Analysis of Canada thistle Biomass Reduction from NOP Approved Non-Tillage/Cultivation Control Methods

Adrian Card, CSU Cooperative Extension
Thomas Saielli, CU Department of Environmental Biology

Canada thistle *(Cirsium arvense)* is considered to be one of the most aggressive and difficult to manage agricultural weeds. Development of an effective weed management program requires greater knowledge of the effectiveness, risks, costs and benefits of various weed control strategies. Our goal was to test a variety of methods for controlling Canada thistle in organic agricultural settings, and to determine how the frequency of applications influences control strategies.

The underlying strategy of these control methods is to exhaust the carbohydrate reserves in the extensive, rhizomatous root system in established stands, prevent seed production, and kill newly germinated seedlings. Investigating several treatment methods and frequencies of application could potentially offer some insight for Canada thistle management planning. One of the main conclusions of this research is that the frequency with which a control method is used could have a significant impact on the effectiveness of that treatment.

Methodology

Research was conducted at Pachamama Organic Farm near Hygiene, Colorado. The farm was not certified organic during the 2005-2006 research, but all practices there would comply with the National Organic Program (NOP) Standards. The area used contained established stands of Canada thistle. Treatments and weekly assessments were conducted during the months of May through October 2005 and 2006. Each of 30 test plots (15 feet by 10 feet) were treated for thistle using one of ten different methods applied at three different frequencies: every two weeks, every four weeks, and every eight weeks. Treatments included several commercial products: Burnout 2 and Matran II (Matran EC in 2006), which are clove oil-based herbicides; AllDown and Deadeye, acetic acid herbicides; and 10%, 15% and 20% generic acetic acid solutions mixed with a yucca-based surfactant. The surfactant is added to aid in breaking the surface tension of the solution, which reduces run-off and allows the treatment to penetrate the leaf cuticle. Handpulling, hoeing, and flame weeding were also tested. All treatments comply with the NOP Standards.

Spray treatments used broadcast applications with a Solo backpack sprayer with a 2-nozzle spray boom at approximately 145 gallons per acre (spraying until run off). Sprays were done only when air temperatures were in excess of 65F, as per manufacturer recommendations or advisable practice.

Hoeing and handpulling involved the removal of all visible surface biomass, and flame weeding involves burning weeds with an open flame until all biomass is severely wilted. All plots are compared to a control plot that was adjacent to the experimental plots and had an even distribution of approximately 200 thistles. **Each of the experimental plots**

was assessed for plant numbers and the percentage of biomass relative to the control plot, which was an untreated plot with approximately 200 well-established thistles.

Products with Acetic Acid as Ingredient:

AllDown – proprietary, perhaps 8% acetic acid with other ingredients

After two seasons of treatments, the AllDown plot treated **every eight weeks** fluctuated between 50 plants (above-ground shoots) and 10% biomass up to 85 plants and 50% biomass. There was an overall increase in Canada thistle numbers (+15) and biomass was up 10%.

When treated **every four weeks** there were great fluctuations in thistle numbers and percent biomass, but overall, after two seasons thistles decreased from 125 plants to 60 plants and biomass decreased from 75% to 40%.

Plots treated **every two weeks** decreased from 80 plants and 20% biomass to start the 2005 season, to 5-10 plants and 5% or less biomass from July 2005 on and throughout the 2006 season.

Although plots treated every two weeks and every eight weeks only had a small percentage of thistle to begin with, the amount of thistle increased in the plot treated every eight weeks and decreased in the one treated every two weeks. The plot treated every four weeks had a lot to begin with, and, although the amount of thistle remained high during 2005 it ultimately went down by 2006. Therefore, AllDown appears to work best when used at a high frequency (every two weeks) and poorly if applied less frequently, as in the plots treated every eight weeks.

Deadeye –acetic acid and sodium chloride

After two seasons of treatment the Deadeye plot treated **every eight weeks** fluctuated between 70 plants (aboveground shoots) and 15% biomass, up to 80 plants and 50% biomass, and then and then back down to 60 plants, with an overall increase in biomass, ending the 2006 season with 30% – a 15% increase.

When treated **every four weeks** there was a slight increase after the 2005 season starting with 40 plants and 10% biomass and ending the season with 60 plants at 25% biomass. However, by the 2006 season the average dropped to approximately 20 plants and 5% biomass – an overall decrease in thistles.

Plots treated **every two weeks** decreased from 80 plants and 20% biomass to start the 2005 season, to an average of 10 plants and approximately 5% biomass.

10% AA plus yucca surfactant

After two seasons of treatment the 10% acetic acid plot treated **every eight weeks** fluctuated around 50 to 70 plants and ended with an increase in biomass, from 15% in May '05 up to 30% in September '06.

When treated **every four weeks** there was a decrease in thistles, beginning the 2005 season with 80 plants and 50% biomass and ending the 2006 season with 60 plants and 25% biomass.

Plots treated **every two weeks** decreased from 50 plants and 10% biomass at the beginning of the 2005 season, to an average of 10 plants and approximately 5% biomass at the end of 2006.

15% AA plus yucca surfactant

After two seasons of treatment the 15% acetic acid plot treated **every eight weeks** increased steadily from 50 plants (aboveground shoots) and 15% biomass in May '05, up to 75 plants and 40% biomass by Sept '05, and then up to 100 plants in May '06 and ending the 2006 season with an increase in thistles of 120 plants and 75% biomass.

When treated **every four weeks** there was an increase in thistles, beginning the 2005 season with 35 plants and 10% biomass, increasing to 90 plants by Sept '05 and ending the 2006 season with 60 plants and 35% biomass.

Plots treated **every two weeks** decreased from 60 plants and 10% biomass at the beginning of the 2005 season, to an average of 10 plants and approximately 5% biomass at the end of 2006.

20% AA plus yucca surfactant

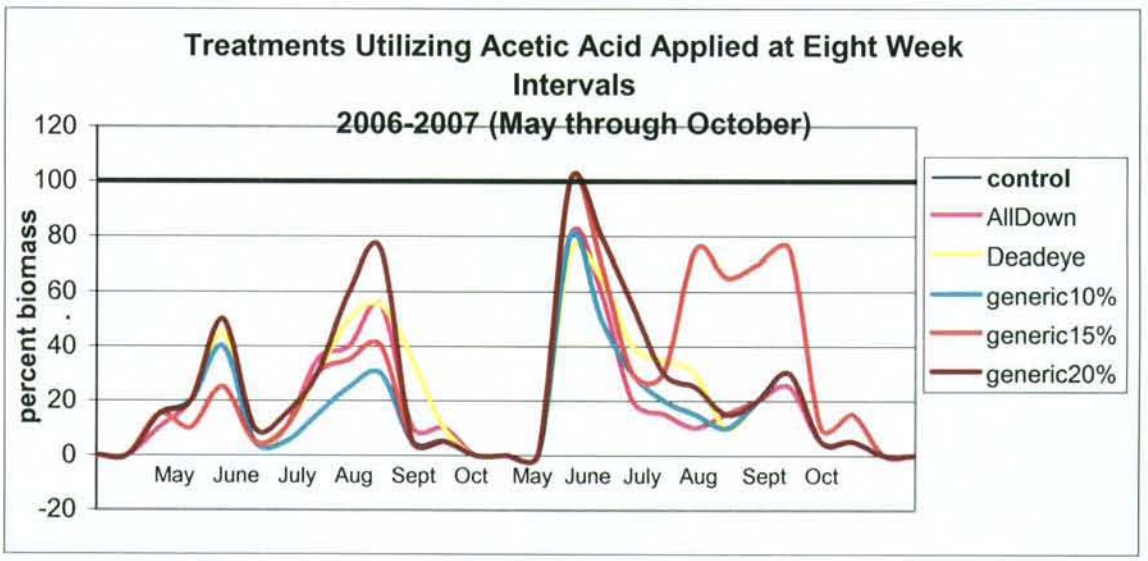
After two seasons of treatment the 20% acetic acid plot treated **every eight weeks** increased from 50 plants (aboveground shoots) and 15% biomass in May '05, up to 100 plants and 75% biomass by Sept '05, and then up to 100 plants and 120% biomass in May '06 and ending the 2006 season with an overall increase in thistles with 75 plants and 30% biomass.

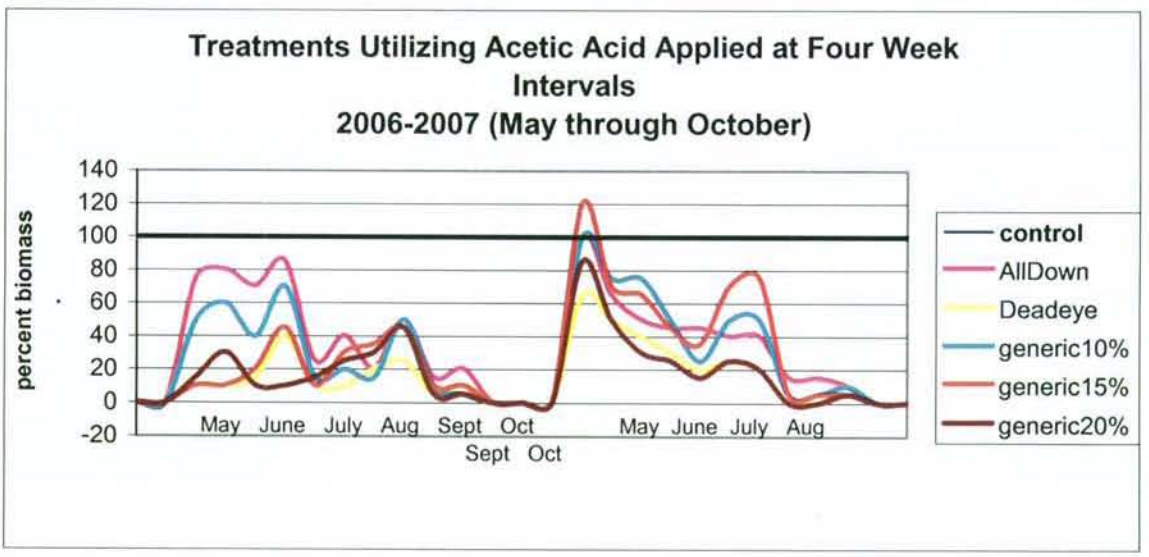
When treated **every four weeks** there was a lot of fluctuation in thistle numbers and percentage of biomass, beginning the 2005 season with 50 plants and 15% biomass, up to 95% biomass to start the 2006 season, and ending the 2006 season with 50 plants and 10% biomass, a slight decrease in thistles overall.

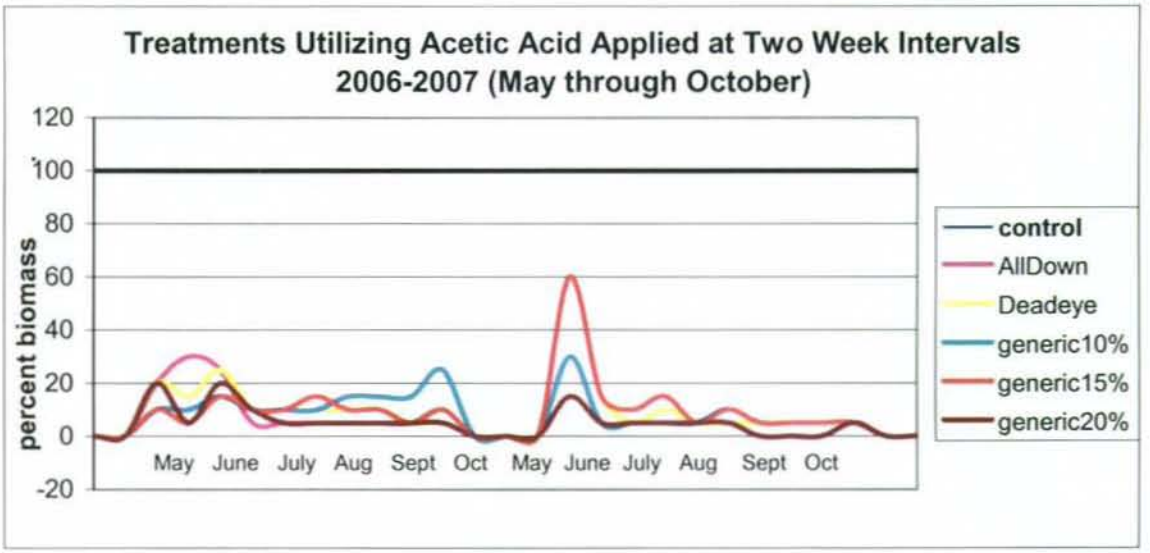
Plots treated **every two weeks** decreased from 75 plants and 20% biomass at the beginning of the 2005 season, to an average of 10-20 plants and approximately 5-10% biomass throughout most of the 2005 and 2006 seasons, ending with no visible thistles remaining – 0 plants and 0% biomass.

With all three of the generic acetic acids mixes, best results were achieved when applied on hot sunny days. They did require more mixing and prep time and a lot of care in their preparation, they're not too hard to work with, they don't separate out of solution and they can be pre-mixed and stored for later use. In all acetic acid solutions, 10%, 15% and 20%, as well as Deadeye and AllDown, there were decreases in thistles when applied every two weeks and were consistently kept to low numbers. Whereas, acetic acid solutions applied less frequently, four to eight week intervals, varied in their results, sometimes decreasing in thistles, but more often increasing – particularly in the plots treated every eight weeks.

The following graphs represent the fluctuations, increases and decreases in thistle biomass over the 2005 and 2006 experiments for all plots treated with acetic acid based solution, at all three frequencies. All graphs are relative to the control plot, which is always 100% of itself.







Important note on acetic acid – CAUSTIC!

Vinegar and acetic acid are synonymous. Household food grade vinegar is about 5% acetic acid. Acetic acid used in this study varies from 8% to 30%.

WHILE PERCEIVED AS LESS TOXIC HERBICIDES, THESE ACETIC ACID PRODUCTS HAVE HUMAN HEALTH HAZARDS THAT SHOULD BE TAKEN SERIOUSLY. WEAR APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT (PPE) - EYE/FACE SHIELD, RESPIRATOR, CHEM GLOVES, CHEM APRON, ETC. WHEN MIXING AND APPLYING ACETIC ACID.

Acetic acid concentrations over 11% can cause burns upon skin contact. Eye contact can result in severe burns and permanent corneal injury. Inhalation can cause temporary or permanent damage to the respiratory system. Current practice suggests a 24-48 hour REI (restricted entry interval – no one may enter the area of application for health hazard reasons) for products equal to or greater than 20% acetic acid (AA).

Acetic acid is also corrosive to metal and rubber components in backpack and tractor mounted sprayers. Immediately triple rinse/flush sprayer components after application to avoid damage to sprayer components.

Products with Clove Oil as ingredient

Burnout II - clove oil based

After two seasons of treatments, the Burnout II plot treated **every eight weeks** increased from 35 plants and 10% biomass in May 2005, to 140 plants and 75% biomass by September 2006.

When treated **every four weeks** there were great fluctuations in thistle numbers and percent biomass, starting in May 2005 with 20 plants and 5% biomass, up to 60 plants and 60% biomass in May 2006, and ending with 50 plants at 5% biomass in September 2006, an overall increase in thistles by 30 plants, with fluctuating percent biomass.

Plots treated **every two weeks** decreased from 80 plants and 20% biomass to start the 2005 season to 45 plants and 10% by September 2006.

Matran 2 (2005) and Matran EC (2006) as per manufacturer – clove oil and lecithin

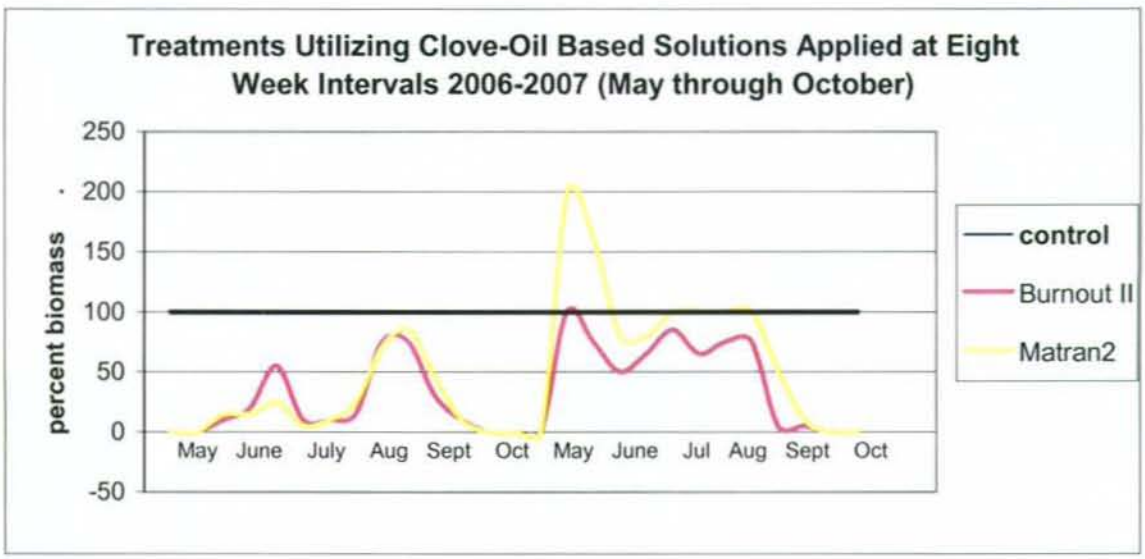
After two seasons of treatments the Matran (II and EC) plot treated **every eight weeks** increased from 35 plants and 15% biomass to 250 plants and 100% biomass, matching or exceeding the control plot during most of both seasons.

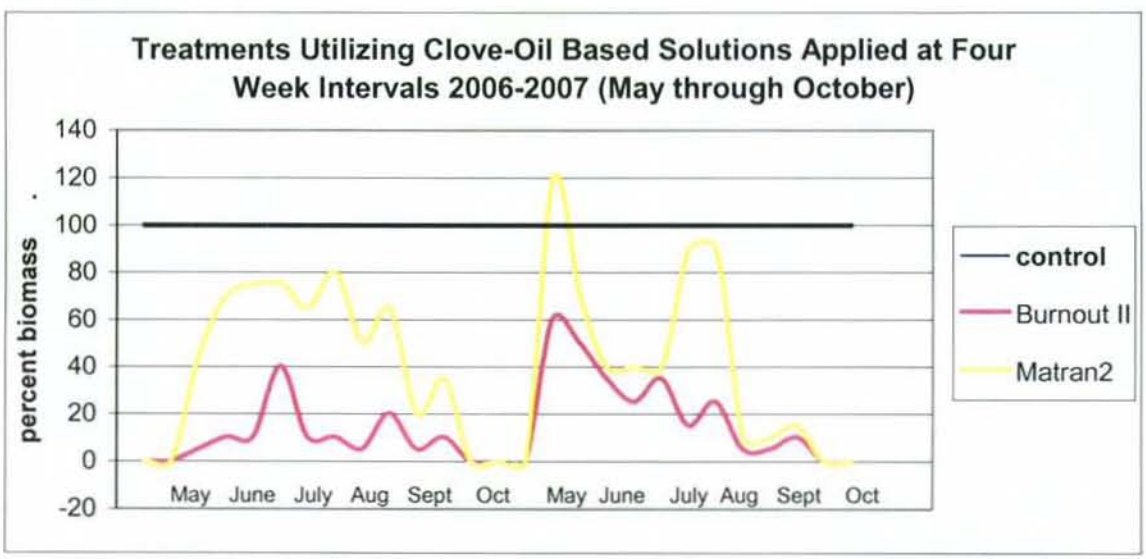
When treated **every four weeks** there were great fluctuations in thistle numbers and percent biomass, starting at 80 plants and 45% biomass, and increasing to 175 plants and 180% biomass, and finally ending in September 2006 with 35 plants and 10% biomass, ending with an overall decrease, but with periods of high numbers throughout both seasons.

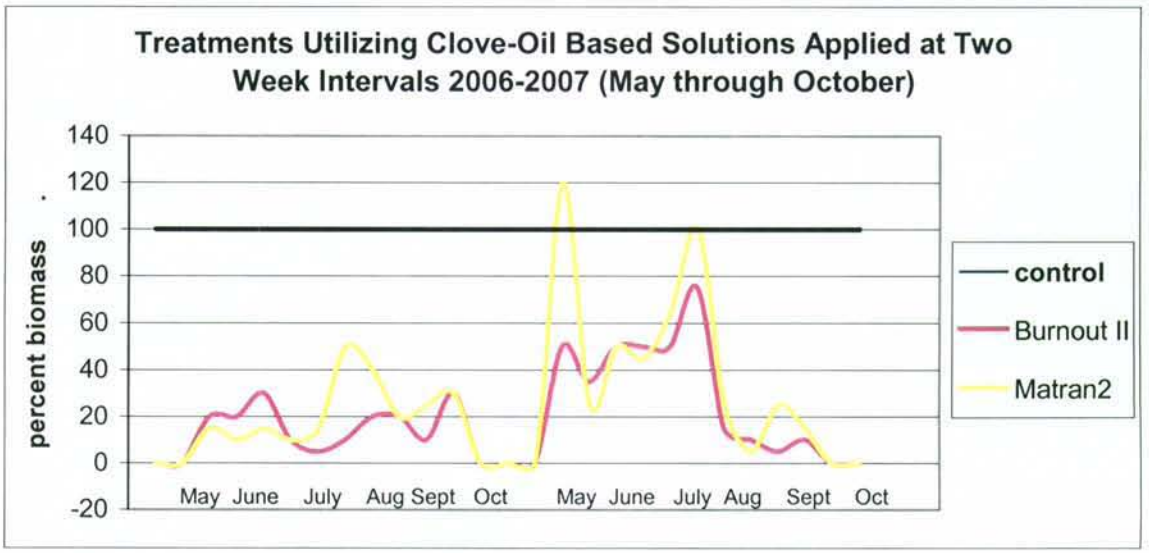
Plots treated **every two weeks** increased from 60 plants and 15% biomass in May 2005 to 90 plants and 25% biomass by September 2006.

We had mixed results with Matran; sometimes it killed everything (especially towards the end of the season, August and September) and other times it didn't appear to do anything. It, as well as Burnout 2, were slightly difficult to work with, as they are clove-oil based and had a tendency to separate. With both the clove-oil products, Burnout 2 and Matran (II and EC), there seemed to be increases in thistle growth that rivaled, or exceeded the control plots during the middle of the growing season (June-August) but declined significantly in September through November. Therefore, even though thistle numbers were ultimately brought down by the end of each season, the high thistle numbers during the middle of the growing season enabled thistle to go to seed, compete with crops, and sequester enough below ground carbohydrates to come back strong the following season.

The following graphs represent the fluctuations, increases and decreases in thistle biomass over the 2005 and 2006 experiments for all plots treated with clove-oil based solution, at all three frequencies. All graphs are relative to the control plot, which is always 100% of itself.







Mechanical/Thermal

Hoeing

After two seasons of treatment the hoeing plot treated **every eight weeks** increased from 50 plants (aboveground shoots) and 25% biomass in May '05, up to 180 plants and 95% biomass by Sept '05, and then up to 140 plants and 175% biomass in May '06 and ending the 2006 season with an overall increase in thistles with 135 plants and 45% biomass.

When treated **every four weeks** there was an increase from 50 plants (aboveground shoots) and 25% biomass in May '05, up to 150 plants and 75% biomass by Sept '05, and then up to 170 plants and 190% biomass in May '06 and ending the 2006 season with an overall increase in thistles with 100 plants and 30% biomass.

With plots treated **every two weeks** there were great fluctuations in thistle numbers and percent biomass, starting at 70 plants and 15% biomass, and increasing to 200 plants and 45% biomass, and finally ending in September 2006 with 10 plants and 5% biomass, ending with an overall decrease, but with periods of high numbers throughout both seasons.

Handpulling

After two seasons of treatment the handpulled plot treated **every eight weeks** increased gradually from 25 plants and 10% biomass in May 2005 to 50 plants and 25% biomass in September 2006.

When treated **every four weeks** there was some fluctuation in thistle numbers and percentage of biomass, with an overall decrease in thistles from 60 plants and 10% biomass in May 2005 to 15 plants and 10% biomass in September 2006.

Plots treated **every two weeks** increased from 75 plants and 20% biomass in May 2005 to 100 plants and 60% in September of 2005, and then decreased during the 2006 season, ending with approximately 10 plants and less then 5% biomass.

Flame weeding

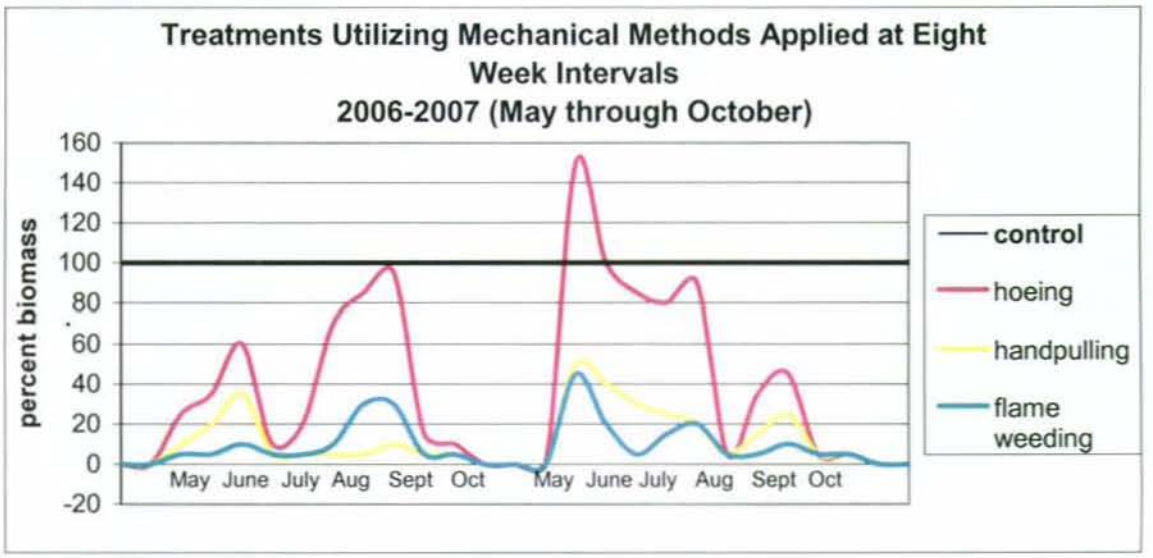
After two seasons of treatment the 20% acetic acid plot treated **every eight weeks** fluctuated throughout both seasons, starting with 10 plants and ~5% biomass, up to 65 plants and 45% biomass, ending with a slight increase at 30 plants and 10% biomass.

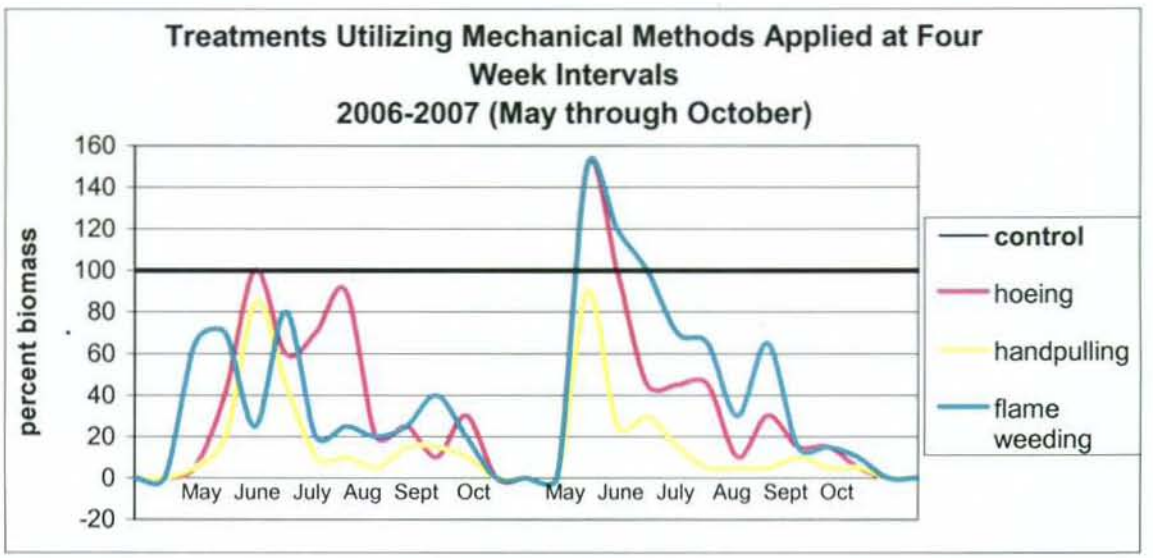
When treated **every four weeks** there was a lot of fluctuation in thistle numbers and percentage of biomass, beginning the 2005 season with 100 plants and 65% biomass, down to 50 plants and 25% biomass in September 2005, and up to 250 plants and 200% biomass to start the 2006 season; ending the 2006 season with 45 plants and 65% biomass, a slight decrease in thistles overall.

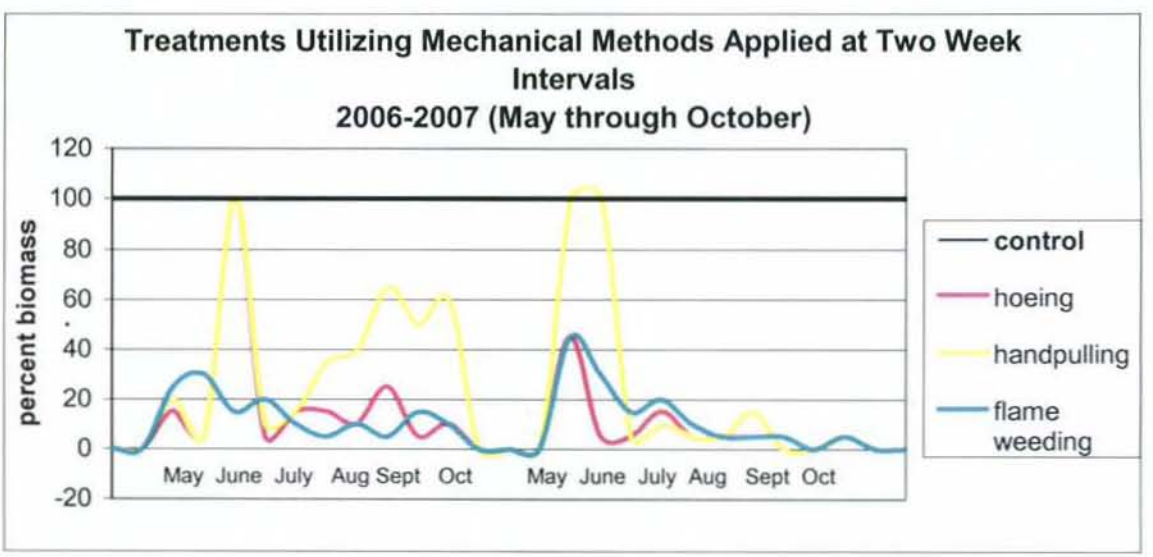
Plots treated **every two weeks** decreased from 75 plants and 25% biomass at the beginning of the 2005 season to 10 plants and 5% biomass by September 2006.

Flame weeding worked best later in the growing season, but near the very end of the season the thistle made a come back, so the results were mixed. This method can be used under any weather conditions (although may have been most effective during the warm dry period between late July and early Sept.).

The following graphs represent the fluctuations, increases and decreases in thistle biomass over the 2005 and 2006 experiments for all plots treated with mechanical methods, at all three frequencies. All graphs are relative to the control plot, which is always 100% of itself.


Treatments Utilizing Mechanical Methods Applied at Eight Week Intervals
2006-2007 (May through October)
percent biomass
160
140
120
100
80
60
40
20
0
-20
May June July Aug Sept Oct
May June July Aug Sept Oct
control
hoeing
handpulling
flame weeding


Treatments Utilizing Mechanical Methods Applied at Four Week Intervals
2006-2007 (May through October)
percent biomass
160
140
120
100
80
60
40
20
0
-20
May June July Aug Sept Oct
May June July Aug Sept Oct
control
hoeing
handpulling
flame weeding


Treatments Utilizing Mechanical Methods Applied at Two Week Intervals
2006-2007 (May through October)
percent biomass
120
100
80
60
40
20
0
-20
May June July Aug Sept Oct
May June July Aug Sept Oct
control
hoeing
handpulling
flame weeding

Conclusions and Recommendations from 2005-2006 research data:

There is no doubt that the frequency with which a treatment is applied was important in this experiment, by far the best results occurred when treatments were applied every two weeks for all of the treatments Even though some of the results varied in the plots treated every four and eight weeks, they did less well then the plots treated every two weeks, and often times had increases in thistles.

The best strategy may involve an aggressive treatment program using one of the spray herbicides or flame weeding every two weeks, early in the season. There are two reasons for this; one is that it could be performed before crops are in place and therefore a broadcast application can be used. Secondly, this would help eliminate a large percentage of new plants springing up from the seed bank leaving only the established perennials to contend with. Once the growing season starts you may try any of the methods considering cost, labor, efficacy of the product and frequency (which could require spot treatments so that treatment could continue at high frequency even when crops are in place). Handpulling is a great way to manage established perennials during the growing season. In fact, we recommend handpulling as a component of any thistle management strategy. The objective is to pull up as much of the root as possible. Handpulling thistle between 8"-12" produced good results, up to 80% or better reduction in numbers and biomass.

Another important observation regarding handpulling involves 'pre-treating' thistles prior to handpulling them. That is – if you treat your thistles with a spray herbicide, flame weeding, or even mowing them to a height of 8 to 12 inches – approximately one week before you intend to pull weeds by hand, they should toughen up and become stiff around the stem making them easier to pull. [Coupled with soil moisture?]

From this study it is apparent that it will take more than 2 years of non-tillage treatments to eradicate established stands of Canada thistle. Edge effect was likely contributing some to the persistence of the C. thistle (i.e. – plants around the plots "feeding" the plants in the plots). Integrating these methods with tillage practices that DO NOT chop and redistribute pieces of C. thistle in the soil (i.e. – rotary tillers, discs, reciprocating spaders, etc.), either mimicking hoeing (sweeps) during the season or moldboard plowing in fall will likely hasten the eradication of C. thistle in production agriculture scenarios. Rotary tillers and disc are primary culprits for spreading C. thistle on farms.

Considerations for clove oil based sprays:

Both products required agitation prior to mixing and also during spray application to prevent the oil fraction from coming out of suspension (remember oil floats on water). Matran EC (emulsifiable concentrate) was formulated to help with this issue, but it was apparent that some of this separation and stratification likely took place during the research with all clove oil based products tested. Thorough agitation of the concentrate in its original container coupled with an in tank agitation may provide better results than those described here.

Weed Management Implications

Cost per acre

AllDown	
Burnout	
Deadeye	
Matran EC	
10% Acetic acid	
15% Acetic acid	
20% Acetic acid	
Handpulling	
Hoeing	
Flame weeding	

Timing

Consider the growth cycles of a rhizomatous perennial weed like Canada thistle. In early spring it is coming out of winter dormancy and will be drawing food from its root carbohydrates until it has sufficient leaf surface area to make enough food for itself from photosynthesis. This is a vulnerable period and one often overlooked by producers. If the plant is not allowed to replenish root reserves then it can be more severely stress from frequent treatments. Look to begin treatments in March/April. [Does the literature support this?]

Similarly on the end of the season, before killing freezes, the plant is preparing for winter dormancy and can be stressed by preventing the storage of sufficient root reserves.

The minimum air temperature requirement of 65F for spray treatments may not be reached in spring and fall. Plan for mechanical or flame treatments during these times. Also rain may prevent spray applications.