Impact of Glucosinolates on Dandelion Germination and Survival

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Summary

The objectives of this series of experiments were to determine the impact of mustard by-products on dandelion germination, seedling survival when applied at various stages of growth and on mature plants. For the initial germination study, the treatments included four sources of glucosinolates: yellow mustard, oriental mustard, wasabi and screenings of oriental mustard as well as corn gluten and soybean meals. All of the agricultural by-products tested in this experiment reduced dandelion seedling counts relative to the control. The mustards and the wasabi were somewhat better than either the corn gluten and soybean meals. Once germination had taken place, the corn gluten and soybean meal were generally ineffective. However, the mustards and wasabi had post-emergent control and as the dandelions aged, the oriental mustard and wasabi continued to have control, while the yellow mustard became less effective. When attempting to control mature dandelions the effects of the products were much reduced. Wasabi, which was incorporated into the rootzone, was the only product that had a significant effect.

Introduction

Dandelions (*Taraxacum officinale*) are an important problem weed in turfgrass. Historically, for the past few decades, they have been controlled largely by herbicide application. Currently, however, some municipal governments in Canada and other countries have proposed a ban on pesticide use in residential and other public areas. In some areas, these bans have already been implemented. Therefore, the development of alternative tools for weed control in home lawns and gardens, school grounds, and municipal parks is needed.

Biologically based weed control methods using agricultural by-products provide an attractive and promising alternative solution to chemical herbicides. There are many plants that have allelopathic properties, including: corn gluten, soybean meal, and mustard meal.

Corn gluten (*Zea mays* L.) can, inhibit weed seed germination but has no effect on established root systems. A corn gluten based product has recently been granted a temporary registration by the Pesticide Management Regulatory Agency as a weed control product in lawns and turfgrass in Canada. Control of seed germination has been reported with a number of other agricultural by-products including: mustard meal and soybean meal (*Glycine max*). To date there have not been any studies that have looked at the effect of mustard by-products on dandelions.

Therefore, the goal of this series of experiments was to determine the impact of mustard by-products on:

- dandelion germination,
- seedling survival when applied at various stages after germination and
- mature plants.

Different sources of glucosinolates were utilized to determine if there were differences in efficacy on dandelions between the allyl and benzyl glucosinolates including:

- yellow mustard (benzyl)
- oriental mustard (allyl)
- wasabi (allyl)

Corn gluten and soybean meal were also included in this study for comparison purposes as they have been identified as being able to control seed germination.

Materials and Methods

Germination Study

This growth chamber study was conducted during November and December of 2006 to determine the impact of various agricultural by-products on dandelion seed germination. Dandelion seeds were planted in 15 cm pots filled with Premier pro-mix Bx growing media™ and a topdressing of the appropriate treatment was applied. Prior to the start of the experiment, a germination test was conducted so that 50 viable seeds could be seeded in each pot. The experiment was established in a Completely Random Design with four replications.

The treatments included 4 sources of glucosinolates: yellow mustard, oriental mustard, wasabi and screenings of oriental mustard. In addition corn gluten and soybean meal were also tested and 2 control treatments: untreated (no topdressing) and growing media topdressing. Each of the agricultural by-products was applied at 3 rates: 60, 120 and 240 g/m^2. The seedlings were rated at 7, 14 and 21 days after treatment (DAT).

In this and following studies, Analysis of Variance was conducted to determine if the treatment differences were statistically significant at $p=0.05$. When the ANOVA indicated that significant differences were present, Least Significant Difference was used for mean separation.

Dandelion Seedling Study

This growth chamber study was conducted during January to March, 2007 to determine the impact of various agricultural by-products on dandelion seedlings at different stages of development. Dandelion seeds were planted in 15 cm pots filled with Premier pro-mix Bx growing media™ and a topdressing of the appropriate treatment was applied at weekly intervals following germination. The first set of treatments was applied at day 10 as the seedlings had just emerged by that time. Prior to the start of the experiment, a germination test was conducted so that 25 viable seeds could be seeded in each pot. The experiment was established in a Completely Random Design with four replications.

Treatments included an untreated control and yellow mustard, oriental mustard, wasabi, corn gluten and soybean meal all applied at the 240 g/m^2 rate. The treatments were applied at day 10 after seeding (therefore following germination) and days 17, 24, 31 and 38 (therefore immediately following germination and 1, 2, 3 and 4 weeks following germination). Each pot was evaluated on 7, 14, 21 and 28 DAT. Evaluations included

seedling counts (live plants per pot), and an evaluation of dandelion injury based on the following 1-9 scale:

1. unaffected
2. some wilting and slight colour change
3. some wilting and 25% of leaf area showing colour change
4. considerable wilting and 50% of leaf area showing colour change
5. considerable wilting and 75% of leaf area showing colour change
6. considerable wilting and 75% colour change with less than 25% mortality
7. significant colour change up to 50% mortality
8. significant colour change up to 75% mortality
9. 100% mortality

Following the 28 DAT evaluation, any plants in each pot were dried and weighed to determine dry weights.

On day 10, before the first set of treatments was applied, the pots were divided into groups based on emergence so that similar numbers of seedlings were present for each treatment date and therefore remove a source of bias. The number of seedlings in each pot was recorded to provide a pre-treatment seedling count. Therefore, a separate trial was conducted for each treatment date (i.e. 10, 17, 24, 31 and 38 days after seeding).

Mature Dandelion Study

This growth chamber study was conducted during November and December, 2006 to determine the effect of selected agricultural by-products on mature dandelions. Mature dandelions were collected from the field on October 24, 2006. They were potted in 15 cm pots using Premier pro-mix Bx growing media^{TM}. The potted plants were then placed into the growth chamber prior to the commencement of the trial for establishment and acclimation. The experiment was conducted as a Randomized Complete Block Design with four replications. Plants of similar size were blocked together to reduce a potential source of variation.

Treatments included three products that are sources of glucosinolates: yellow mustard, oriental mustard and wasabi. In addition, each of the products was applied either as a top dressing or placed into 6 holes scattered around the base of the plant. There were two control treatments: an untreated control and one with the incorporation holes, but no product added. All of the products were applied at the rate of 480 g/m^2.

The plants were evaluated on 5, 7, 14 and 21 DAT using the following 1-9 scale:

1. completely healthy
2. some leaves don't look healthy, but still green
3. plant alive, but wilted or unhealthy in appearance
4. necrosis on some tissues
5. lower leaves (some leaves) dead, upper leaves (some) healthy
6. lower leaves (some leaves) dead, upper leaves alive, but don't look healthy
7. lower leaves (some leaves) dead and damage throughout plant
8. almost, dead but youngest tissue alive

9. completely dead

Results and Discussion

Germination Study

All of the agricultural by-products tested in this experiment reduced dandelion seedling counts relative to the control (Table 1). While it has been previously reported that corn gluten and soybean meal can reduce dandelion seed germination, this study confirms that products producing glucosinolates can also reduce dandelion seed germination. Also, these were at least as effective as corn gluten.

Of the products tested that produce glucosinolates, the mustards and the wasabi, there were no significant differences between products. This may be important as mustard screenings, for example, would likely be less expensive than wasabi.

Table 1. Impact of products on seedling counts at 7, 14 and 21 days after application.

Product	Rate	7 DAT[a]	14 DAT	21 DAT
		Seedlings per 15 cm pot		
Untreated control		3bc	47a	50a
Untreated control top dressing		16a	48a	48a
Yellow mustard	60g/m^2	2cd	10cdef	14cde
Yellow mustard	120g/m^2	1cd	6cdef	7ef
Yellow mustard	240g/m^2	0d	2ef	2f
Oriental mustard	60g/m^2	0d	8cdef	14cde
Oriental mustard	120g/m^2	0d	4def	9def
Oriental mustard	240g/m^2	0d	1f	4def
Wasabi	60g/m^2	1cd	11cde	19c
Wasabi	120g/m^2	0d	4def	5f
Wasabi	240g/m^2	0d	1f	2f
Corn gluten	60g/m^2	6b	27b	31b
Corn gluten	120g/m^2	1cd	13cd	17cd
Corn gluten	240g/m^2	0d	5def	9def
Soybean meal	60g/m^2	3bc	28b	35b
Soybean meal	120g/m^2	2cd	15c	21c
Soybean meal	240g/m^2	1cd	11cde	22c
Mustard screenings	60g/m^2	0d	7cdef	14cde
Mustard screenings	120g/m^2	0d	3ef	4f
Mustard screenings	240g/m^2	0d	3ef	3f
	$LSD_{0.05}$=	3	9	8

[*] Within a column, values followed by the same letter are not significantly different at p=0.05.

Product rate did play an important role in the level of control as there was an increased reduction in the seedling counts associated with the higher rates on 21 DAT. However, in terms of the products that produce glucosinolates, there were no significant differences between the two higher rates.

Corn gluten and soybean meal also reduced seed germination, but at the rates studied, soybean meal was not as effective as the other products.

Of the control treatments, the only difference occurred at 7 DAT when the control with top dressing had a higher seedling count. Therefore, the presence of the topdressing enhanced the rate of germination, but didn't impact the rate of germination by 14 DAT. In a natural setting, the dandelion seeds would not receive a topdressing treatment, although the seeds may become embedded in the thatch of the turf, for example.

Dandelion Seedling Study

Seedling emergence generally occurred by about day eight or nine after seeding. Therefore, when the treatments were applied on day 10 or later, the treatments were designed to determine whether these products have post-germination or post-emergence effects.

Treatments applied on day 10 after seeding

When the treatments were applied on day ten after seeding, by 14 DAT seedling counts were significantly reduced for the mustards and wasabi compared to the control (Table 2). Also, the mustards and wasabi produced greater seedling injury and reduced dry weight (Table 3).

Table 2. Impact of products applied 10 days after seeding on seedling counts.

Product and Rate		Pretreatment[a]	7 DAT	14 DAT	21 DAT	28 DAT
		Seedlings per 15 cm pot				
Untreated control		23a	23a	23a	22a	22a
Yellow mustard	240g/m^2	23a	19a	9b	3b	2b
Oriental mustard	240g/m^2	21a	17a	8b	3b	0b
Wasabi	240g/m^2	24a	22a	7b	2b	0b
Corn gluten	240g/m^2	19a	19a	18a	18a	18a
Soybean meal	240g/m^2	23a	22a	19a	19a	19a
	$LSD_{0.05}$ =	n/s	n/s	5	4	4

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 3. Impact of products applied 10 days after seedling on injury and dry weight.

Product and Rate		7 DAT[a]	14 DAT	21 DAT	28 DAT	Dry Wt.
		1 -9 scale				grams
Untreated control		1c	1b	2b	1c	4.6b
Yellow mustard	240g/m^2	3ab	5a	8a	8b	1.4c
Oriental mustard	240g/m^2	4a	6a	8a	9a	0.0c
Wasabi	240g/m^2	4a	6a	8a	9a	0.0c
Corn gluten	240g/m^2	2bc	2b	1b	1c	8.0a
Soybean meal	240g/m^2	1c	1b	1b	1c	7.7a
	$LSD_{0.05}$ =	1	1	1	1	2.6

*Within a column, values followed by the same letter are not significantly different at p=0.05.

There was a continued reduction in seedling counts for the mustards and wasabi from 14 DAT to 28 DAT (Table 2). Also, there was an associated increased in seedling injury between 14 DAT and 28 DAT. This may be related to the chemistry of the glucosinolates themselves. It is actually the breakdown products of the glucosinolates,

the isothiocyanates (or ITC's) that have allelopathic, qualities. When the cell vacuoles are ruptured the glucosinlates are hydrolyzed by the enzyme myrosinase to form a variety of potential allelochemicals. Therefore, the ITC's are released over time providing a longer period of activity.

In contrast, the corn gluten and soybean meal had no post-emergent impact on the dandelion seedlings (Table 2) and were not injured (Table 3). In fact, the dry weight was even increased, presumably due to the release of nutrients from the breakdown of the corn gluten or soybean meal.

Treatments applied on day 17 after seeding

The results from this trial were similar to the results from the trial where the treatments were applied on day ten after seeding, or immediately following emergence (Tables 4 and 5). One difference is that by 28 DAT there were some significant differences between the yellow mustard and both the oriental mustard and wasabi. By 28 DAT all seedlings in the pots containing oriental mustard or wasabi were dead, but in the pots containing yellow mustard there were a few seedling still alive (Table 4) although they were still showing injury symptoms (Table 5).

Table 4. Impact of products applied 17 days after seeding on seedling counts.

Product and Rate		Pretreatment[a]	7 DAT	14 DAT	21 DAT	28 DAT
		Seedlings per 15 cm pot				
Untreated control		20a	19a	19a	18a	16a
Yellow mustard	240g/m^2	21a	16a	9c	6c	4b
Oriental mustard	240g/m^2	21a	14a	8c	4cd	0c
Wasabi	240g/m^2	19a	15a	6c	2d	0c
Corn gluten	240g/m^2	19a	17a	16b	15b	15a
Soybean meal	240g/m^2	19a	18a	18ab	15b	14a
	$LSD_{0.05}$ =	n/s	n/s	3	3	4

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 5. Impact of products applied 17 days after seeding on seedling injury and dry weights.

Product and Rate		7 DAT[a]	14 DAT	21 DAT	28 DAT	Dry Wt.
		1 -9 scale				grams
Untreated control		1b	1b	1b	1c	9.6a
Yellow mustard	240g/m^2	2ab	6a	7a	7b	2.0b
Oriental mustard	240g/m^2	3a	7a	8a	9a	0.0b
Wasabi	240g/m^2	3a	7a	8a	9a	0.0b
Corn gluten	240g/m^2	1b	1b	1b	1c	9.9a
Soybean meal	240g/m^2	1b	1b	1b	1c	10.7a
	$LSD_{0.05}$ =	1	2	1	1	2.1

*Within a column, values followed by the same letter are not significantly different at p=0.05.

The two broad classes of glucosinolates are the aromatic glucosinolates which contain a benzene ring in their chemical structure (referred to as benzyl) and the aliphatic

glucosinolates which do not contain a benzene ring (referred to as allyl). Each of these different types of glucosinolates produce different breakdown products.

Different breakdown products have different residence times in the soil. It is possible that differences in allelopathic activity may be related to residence times of the breakdown products as well as to amount and type of glucosinolates produced. From this data, it is apparent that yellow mustard (benzyl) is less effective or is broken down more quickly than the oriental mustard or wasabi (allyl).

Treatments applied on day 24 and day 31 after seeding

The results are similar to the previous trials except that there is in increasing difference between the yellow mustard (benzyl) and oriental mustard or wasabi (allyl). The yellow mustard was increasingly less effective at killing or injuring the dandelion seedlings (Tables 6 to 9). For example, when the treatments were applied on day 24 after seeding, the yellow mustard was significantly less effective by 21 DAT (Tables 6 and 7). When the treatments were applied on day 31 after seeding, there were significant differences between the yellow mustard and the oriental mustard and wasabi by 14 DAT (Tables 8 and 9). This difference for the first time was also evident in the dry weight. This would indicate that the benzyl forms of the glucosinolates are less effective against older seedlings.

Table 6. Impact of products applied 24 days after seeding on seedling counts.

Product and Rate		Pretreatment[a]	7 DAT	14 DAT	21 DAT	28 DAT
		Seedlings per 15 cm pot				
Untreated control		16a	16a	16a	15a	15a
Yellow mustard	240g/m^2	14a	14a	10b	9b	8b
Oriental mustard	240g/m^2	14a	13a	7b	1c	0c
Wasabi	240g/m^2	14a	13a	7b	0c	0c
Corn gluten	240g/m^2	15a	15a	15a	13a	13a
Soyameal	240g/m^2	16a	16a	15a	16a	16a
	$LSD_{0.05}$ =	n/s	n/s	4	3	3

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 7. Impact of products applied 24 days after seeding on injury and dry weight.

Product and Rate		7 DAT[a]	14 DAT	21 DAT	28 DAT	Dry Wt.
		1 -9 scale				grams
Untreated control		1b	1c	1c	1c	8.1b
Yellow mustard	240g/m^2	3a	6b	7b	7b	2.1c
Oriental mustard	240g/m^2	4a	8a	8a	9a	0.0c
Wasabi	240g/m^2	4a	8a	9a	9a	0.0c
Corn gluten	240g/m^2	1b	1c	1c	1c	11.7a
Soybean meal	240g/m^2	1b	1c	1c	1c	8.1b
	$LSD_{0.05}$ =	1	1	1	1	2.6

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 8. Impact of products applied 31 days after seeding on seedling counts.

Product and Rate		Pretreatment[a]	7 DAT	14 DAT	21 DAT	28 DAT
		Seedlings per 15 cm pot				
Untreated control		18a	17a	15a	15a	15a
Yellow mustard	240g/m^2	16a	14a	11a	10b	10b
Oriental mustard	240g/m^2	18a	13a	1b	0c	0c
Wasabi	240g/m^2	19a	14a	2b	0c	0c
Corn gluten	240g/m^2	14a	13a	13a	13ab	13ab
Soybean meal	240g/m^2	15a	13a	13a	13ab	13ab
	$LSD_{0.05}$ =	n/s	n/s	4	3	3

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 9. Impact of products applied 31 days after seeding on injury and dry weight.

Product and Rate		7 DAT[a]	14 DAT	21 DAT	28 DAT	Dry Wt.
		1 -9 scale				grams
Untreated control		1b	1c	1c	1c	7.7a
Yellow mustard	240g/m^2	3a	4b	6b	6b	2.3b
Oriental mustard	240g/m^2	3a	8a	9a	9a	0.0c
Wasabi	240g/m^2	4a	8a	9a	9a	0.0c
Corn gluten	240g/m^2	1b	1c	1c	1c	8.6a
Soybean meal	240g/m^2	1b	1c	1c	1c	9.4a
	$LSD_{0.05}$ =	1	1	1	1	2.0

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Treatments applied on day 38 after seeding

There were similar results in this trial as in previous trials (Tables 10 and 11). However, it is important to note that when the oriental mustard or wasabi were applied 38 days after seeding or 28 days after emergence, they still had an inhibitory effect on the dandelion seedlings. By 14 DAT only one seedling was alive in each pot for both products and by 21 DAT, there was complete mortality of the seedlings. This is potentially quite important as this greatly increases the window of application for these products. Unlike the corn gluten or soyameal, they not only inhibit seed germination, but have a post-emergence impact that lasts for at least 28 days after emergence.

Table 10. Impact of products applied 38 days after seeding on seedling counts.

Product and Rate		Pretreatment[a]	7 DAT	14 DAT	21 DAT	28 DAT
		Seedlings per 15 cm pot				
Untreated control		18a	17a	17a	17a	17a
Yellow mustard	240g/m^2	14a	10bc	10c	8c	8c
Oriental mustard	240g/m^2	13a	9c	1d	0d	0d
Wasabi	240g/m^2	14a	10bc	1d	0d	0d
Corn gluten	240g/m^2	13a	13b	13b	13b	13b
Soybean meal	240g/m^2	13a	13b	13b	13b	13b
	$LSD_{0.05}$ =	n/s	3	2	3	3

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Table 11. Impact of products applied 38 days after seeding on injury and dry weight.

Product and Rate		7 DAT[a]	14 DAT	21 DAT	28 DAT	Dry Wt.
		1 -9 scale				grams
Untreated control		1c	1c	1c	1c	5.5b
Yellow mustard	240g/m^2	4b	6b	6b	6b	2.8c
Oriental mustard	240g/m^2	6a	8a	9a	9a	0.0d
Wasabi	240g/m^2	6a	8a	9a	9a	0.0d
Corn gluten	240g/m^2	1c	1c	1c	1c	7.9a
Soybean meal	240g/m^2	1c	1c	1c	1c	7.6a
	$LSD_{0.05}$ =	1	1	1	1	1.9

*Within a column, values followed by the same letter are not significantly different at p=0.05.

Mature Dandelion Study

This study was designed to determine if products containing glucosinolates had any negative impact on mature dandelions. Therefore, the products were applied at a rate of 480 g/m2 which was higher than the rates used in the previous experiments.

One treatment, wasabi, incorporated into the rooting zone, caused significant damage to the dandelions compared to the control treatments (Table 12). By 14 DAT there were significant differences between the incorporated wasabi and the control treatments. By 21 DAT, the injury rating for the incorporated wasabi was eight which means that the older leaves were dead and the only green still showing was in the younger leaves. At this time, there were new shoots beginning to appear so it is unlikely that this treatment would kill the dandelions outright. However, this treatment clearly damaged and weakened the dandelions and if applied at a time when the dandelions were entering a period of stress might actually help in killing mature plants. For example, application in the fall, combined with the stress caused by winter weather might have a greater impact on the dandelions.

Table 12. Impact of products either applied topically or incorporated on injury rating to mature dandelions either applied topically or incorporated.

Product	Application	5 DAT[a]	7 DAT	14 DAT	21 DAT
		1- 9 scale			
Untreated control		1a	1a	2b	3bc
Untreated control	incorporation holes	1a	1a	2b	2c
Yellow mustard	topical	1a	2a	2b	5b
Yellow mustard	incorporated	1a	2a	2b	3bc
Oriental mustard	topical	1a	2a	3b	3bc
Oriental mustard	incorporated	1a	2a	3b	5b
Wasabi	topical	1a	1a	2b	3bc
Wasabi	incorporated	1a	2a	6a	8a
	$LSD_{0.05}$ =	n/s	n/s	2	2

*Within a column, values followed by the same letter are not significantly different at p=0.05.

It is interesting to note that the top dressing applications had no impact on the mature dandelions. The dandelions were collected from the field in late October. At this time, they would have been preparing for winter. They were then placed in a growth chamber for a period of time under conditions that would stimulate growth. Confirmation of this

was that new growth did occur. Therefore, for the dandelions, conditions would be somewhat similar to spring when nutrients are drawn from the roots to provide energy for the new growth. It is possible that a topical application in the fall, when nutrients are being translocated to the roots may have more of an impact. Fall application of herbicide is considered to provide better control of dandelions than a spring application.

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