied on April 8, 2002. Each flame treatment plot was treated for 60 seconds. Temperature at time of 1st flame application was 42 degrees Fahrenheit, humidity 66% and wind from the north at 9 mph. The second flame application was applied on April 17, 2002. Each flame treatment plot was treated for 45 seconds. Temperature at time of 2nd flame application was 63 degrees Fahrenheit, humidity 20% and wind from the north at 8 mph. The third flame application was applied on May 4, 2002. Each flame treatment plot was treated for 45 seconds. Temperature at time of 3rd flame application was 48 degrees Fahrenheit, humidity 62% and wind from the west at 5 mph. The fourth flame application was applied on May 20, 2002. Again each flame treatment plot was treated for 45 seconds. Temperature at time of 4th flame application was 52 degrees Fahrenheit, humidity 62% and wind from the south at 9 mph.

The perennial weeds used in this study were stinging nettle (*Urtica dioica);* scouringrush (*Equisetum hyemale);* and poison hemlock (*Conium maculatum)*. Flaming occurred when stinging nettle was 1 to 3 inches tall. Poison hemlock was 2 to 4 inches in size and scouringrush was 1 to 4 inches tall. Plant densities in each plot averaged 22 stinging nettle, 7 poison hemlock and 4 scouringrush per square foot. Successful flaming requires only a blanching of weed tissue without allowing the fire point to be reached (The fire point is the temperature at which the flame becomes self-sustained so as to continue burning).

Treatments were evaluated for effects on weeds on April 10, 16, 22, 24, 30, May 4, 14, 20, 29 and June 14, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Tukey's Least Significant Difference method.

Results

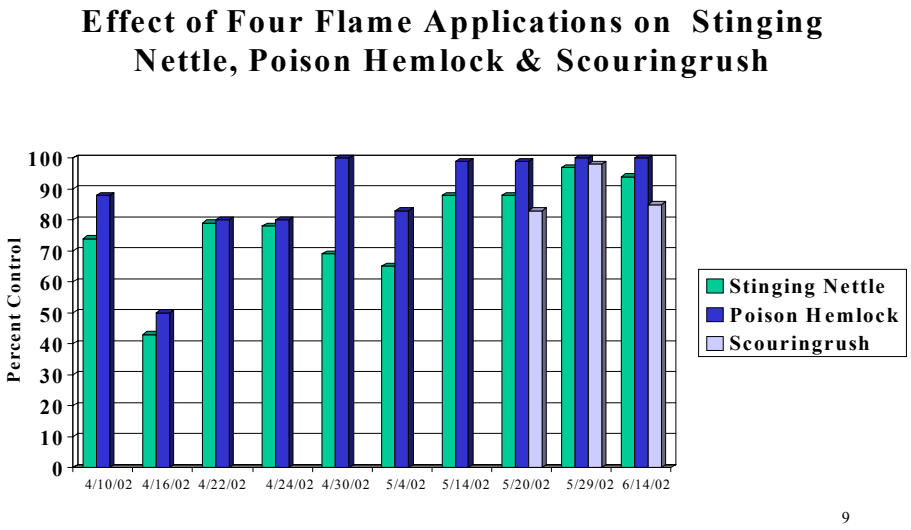
Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on 0-100% scale.

	Percent Control of Stinging Nettle	
Date of Evaluation	Flame treatment	Untreated check
April 10, 2002 (2 DAT of 1st Application)	73.75	0
April 16, 2002 (8 DAT of 1st Application)	42.50	0
April 22, 2002 (5 DAT of 2nd Application)	78.75	0
April 24, 2002 (7 DAT of 2nd Application)	77.50	0
April 30, 2002 (13 DAT of 2nd Application)	68.75	0
May 4, 2002 (17 DAT of 2nd Application)	65.00	0
May 14, 2002 (9 DAT of 3rd Application)	87.50	0
May 20, 2002 (15 DAT of 3rd Application)	87.50	0
May 29, 2002 (9 DAT of 4th Application)	97.25	0
June 14, 2002 (25 DAT of 4th Application)	93.75	0

	Percent Control of Poison Hemlock	
Date of Evaluation	Flame treatment	Untreated check
April 10, 2002 (2 DAT of 1st Application)	87.50	0
April 16, 2002 (8 DAT of 1st Application)	50.00	0
April 22, 2002 (5 DAT of 2nd Application)	80.00	0
April 24, 2002 (7 DAT of 2nd Application)	80.00	0
April 30, 2002 (13 DAT of 2nd Application)0	100.00	0
May 4, 2002 (17 DAT of 2nd Application)	82.50	0
May 14, 2002 (9 DAT of 3rd Application)	99.50	0
May 20, 2002 (15 DAT of 3rd Application)	99.00	0
May 29, 2002 (9 DAT of 4th Application)	100.00	0
June 14, 2002 (25 DAT of 4th Application)	100.00	0

	Percent Control of Scouringrush	
Date of Evaluation	Flame treatment	Untreated check
April 10, 2002 (2 DAT of 1st Application)	NA	NA
April 16, 2002 (8 DAT of 1st Application)	NA	NA
April 22, 2002 (5 DAT of 2nd Application)	NA	NA
April 24, 2002 (7 DAT of 2nd Application)	NA	NA
April 30, 2002 (13 DAT of 2nd Application)	NA	NA
May 4, 2002 (17 DAT of 2nd Application)	NA	NA
May 14, 2002 (9 DAT of 3rd Application)	NA	NA
May 20, 2002 (15 DAT of 3rd Application)	82.50	0
May 29, 2002 (9 DAT of 4th Application)	97.50	0
June 14, 2002 (25 DAT of 4th Application)	85.00	0

NA = (Not available) the scouringrush have not yet emerged.



9

Discussion and Conclusion

Evaluations of treatments taken two days and 8 days after the 1st flame application showed poor to fair activity on stinging nettle and poison hemlock in the flamed plots. The evaluations of stinging nettle taken 5, 7, 13, and 17 days after the 2nd flame application showed control levels that varied from 65% to 78.5%. Poison hemlock evaluations at 5, 7, 13, and 17 days after the 2nd flame application showed levels of control of 80% to 100%.

After the third flame application, control levels of stinging nettle increased. At 9 and 15 days after the third flame application, 87.5% control of stinging nettle in the flame treatment was seen. During this time excellent control (at least 99% control) of poison hemlock was observed. At 9 and 25 days after the fourth flame application, 97.25% and 93.75% control of stinging nettle in the flame treatment was observed, respectively. Poison hemlock was completely controlled at 9 and 25 days after the fourth and final flame application. The flame treatment appeared to show good activity on scouringrush with control levels of 82.5% control at 15 DAT of third flame application. Nine days after the fourth flame treatment, 97.5% control of scouringrush was observed. Twenty- five days after the last flame treatment, 85% control of scouringrush was seen. At this time the untreated check had 40-inch tall stinging nettle, 36-inch poison hemlock and 12-inch scouringrush.

Drought conditions could have played a major role in steam weed control efficacy and possibly increased the benefit of flame treatments.

After four applications, a statewide burning ban prevented further flame treatments. Based on results experienced in this study, four flame treatments using the Atarus Ranger flamer weed control device provided good to excellent control of stinging nettle, poison hemlock and scouringrush. Multiple applications of flame will need to be applied to manage perennial weeds such as those tested. The Atarus Ranger allowed the flame applications to be applied quickly and easily. This device is a well-designed weed management tool. Based on experience in the field this summer with the Atarus Ranger, this device should provide years of reliable service for those who want to adopt weed flaming technology.

Trial 6. *Perennial weed control using the Atarus Ranger Propane Flamer and the Sioux Weed Blaster Steamer in a non-cropland environment*

Summary

Perennial weeds are common pests of non-cropland areas such as ditch banks, fencerows and irrigation canals along the Front Range of Colorado. The perennial weeds encountered in this study were stinging nettle (*Urtica dioica)* and poison hemlock (*Conium maculatum)*. The purpose of this study was to examine whether steam or flame treatments of non-cropland (ditch banks) in the late spring could reduce perennial weed populations. Weeds were steamed using the trailer mounted Sioux Weed Blaster Steamer weed control device. The flamed treatment involved using the handheld Atarus Ranger Thermal weed control device. The first steam and flame treatments were applied on May 4, 2002, when the stinging nettle and poison hemlock were 3 to 6 inches tall. At the time of the second set of treatments on May 20, the weeds were over 6 inches tall. All weed species plant densities averaged about 5 plants per square foot. Steaming weeds using the Sioux Weed Blaster Steamer weed control device gave little to no control of stinging nettle following the two steam applications. Steam treatments gave some control (42%) of poison hemlock 9 days after the second application, but no control by 25 days after treatment. Flaming weeds using the Atarus Ranger gave fair weed control (76.7%) of the perennial weeds stinging nettle and poison hemlock following just two flame applications. Poison hemlock appeared to be more sensitive to steam and flame applications than stinging nettle.

Materials and Methods

The field research test site was located at Berry Patch Farms, near Brighton, Colorado. Berry Patch Farms is a certified organic operation. The treatments selected for this experiment were:

1. Two steam applications
2. Two flame applications
3. Untreated check

The perennial weeds used in this study were stinging nettle (*Urtica dioica)* and poison hemlock (*Conium maculatum)*. All weed species plant densities averaged about 5 plants per square foot. Each weed control treatment was replicated 3 times. Each plot was 4 feet by 5 feet (20 square feet). Weeds were steamed using the trailer mounted Sioux Weed Blaster Steamer weed control device. The Sioux Weed Blaster Steamer uses diesel as a fuel source and applies 2 gallons of water per minute, which produces 350 degree F saturated steam at 250 psi. This machine holds 125 gallons of water, which allows about one hour of steaming operation. The flamed treatment involved using the handheld Atarus Ranger Thermal weed control device. This device uses propane as the fuel source and provides about 45 minutes of flaming per 3 kg tank of propane when used at high flame setting. Successful flaming requires only a blanching of weed tissue without allowing the fire point to be reached (The fire point is the temperature at which the flame becomes self-sustained so as to continue burning). Two steam and two flame applications were used during this experiment. The first steam and flame treatments were applied on May 4, 2002, when the stinging nettle and poison hemlock were 3 to 6 inches tall. Each steam and flame treatment plot was treated for 30 seconds. Temperature at time of 1st flame application was 48 degrees Fahrenheit, humidity 62% and wind from the west at 5 mph. The second flame application was applied on May 20, 2002, when weeds were over 6 inches tall in the untreated check. At this time, each steam and flame treatment plot was treated for 60 seconds. Temperature at time of 2nd steam and flame applications was 52 degrees Fahrenheit, humidity 62% and wind from the south at 9 mph.

Treatments were evaluated for effects on weeds on May 14, 20, 29 and June 14, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Tukey's Least Significant Difference method.

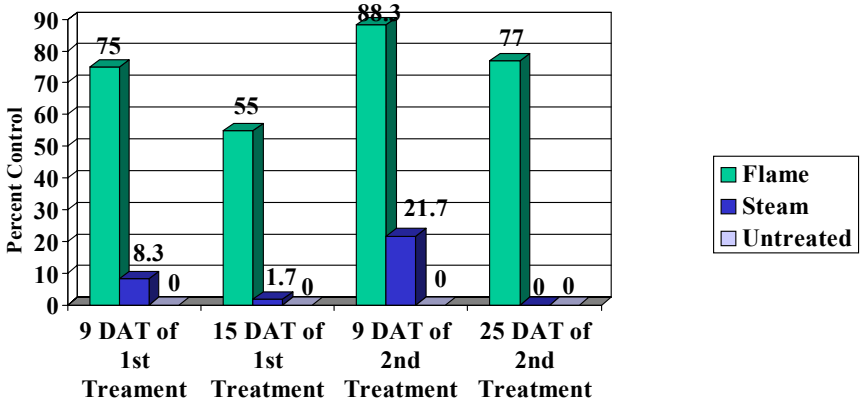
Results

Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on a 0-100% scale.

Date of Evaluation	Percent Control of Stinging Nettle Steam Treatment	Flame Treatment	Untreated Check
May 14, 2002 (9 DAT of 1st Application)	8.33	75.00	0
May 20, 2002 (15 DAT of 1st Application)	1.67	55.00	0
May 29, 2002 (9 DAT of 2nd Application)	21.67	88.33	0
June 14, 2002 (25 DAT of 2nd Application)	0.00	76.67	0

Date of Evaluation	Percent Control of Poison Hemlock Steam Treatment	Flame Treatment	Untreated Check
May 14, 2002 (9 DAT of 1st Application)	18.33	83.33	0
May 20, 2002 (15 DAT of 1st Application)	4.00	78.33	0
May 29, 2002 (9 DAT of 2nd Application)	41.67	88.33	0
June 14, 2002 (25 DAT of 2nd Application)	0.00	76.67	0

Effect of Two Flame and Two Steam Applications on Stinging Nettle in a Non-Cropland Environment



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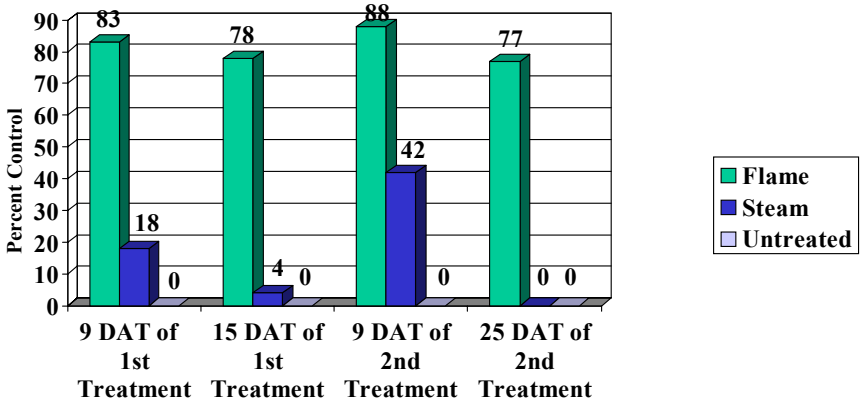
Effect of Two Flame and Two Steam Applications on Poison Hemlock in a Non-Cropland Environment



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Discussion and Conclusion

Evaluations of treatments taken 9 days after the 1st flame and steam application showed the following: The flame treatment showed fair activity on stinging nettle and good activity on poison hemlock. The steam application showed very little activity on either stinging nettle or poison hemlock at this

time. On May 20, 2002, 15 days after treatment of first application, weed control activity was reduced in both the steam and flame plots because of weed re-growth.

The evaluation of weeds taken 9 days after the 2nd application of flame showed greater than 83% control of stinging nettle and 88% control of poison hemlock. The steam treatment showed 21% control of stinging nettle and 42% control of poison hemlock. On June 14, 2002, 25 days after the 2nd flame and steam application, weed control diminished. Stinging nettle and poison hemlock control dropped to 77% in the flame treatment. No stinging nettle or poison hemlock control was observed in the steam treatment 25 days after the 2nd application. A statewide burning ban prevented further flame treatments.

Drought conditions could have played a major role in steam weed control efficacy and possibly decreased the benefit of steam treatments and yet benefited the flame treatments. After two applications, a statewide burning ban prevented further flame treatments. Based on results experienced in this study, two flame treatments using the Atarus Ranger flamer weed control device provided fair to good control of stinging nettle and poison hemlock. Multiple applications of flame will need to be applied to manage perennial weeds such as those tested. The Atarus Ranger allowed the flame applications to be applied quickly and easily. This device is a well-designed weed management tool. Based on experience with the Atarus Ranger in the field this summer, this device should provide years of reliable service for those who want to adopt weed flaming technology.

Two steam treatments using the Sioux Weed Blaster device provided very poor control of stinging nettle and poison hemlock. Multiple applications of steam and increasing the duration could possibly increase control levels but would also increase the costs of weed control. Based on our experience in this study, the Sioux Weed Blaster did not give commercial acceptable weed control.

Trial 7. (Non-organic) *Weed and insect control using the Sioux Weed Blaster Steamer and Atarus Ranger Propane Flamer in dryland alfalfa*

Summary

Annual weeds and early spring insects are common pests of alfalfa grown along the Front Range of Colorado. Annual weeds of alfalfa include kochia, *Kochia scoparia,* and netseed lambsquarter, *Chenopodium berlandieri*. These weeds compete with newly growing alfalfa and become readily visible in alfalfa stands in the late spring. These weeds commonly contaminate first-cutting hay, thereby reducing the quality and economic value of the hay. The alfalfa weevil, *Hypera postica,* typically is the most frequently encountered insect pest in Northeastern Colorado and can significantly reduce the quality and quantity of first and second cutting alfalfa. The purpose of this study is to examine whether steam or flame treatments of alfalfa fields in early spring could reduce weed and alfalfa weevil populations in a dryland alfalfa field. Alfalfa was flamed using the handheld Atarus Ranger and was steamed using the Sioux Weed Blaster on April 22, 2002. Pursuit herbicide was applied on April 22, 2002. Warrior insecticide was applied on May 23, 2002. Weeds were 1 to 2 inches in size at the time of flame, steam and Pursuit application. Evaluations of weed control showed the following: The flame treatment showed excellent activity in controlling both kochia and netseed lambsquarter with only one application. Neither the steam nor the Pursuit treatments controlled any weeds in this experiment. It appears that drought conditions had a dramatic effect on alfalfa weevil populations. Low populations of alfalfa weevil larvae prevented detectable differences between treatments. Drought could have also affected the performance of the Pursuit and steam treatments in controlling weeds.

Materials and Methods

The field research test site was located at the Edna Chase Farm near Bennett, Colorado. The treatments selected for this experiment were:

1. One flame application
2. One steam application
3. 4 ounces/A of Pursuit herbicide application
4. 3 ounces/A of Warrior insecticide application
5. Pursuit herbicide and Warrior insecticide application
6. Untreated check

Each weed control treatment application was replicated 4 times. Each plot was 6 feet by 25 feet (150 square feet). Weeds were steamed using the Sioux Weed Blaster Steamer furnished by A-J Sales and Service Company of Commerce City, Colorado. The Sioux Weed Blaster Steamer uses diesel as a fuel source and applies 2 gallons of water per minute, which produces 350 degrees F saturated steam at 250 psi. This machine holds 125 gallons of water, which allows about one hour of steaming operation. The flamed treatment involved using the handheld Atarus Ranger Thermal weed control device. The Atarus Ranger uses propane as the fuel source and provides about 45 minutes of flaming per 3 kg tank of propane when used at the high flame setting. Successful flaming requires only a blanching of weed tissue without allowing the fire point to be reached (The fire point is the temperature at which the flame becomes self-sustained so as to continue burning).

The steam, flame and Pursuit herbicide treatments were applied on April 22, 2002, when weeds were 1 to 2 inches tall and required 120 seconds of steaming and flaming to treat all weeds in each plot. The temperature at the time of application was 52 degrees F, wind 4 mph and humidity 22%. Pursuit

was applied at 4 oz/A of product. The Warrior insecticide was applied on May 23, 2002, when weevil populations were expected to be at their highest. Warrior was applied at 3 oz/A of product. The temperature was 52 degrees F, winds out of the south at 1-5 mph, and humidity was 30%. Both the Pursuit and Warrior pesticides were applied using a CO_2 backpack sprayer. The spray pressure was 30 psi with an output of 20 gallons of spray solution per acre.

The weeds encountered in this study were kochia (*Kochia scoparia*) and netseed lambsquarter (*Chenopodium berlandieri*).

Treatments were evaluated for effects on weeds on April 30, May 13, and May 31, 2002. A percentage of weed control was assigned to each plot, with a treatment average derived from this information. Statistics were analyzed using Tukey's Least Significant Difference method.

Results

Treatment plots were evaluated in the morning of each selected date. Weed plants in each plot were inspected for chlorosis, necrosis and plant death. The percent control is based on a 0-100% scale.

Date 4/30/02 (8 days after application of weed treatments)

	Average Percent Control	
Treatment	Kochia	Lambsquarter
Flame application	93.0	95.0
Steam application	0	0
Pursuit application	0	0
Warrior application	0	0
Pursuit + Warrior application	0	0
Untreated Check	0	0

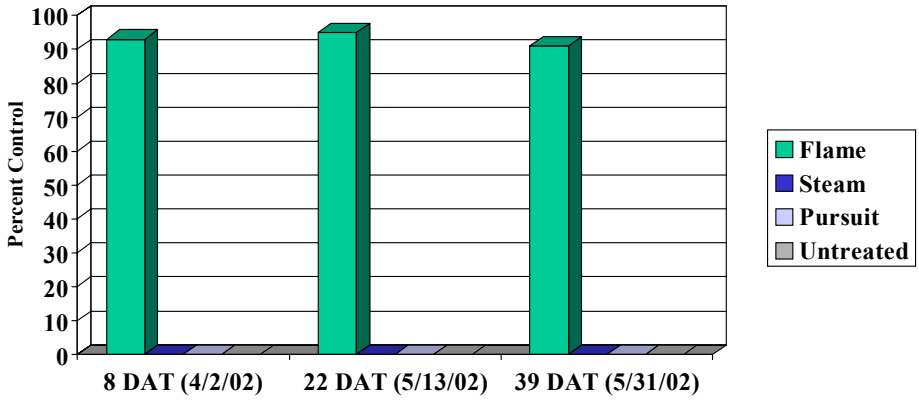
Date 5/13/02 (22 days after application of weed treatments)

	Average Percent Control	
Treatment	Kochia	Lambsquarter
Flame application	95.0	94.0
Steam application	0	0
Pursuit application	0	0
Warrior application	0	0
Pursuit + Warrior application	0	0
Untreated Check	0	0

Date 5/31/02 (39 days after application of weed treatments)

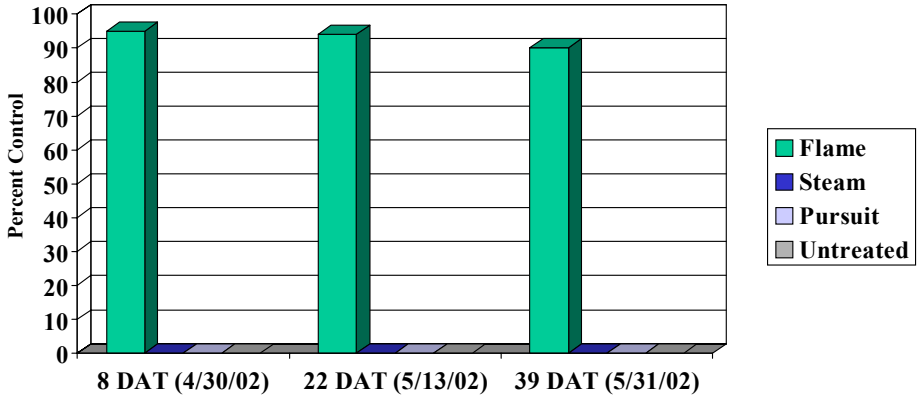
	Average Percent Control	
Treatment	Kochia	Lambsquarter
Flame application	91.0	90.0
Steam application	0	0
Pursuit application	0	0
Warrior application	0	0
Pursuit + Warrior application	0	0
Untreated Check	0	0

Effect of Flame and Steam Applications on Kochia in Dryland Alfalfa



6

Effect of Flame and Steam Applications on Netseed Lambsquarter in Dryland Alfalfa



7

Discussion and Conclusion

Evaluations taken 8, 22 and 39 days after the steam, flame and Pursuit treatments found the following: The flame treatment gave greater than 90% control of both kochia and netseed lambsquarter. The steam treatment did not control any weeds in this experiment. Also, the Pursuit treatment did not show any activity against the weeds. The drought stressed weeds did not appear to be affected by the steam or Pursuit applications. This level of control would not be acceptable to commercial growers.

Drought also affected the alfalfa weevil larvae populations. Alfalfa weevil populations never fully developed in this field. Sampling of the untreated check revealed less than two weevil larvae present per 20 alfalfa stems. No significant differences were seen between treatments because of low insect pressure.

The Atarus Ranger flame device generally provided weed control levels comparable to herbicide treatments commonly used in alfalfa. The use of flame technology does reduce the turning or disturbing of soil and mimics no-till farming.