Investigation of Spot Treatment Control Methods for *Solidago Altissima*

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Abstract

This report explores the different methods of cutting and treating with herbicide the plant *Solidago altissima*. Four experimental and two control plots were created in four different prairies for a total of 24 plots. Half of the plots were cut 40 inches high and the other half were cut five inches high. One third of the plots was treated with Garlon 3A, another Round-Up Pro, and the last third was not treated with herbicide. They were all monitored for signs of death by determining percent green of each ramet. Statistical tests were performed on the results and no significant differences were found between the different cuts or the herbicides.

Introduction

Many methods are employed when restoring an area to its natural state. Native species need to be reintroduced and non-natives need to be removed. However, the balance of the natives in the ecosystem is also important. For example, at Litzsinger Road Ecology Center, the native plant *Solidago altissima* is very invasive and threatening the biodiversity at the center. Therefore, the restorationists at the center have been removing large patches of it to allow for other species to prosper. The purpose of this project is to determine the most efficient method of killing *Solidago altissima* using herbicide. *S. altissima* spreads rhizomically, which allows it to colonize areas quickly. Also, it grows well in disturbed areas because the broken rhizomes shoot up, producing more ramets. Therefore, pulling is not an effective method of removal. It grows near desirable native plants; therefore a way to specifically target *S. altissima* is desired. Cutting a ramet and treating it with herbicide takes into account these restraints. However, whether a ramet must be cut near the base or not and which herbicide is most effective on *S. altissima* was unknown. This study investigates whether cutting 5 inches high or 40 inches high causes a difference in kill rates and whether Garlon 3A or Round-Up is the more effective herbicide on S. *altissima*. In order to systematically measure death an index of greenness was created. The null hypothesis is that there is no significant difference between the means of the percent change in greenness between the different types of treatments. The alternative hypothesis is that there is a significant difference between the means.

Garlon 3A and Round-Up have different active ingredients and methods of killing a plant. Triclopyr is Garlon 3A's active ingredient and Round-Up's is glyphosate. Glyphosate is a non-selective, systemic herbicide, which means that it will kill any plant and it travels to and effects parts of the plant other than where it was applied. It is of the family of herbicides that are amino acid synthesis inhibitors. Specifically, glyphosate inhibits the shikimate pathway enzyme *5-enol* Pyruvylshikimate-3-phosphate synthase (EPSPS). This prevents the biosynthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophane (Dekker). Animals do not have the EPSPS enzyme and therefore must obtain aromatic amino acids by consuming plants, bacteria, or fungi, which all contain the enzyme (Roundup). The blocked production of the amino acid obstructs protein synthesis. The lack of proteins causes the plant to cease growing and for its tissues to degrade. Desiccation and dehydration are the ultimate causes of death (Dekker).

Triclopyr has a different mode of action. It is an auxin mimic and regulates plant growth. The herbicide penetrates foliage, is easily absorbed by roots, and can be translocated by phloem and xylem. Auxin is a plant hormone that regulates cell growth and protein synthesis among other things (Lecture). Triclopyr imitates auxin. The additional perceived auxin triggers increased disorganized growth. Also, it makes cell walls more elastic and guard cells swell. This increases photosynthesis (Modes). Essentially, triclopyr makes plants "grow themselves to death" (Lecture). It is selective, unlike glyphosate, and systemic. It has a very small to no impact on grasses.

Methodology

Litzsinger Road Ecology Center has four separate areas of prairie. In each of the four prairies, there were several different plots with different treatments and different heights. There were 3 high cut plots in each of the 4 prairies, each with a different treatment of either Round-Up, Garlon 3A, or nothing, and 3 low cut plots in each prairie, each with a different treatment as above. There were a total of 6 plots in each prairie for a grand total of 24 plots in the study. Each plot was one meter squared with rebar marking the four corners. The rebar will be able to withstand fire and will therefore make the plots available for future research. The meter plots contained 30-90 ramets. The average number of ramets was *54* and 1304 ramets total were treated. High cut ramets were cut 40 inches from the ground and low cut ramets were cut *5* inches from the ground. The sites of the plots were selected by searching for dense areas of *Solidago altissima.* Shoe polish bottles were used as applicators for the herbicides. They were thoroughly cleaned out and the herbicides were added, along with a blue dye called Signal spray colorant. After the plot was marked out, the researcher and an assistant used a precut stick to measure the *Solidago altissima* ramets and cut accordingly. Next, the herbicide was applied to the cut end of each ramet. During both the cutting and painting, each ramet was counted to ensure that each cut ramet was painted.

Each plot was carefully monitored. Biweekly, the researcher determined the percent green of each ramet and assigned it a number 1-5 based on the index of greenness. The index is graded as follows:

1- 0-20% green

2- 21-40% green

3- 4l-60% green

4- 61-80% green

5- 81-100% green

Also, on the final observation day, the researcher counted the number of ramets she considered dead and dying, or well on their way to being dead.

For analysis, the number of ramets in a particular category of greenness was multiplied by the median of that category (i.e.- 42 ramets in category l=42 x 10%). This method was used to calculate the average percent greenness of a plot for a certain date. This was then graphed. Also, from these numbers, change in average percent greenness was calculated from the first date to the last. The results of like plots from different prairies were aggregated.

Results

A single factor ANOVA test was performed on average change percent greenness data for all of the different types of treatment. Alpha was set at 0.05 (a=0..05) and the p-value was 0.00018950. Therefore, the null hypothesis that there was no significant difference between the average change percent greenness was strongly rejected. The alternate hypothesis was that there was a significant difference between the different types of treatment. Next, two-sample t-tests assuming unequal variances were performed on each of the combinations of kinds of treatments in order to determine specifically where the difference was. The alpha was again set at 0.05. The p-values of these t-tests are listed in Table 1.

Key:
HC= High Cut
LC= Low Cut
RU= Round-Up
GA= Garlon
NO= No herbicide

Table 1, Average Change in Percent Greenness

	HCRU	HCGA	HCNO	LCRU	LCGA	LCNO
Avg. change % greenness	50.52014652	35.23065476	1.598837209	15.264802	37.96000418	-6.0914785

Table 1 displays the average change in percent green from the first day of observations to the last. The ANOVA and t-tests were performed to determine if these means were significantly different.

Table 2, P-values of T-tests

Treatment	p-value	Treatment	p-value
HCRU v HCGA	0.05159	*LCRU v HCGA	0.01687948*
*HCRU v HCNO	0.0077892*	LCRU v HCNO	0.071648
HCRU v LCGA	0.4075622	*HCGA v HCNO	0.00096*
*HCRU v LCNO	0.003012644*	HCGA v LCGA	0.852078
LCRU v LCGA	0.17562828	*HCGA v LCNO	0.008553*
LCRU v LCNO	0.0668298	HCNO v LCGA	0.067793
*LCRU v HCRU	0.00270868*	HCNO v LCNO	0.399088
*LCGA v LCNO	0.032924*		

Table 2 lists all of the p-values for the t-tests between each combination of treatments. The (*) signifies a p-value less than a = 0.05.

Table 3, Failed P-values and the Treatment with the Greater Mean Difference

Greater Mean Difference Treatment	Lesser Mean Difference Treatment	p-value
HCRU	HCNO	0.0077892
HCRU	LCNO	0.003012644
HCRU	LCRU	0.00270868
LCGA	LCNO	0.032924
HCGA	HCNO	0.00096
HCGA	LCRU	0.01687948
HCGA	LCNO	0.008553

Table 3 lists, from the failed t-tests, which treatment had the greater mean change in average percent greenness from the first to last observation day.

Table 4, Percent Dead and Dying in Each Type of Plot

	HCRU	HCGA	HCNO	LCRU	LCGA	LCNO
% Dead	24.1573	11.37725	0	95	95.85062	4.90566
% Dying	57.86517	86.22754	0	3.333333	2.904564	0

Table 4 records the percent dead and dying as determined by the researcher. First, she counted the # of ramets she considered dead. The data was then compiled and percents calculated.

Charts 1-6 display the average percent greenness for each type of plot over the course of the study.

Chart 1, Average HCGA

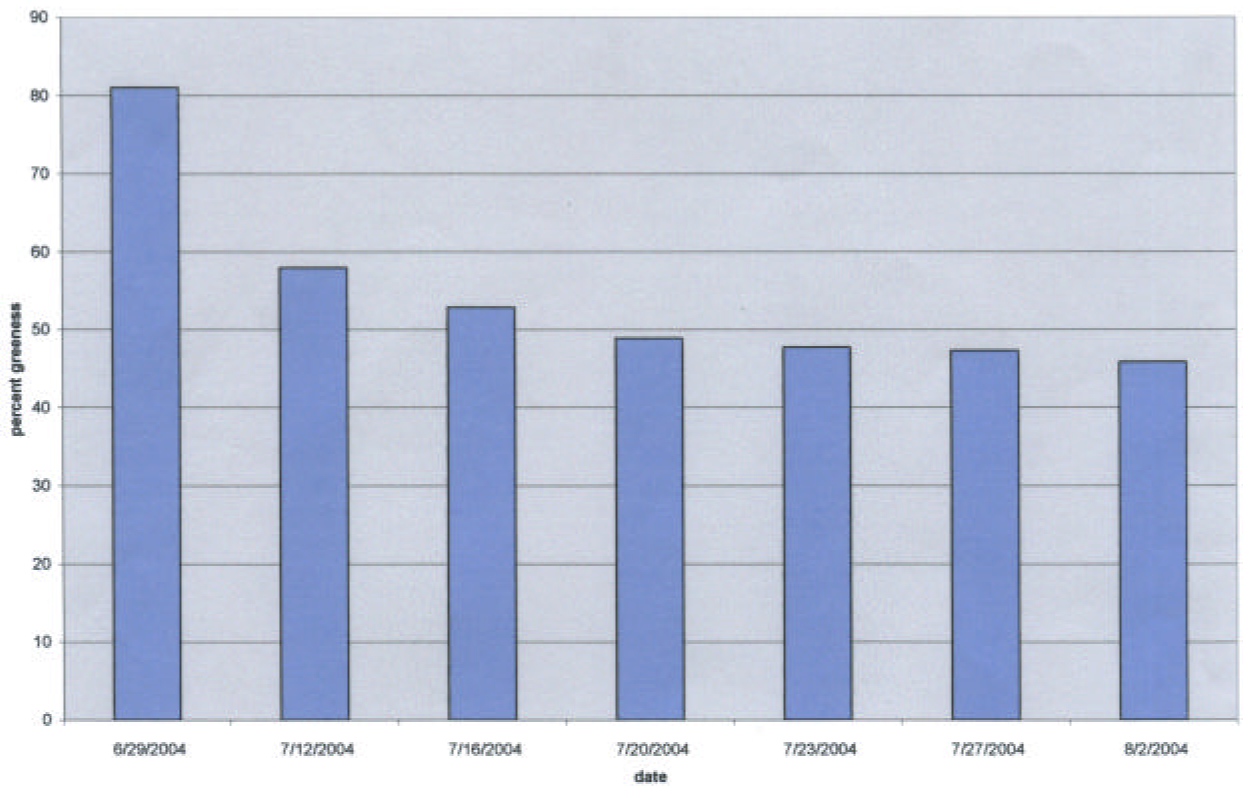


Chart 2, Average LCGA

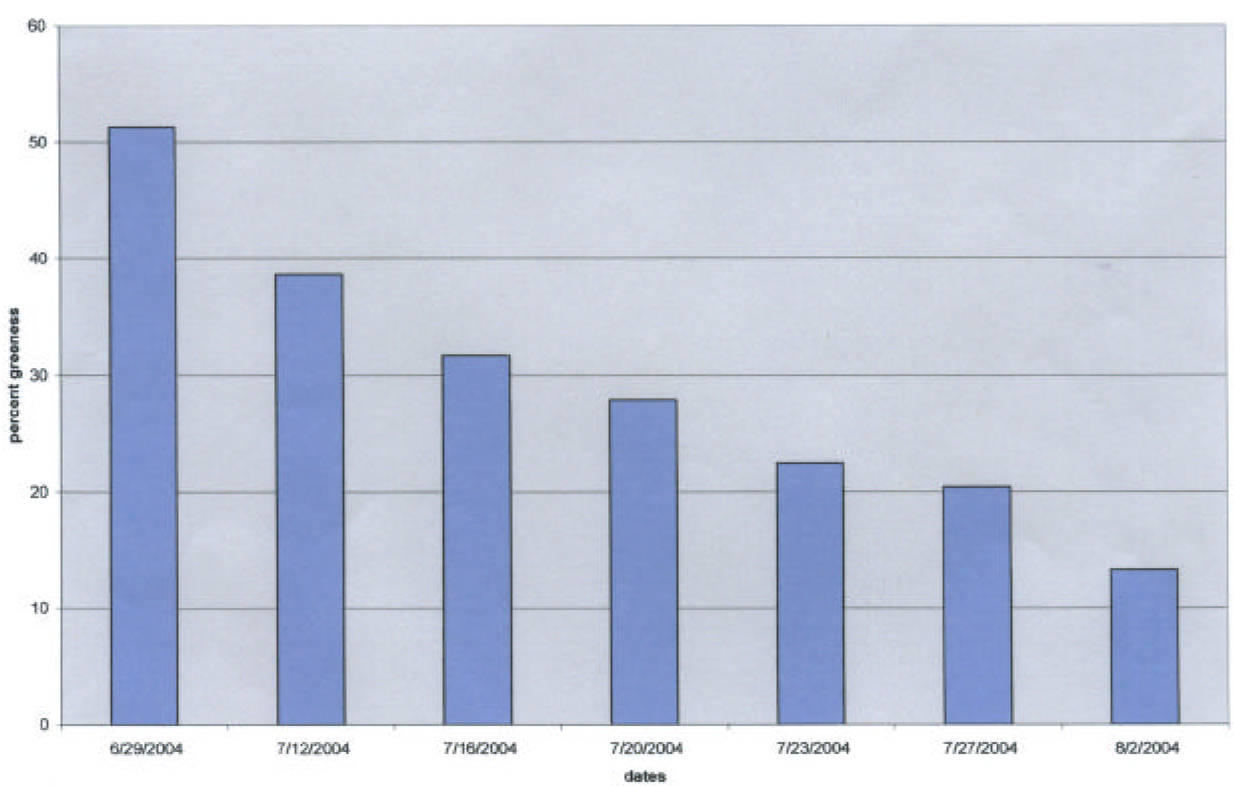


Chart 3, Average HCRU

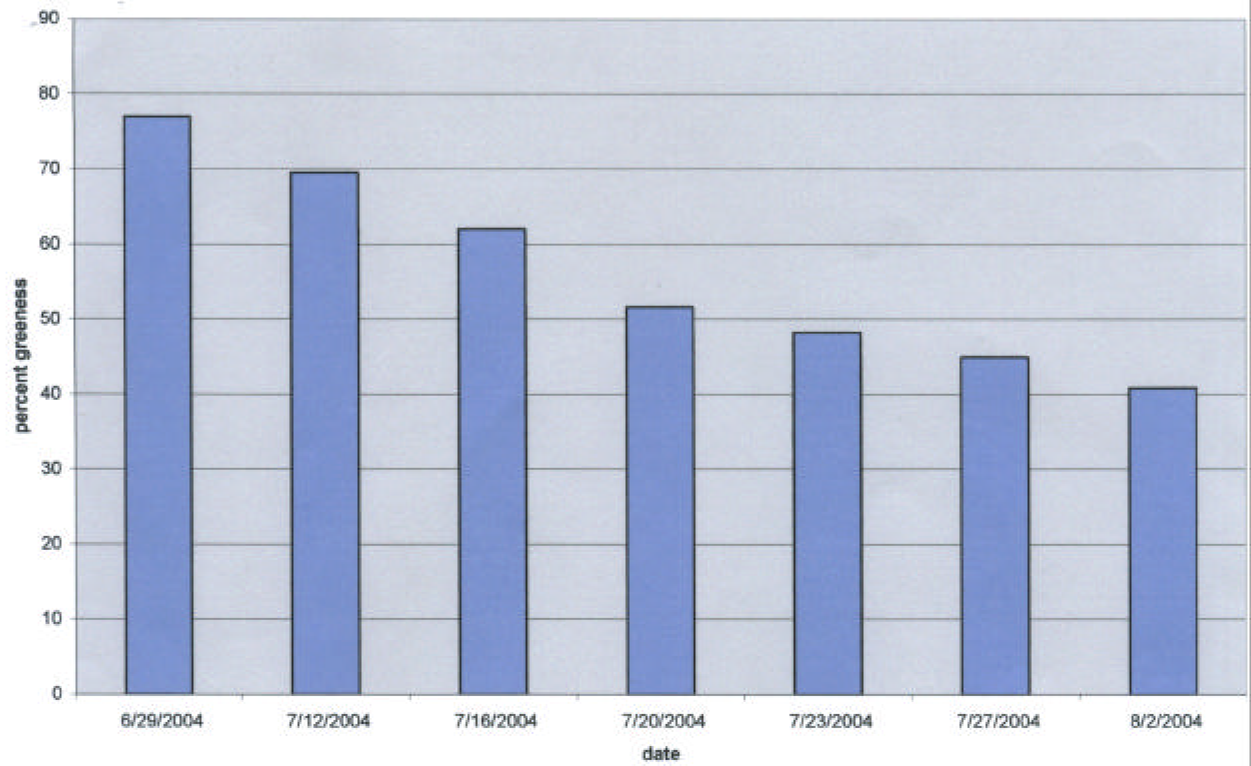


Chart 4, Average LCRU

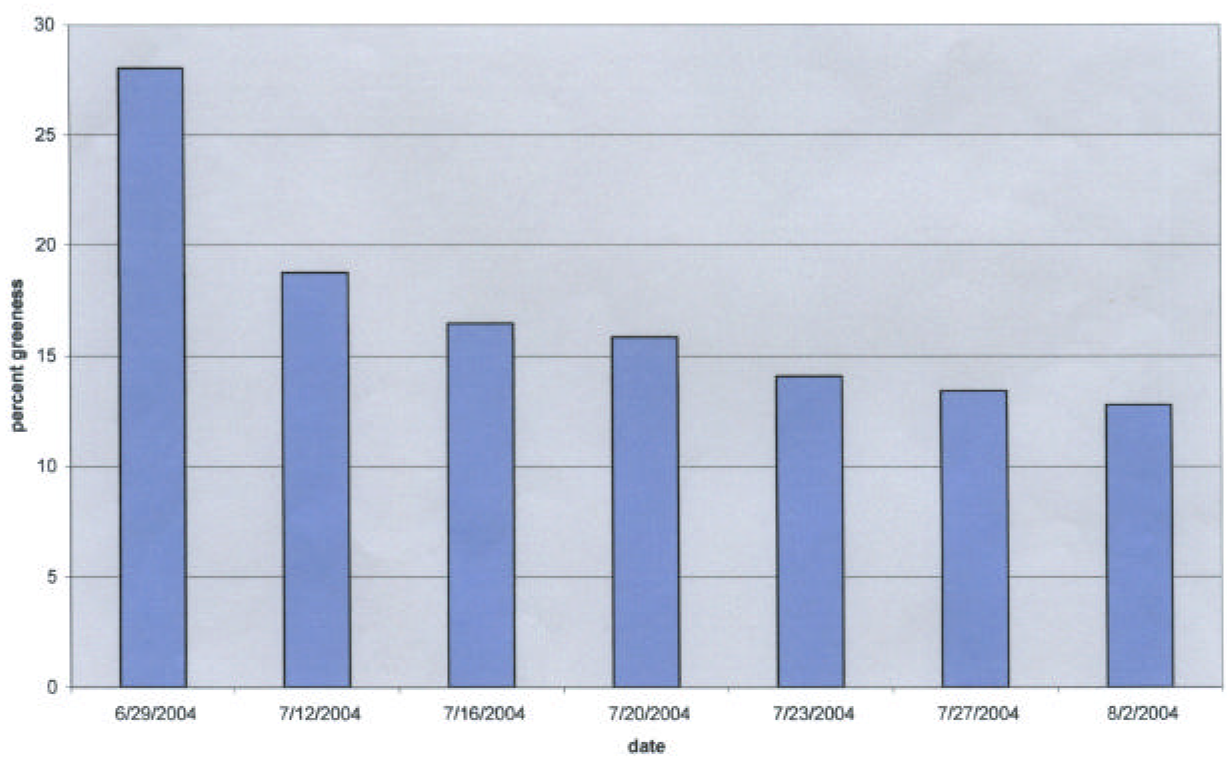


Chart 5, Average HCNO

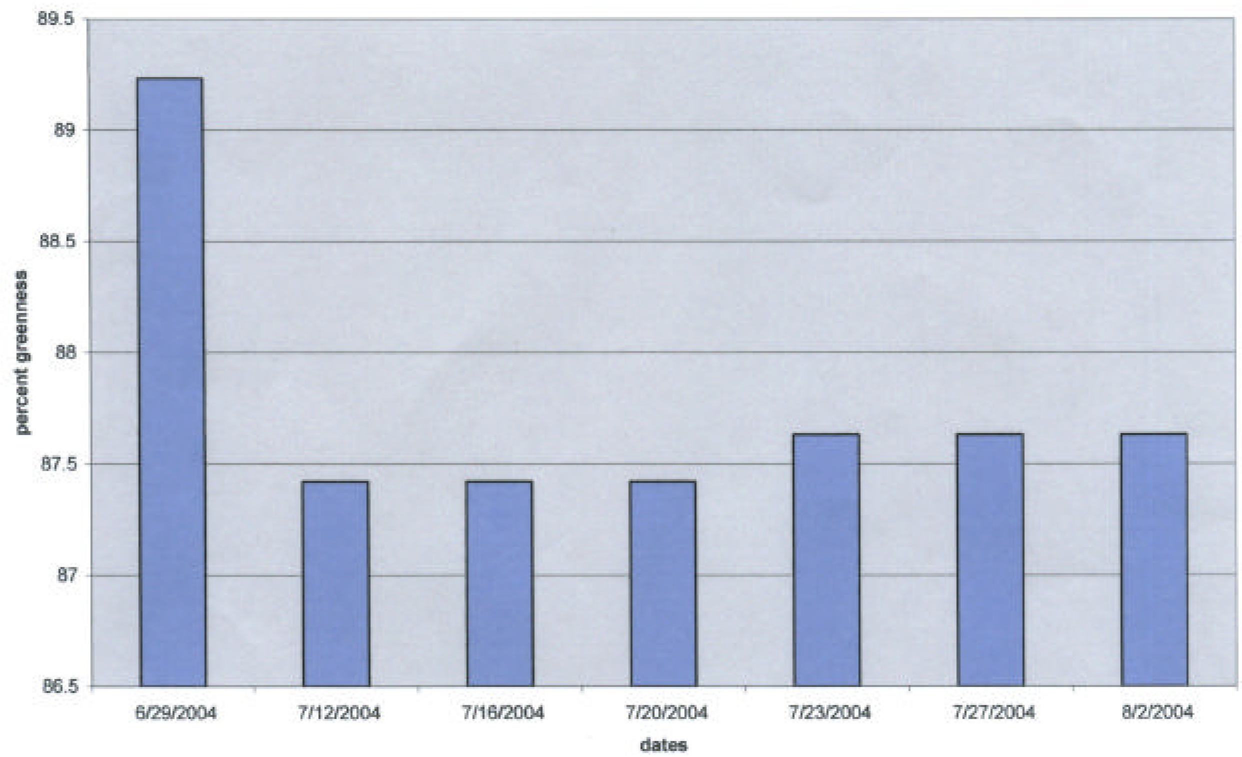
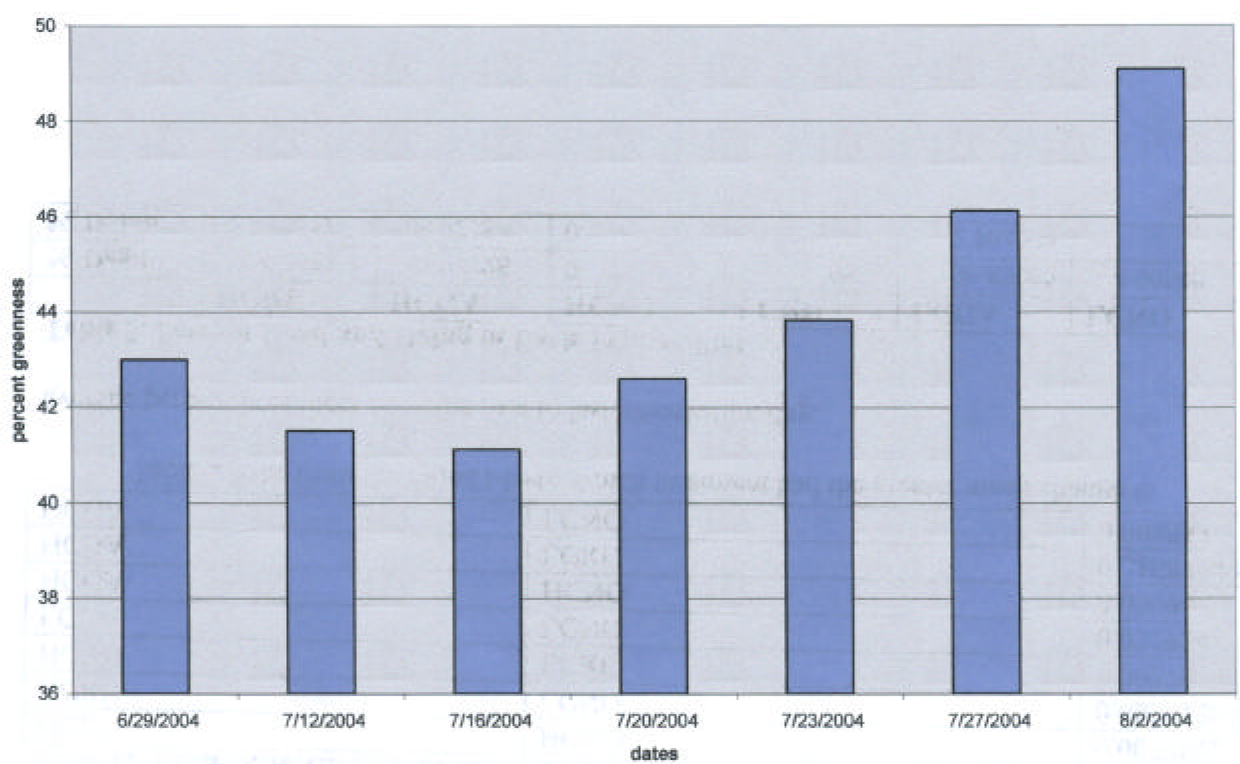


Chart 6, Average LCNO



Discussion

The results from seven out of the fifteen possible combinations of methods rejected the null hypothesis. This means that seven t-tests showed significant difference between the means of change in average percent greenness for the different treatments. Eight of the tests failed to reject the null hypothesis, however one of the tests showed a very strong trend of difference. Out of the 15 t-test that were performed, high cut Round-Up plots and high cut Garlon plots most frequently had a significantly greater change in average percent greenness than the plot it was compared to. They each had the greatest change of a pair three times. When they were compared against each other, though, there was not a significant difference. Low cut Garlon plots had a greater change in percent greenness than low cut plots cut low with no herbicide. This is not a surprising discovery. What is surprising, however, is that there was not a significant difference between low cut Round-Up and low cut no herbicide. This may be because low cut Round-up plots started with a lower percent greenness, which does not leave room for much change. Low cut plots usually had a lower starting percent greenness because the stalks were short.

On a healthy *S. altissima* ramet, the lower part of the stalk is normally darker than the upper part. This may be because surrounding plants shades it and therefore the bottom does not need to be as green. This darkness was not a sign of poor health. However, measuring percent greenness did not take into account “healthy” darkness. In order to compensate for this lapse in accounting procedure, the researcher noted the number of ramets she deemed dead and mostly dead, or dying, regardless of the percent greenness. The percents of the number dead per each kind of plot are recorded in Table 3. The type of darkness, the texture of the stalk, and other factors were considered when determining death. Often, the top parts of the stalks were dead, but not the bottom half. Ramets that matched that description we placed in the dying category. The ramet was clearly dying, but signs of death were not yet apparent throughout the entire ramet. The high cut plots that were treated with herbicide had a very high “dying” rate, but not very high death rates. On the other hand, low cut plots that were treated with herbicide had extremely high (=?95%) death rates, and low dying rates. Because the ramets in low cut plots had a smaller amount of surface area to indicate death, it was easier for them to completely die. The ramets in high cut plots had more surface area to show signs of death. Therefore, they were more often judged dying than dead. While high cut plots were not considered dead as often as low cut plots, they did have a higher change in percent greenness. From this, one can conclude that high cutting and low cutting are nearly equivalent methods of removal.

In the short term (the duration of this study), there does not appear to be a significant difference between the two herbicide treatments. The change in average percent greenness was significantly different between groups with different herbicides for only one set out of four- high cut Garlon and low cut Round-Up. The other significantly different pairs were between and an herbicide group and a non-herbicide group and one pair was between two like herbicide groups. There was not a significant difference in the other comparisons between Round-Up and Garlon groups. High cut Garlon had a greater change in average percent greenness than low cut Round-Up. However, low cut Round-Up bad 95% dead ramets and high cut Garlon had only 11.4% dead ramets in the end. From the lack of significant difference and the discrepancy between change in average percent greenness and percent dead, it can be concluded that there is no short term difference between Round-Up and Garlon on *Solidago Altissima.* The true test, however, will be to revisit the study plots the following year and inspect the presence of *S. altissima.* Because each of the plots is marked with rebar, they will withstand a prairie burn. Also, they are tagged with what treatment they received. The tags use the same abbreviations for treatments as this report.

The control plots (those with no herbicide), demonstrated that simply cuffing the ramets was not sufficient to kill them, whether they were cut high or low. In five out of the eight possible combinations that pair a control group with an experimental group, there was a significant difference between them. The herbicide group always had the greater change in percent greenness than the no herbicide group. In fact, the low cut no herbicide group had a negative mean of average change in percent greenness (-6.0914785). This indicates that the ramets became greener as time went on. This is visible in Chart 6. In Chart 5, which graphs the progress of percent greenness for high cut no herbicide, one can also see that after the first day, there was a sharp decline in greenness. However, percent greenness started to slowly climb back up. It did not exceed the original greenness, though, like the low cut nothing. The =?5% dead in found in the low cut nothing plots may seem confusing. However, those ramets may have already been dead before the study began. The increase in percent greenness is a strong enough factor to outweigh the few dead ramets in low cut no herbicide.

Charts 1-4 all demonstrate the decrease in average percent greenness that plots treated with herbicide experienced. They also demonstrate that the high cut plots started off with a higher percent greenness than the low cut plots. The average change in percent greenness is listed in Table 1.

There are some places for possible experimental error. The method of determining death was subjective to the researcher. However, the same person performed the assessment throughout the entire study. This helped limit the amount of subjectivity. Also, when first setting up the study, some ramets may not have been equally treated with the herbicide. They may have been cut, but then did not receive as much herbicide in their dab as the others. The same type of bottles and method of dabbing was used throughout the experiment to limit error from this. This could account for the few exceptionally green ramets in low cut plots where the rest are completely dead.

Conclusion

From this study, it is clear that simply cutting *Solidago altissima* and not treating it with herbicide does not kill the ramet. The study is not as clear on the differences between high cutting and low cutting, and Round-Up and Garlon. High cut groups had a higher change in percent green, but a smaller percent dead. The low cut groups had a smaller change in percent green, but a larger percent dead. These inconsistencies indicate that there is no significant difference between high cutting and low cutting. The comparisons between the different herbicide treatments were also inconsistent. Only one of the four combinations that compared herbicides showed a signicant difference. Also, this one comparison was between a high cut group and a low cut group, which adds another variable. High cut Garlon had a higher change in percent greenness than low cut Round-Up. This is consistent with the results for high cut versus low cut. Also, the Garlon group had only 11.4% dead while the Round-Up group had 95% dead. This ambiguity also indicates that there is no short-term difference between the two herbicide treatments.

Works Cited

Dekker, J. "Glyphosate Advanced Topics."

<http://www.agron.iastate.edu/~weeds/Ag317/manage/herbicide/Atgly/html>

"Lecture: Auxin Type Plant Growth Regulartors."

www.lsuagcenter.com/weedscience/pdf/AGRO4070/Handout 13 .pdf

"Modes of Action." http://depts.washington.edu/proppint/Herbicides.htm

"Roundup Ready Corn." Food Program, Canada. April 2001.

http://www.hc_sc.ga/foodailment/mhdm/ofbbba/nfiani/e_roundu_ ready_corn_603.html