Evaluation of Agricultural By-Products for the Control of Weeds in Turfgrass

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SUMMARY

Three studies were initiated in four cities (Calgary, Regina, Kelowna and Penticton) across western Canada in order to evaluate various agricultural by-products for control of broadleaf weeds in turfgrass. The first study, located at two sites in Calgary tested the efficacy of corn gluten in controlling dandelions (*Taraxicum officinale)*. In this study, the dandelions were killed in 2002 with two herbicide applications. In this study, different rates and timing of application of corn gluten was tested relative to spring and fall herbicide applications. The second study was located at two sites in Regina and Penticton and one site in Kelowna. In this study, the weeds were not killed with herbicide prior to the initiation of the study. Varying rates of corn gluten, soybean meal and sugar beet extract were applied to control weeds. The third study was located at one site in Penticton and one site in Kelowna. In this study varying rates of corn gluten and mustard meal were used to control weeds. In each study, data was collected for weed counts, turfgrass colour and density.

In the first study, the pre-trial herbicide applications almost completely eliminated the dandelion population at both sites. In the untreated control plots, dandelion populations then increased from less than 1 weed per m^2 on Sept 2002 to 9 weed per m^2 by Sept 2004. At the opposite extreme, the application of corn gluten at the 15x rate twice a year effectively maintained a dandelion population of less than 1 per m^2 throughout the rating period.

Application of the corn gluten during the fall produced a consistently lower dandelion population although the numbers were not significantly different. Increasing the rate and the number of applications also increased efficacy. The greatest impact on the dandelion population was provided by the use of the corn gluten at the 15x rate applied in both spring and fall. At all rating periods in 2003 and 2004, this treatment exceeded the PMRA criteria for weed control (at least 80% reduction).

In the second study, dandelion populations increased from 14 to 21 per m^2 over the period from May 2003 to Sept 2003. In contrast, the use of corn gluten and soybean meal at the 10x and 15x rates maintained or slightly reduced the population of dandelions over the period of the study. At the 1x rate for corn gluten and soybean meal, the dandelion population increased slightly. The sugar beet extract was less effective than the corn gluten or soybean meal at the rates studied. Therefore, if using corn gluten or soybean meal to control dandelions, it would be best to first eliminate the dandelions and use the amendments to control new weeds. Also, the 1x rate may not be effective over a long term.

In this study, there were populations of veronica and clover in Kelowna and plantain at one site in Penticton. There was no significant impact of corn gluten, soybean meal or sugar beet extract in controlling these weeds. However, since there was only data from one site for each weed, and there was a lot of variability within the plots, the true impact was hard to assess.

The third study demonstrated that mustard meal was less effective than corn gluten at controlling dandelions at the rates studied.

INTRODUCTION

Turfgrass is described as the use of grasses for functional, recreational and ornamental purposes (Beard, 1973). As these grasses are mowed, particularly for recreational uses, their ability to resist the encroachment of weeds is reduced. As a result, controlling weeds in turf has become a common practice in the management of turfgrasses.

About 44 tonnes of herbicides were applied for weed control on home lawns and gardens in Alberta in 1998 (McLean, 2000). Several additional tonnes of herbicides were applied to other urban and suburban settings such as school grounds, municipal parks and golf courses. In Calgary parks alone, about 3.5 tonnes of herbicides, accounting for 98% of pesticides used, were applied for weed control in 1998 (Alberta Environmental Protection, 1998). The intensive use of synthetic chemical herbicides in urban and suburban areas has resulted in increased environmental sustainability concerns and other societal concerns. Some municipal governments in Canada and other countries have instituted a ban on pesticide use in residential and other public areas. Development of alternative tools for weed control in home lawns and gardens, golf courses, school grounds, and municipal parks is needed. This research is intended to directly address environmental and societal concerns over chemical herbicide use by the testing of agricultural by-products for weed control.

Cultural control of weeds has also shown to be somewhat effective. A high rate of nitrogen fertilizer reduces populations of crabgrass, dandelion and other broad-leaf weeds in cool-season turf (Busey, 2003). In addition, higher mowing height, 4 to 8 cm, reduces populations of crabgrass in Kentucky bluegrass and fescue. In a previous study, species selection and mowing height had an effect on weed reduction (McKernan et al., 2001).

Biologically based weed control methods using agricultural by-products provide an attractive and promising alternative solution to chemical herbicides. Corn gluten can inhibit weed seed germination but has no effect on established root systems (Liu, 1994). Based on this mode of action, 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. Whether this agricultural by-product can be used successfully under western Canada conditions is unknown.

About 1.8 million tonnes of canola meal is produced across Canada each year (Statistics Canada, 2001). The present price for canola meal is about $0.2/kg (Statistic Canada, 2001). Large quantities of other agricultural by-products are also produced and sell at relatively low prices. On the other hand, the average price of TurfMaize®, the corn gluten based weed control product temporarily registered in Canada, is about $3.00/kg. The recommended application rate in turfgrass is around 10 kg per 100 square meters. Therefore, the development of agricultural by-products as weed control agents has great potential to add value to some of the common Canadian agricultural by-products.

There is a large market potential for biologically based weed control products. In Alberta, the estimated area of home and garden is about 23,000 ha, Calgary parks 5,300 ha, Edmonton parks 3,700 ha, and golf courses 9,000 ha (Alberta Environmental Protection, 1998). Based on the application rate of TurfMaize®, total corn gluten required could be 41,000 tonnes. If considering other provinces, the required agricultural by-products for weed control will be much greater.

Corn gluten is a by-product of the wet milling of corn kernels for use in corn syrup and corn starch. The remaining material has shown some properties as a pre-emergent herbicide (Christians, 1993). Water soluble (hydrolyzed) root-inhibiting components of the corn gluten were isolated (Liu et al., 1994:Liu and Christians, 1994). These inhibitory compounds were identified as the dipeptides glutaminyl-glutamine, alaninyl-asparagine, alaninyl-glutamine, glycinyl alanine, and alaninyl-alaine. Of the five identified dipeptides identified alaninyl-alanine and glycine-alanine were the most bioactive (Liu and Christians 1994).

Besides corn gluten, control of weeds has been reported with a number of other agricultural by-products. These include sugar beet extract (Natural Weed Control, www.greenerpastures.com), mustard meal (Petersen et al., 2001) and soybean meal (Liu et al., 1994). These products were included in these preliminary trials to attempt to determine if there is sufficient control to warrant further research.

As well, two organisms, *Sclerotinia sclerotiorum* (Riddle, et al., 1991) and *Phoma herbarum* (Neuman and Boland, 2002), have shown to reduce dandelion populations when inoculated. However, these studies have been conducted in a controlled environment and introduction of the organisms into existing turf remains a challenge for effective control.

The above mentioned bio-herbicides are all thought to have some pre-emergent weed control properties and sugar beet extract is also reported to have post-emergent properties. In order to have successful pre-emergent control timing of application of the products is very important. In field studies on the effect of corn gluten on crabgrass control, greater quantities of the product were required when applied four weeks prior to crabgrass germination than when it was applied one week prior to germination (Christians, 1993).

Some information regarding germination of dandelion in Canada is available for agricultural crops (Stewart-Wade et al., 2002), however, there is little information regarding its germination in turfgrass. In order to achieve effective control a thorough understanding of the biology of the weeds that are being targeted is necessary. This study will also examine the biology of the weeds that are present at the various sites.

This research is intended to determine the effectiveness of agricultural by-products as natural control products for broadleaf and grass weeds in turfgrass. Specific objectives are to:

- Evaluate various agricultural by-products as a weed control agent under cold climate conditions of the Canadian Prairie Provinces and the Okanagan Valley of British Columbia
- Determine the most effective rate and timing of application of the material
- Compare the effectiveness with a standard chemical pesticide control product

Three separate, but related trials were initiated across the three western provinces of BC, Alberta and Saskatchewan. In each of the trials, dandelions were a significant problem, so dandelion control became the main focus of the investigation. These trials were:

1. Field testing of corn gluten for weed control.
2. Field testing of corn gluten, soybean meal and sugar beet extract for weed control.
3. Field testing of corn gluten and mustard meal for weed control.

RESEARCH METHODOLOGY

Study 1: Field testing of corn gluten meal for weed control

This three year study was conducted at two sites in Calgary AB. The study was established to examine the effects of corn gluten (Nutrite Organic Lawn Food with Corn Gluten 8-2-4) on dandelion control in turf on two sites within the Calgary Parks system in June, 2002. Plot sizes were 1 by 5 meters and were replicated four times in a randomized block design. Plots were established on sites that had a consistent infestation of dandelions.

In this study, dandelions were eradicated within the test area prior to the initiation of the experiment. Plots were sprayed twice in late spring, one week apart on June 16 and 23 with Killex 500 (active ingredients 2-4D 385.25g/l, mecoprop 75 g/l and dicamba 18.75 g/l)at a rate of 3.25 l/ha. Three application rates of corn gluten (Table 1) were applied each year in spring, fall, and in spring and fall. Application rates were chosen based on the standard nitrogen fertilizer application rate of 500 g N/100m^2 which equates to 62.5 g/m^2 corn gluten. Applications of the products were applied twice in 2002, on June 27 and September 6 and again on May 21 and September 10, 2003 and on May 19 and September 8, 2004. The corn gluten was compared with spring and fall applications of Killex 500 (Table 1).

Table 1. List of treatments used in the Calgary corn gluten meal study.

Treatments
1) Untreated control
2) Killex 500 32.5 ml/100m^2 - spring only
3) Killex 500 32.5 ml/100m^2 - fall only
4) Spring treatment corn gluten - 1.0X rate (62.5 g/m^2)
5) Spring treatment corn gluten– 10.0X rate (625 g/m^2)
6) Spring treatment corn gluten – 15.0X rate (937 g/m^2)
7) Spring and fall treatment corn gluten - 1.0X rate (62.5 g/m^2)
8) Spring and fall treatment corn gluten – 10.0X rate (625 g/m^2)
9) Spring and fall treatment corn gluten– 15.0X rate (973 g/m^2)
10) Fall treatment corn gluten - 1.0X rate (62.5 g/m^2)
11) Fall treatment corn gluten – 10.0X rate (625 g/m^2)
12) Fall treatment corn gluten – 15.0X rate (974 g/m^2)

Applications of the corn gluten were applied with a Gandy (Model 100) drop spreader calibrated to apply the appropriate quantities, while the Killex 500 was applied with a compressed CO_2 propelled plot sprayer (nozzles Teejet VS 11002) with an effective boom width of 1.5metres.

Dandelion numbers were recorded prior to each application by counting individual weeds per plot and then converting to weeds per m^2. Colour and quality were also rated at that time to evaluate any impact on turf quality. The National Turfgrass Evaluation Program system of rating, which uses a 1-9 scale, was used for turfgrass colour and quality. For colour, 1 indicated a brown dormant turf and 9 indicated a dark green turf. Density, which is a subjective rating of shoots per unit of area, is rated as 1 is poor density and a density rating of 9 is superior.

All data were analyzed using MSTAT. When analysis of variance (ANOVA) indicated the presence of significant treatment differences, mean separation was conducted using least significant difference (LSD).

Study 2: Field testing of corn gluten, soybean meal and sugar beet extract for weed control. This two year study was conducted at two sites in Regina SK, two sites in Penticton BC and one site in Kelowna BC. Three products: corn gluten, soybean meal (Archer, Daniels and Midland, Decantur, Illinois 7.5% nitrogen) and sugar beet extract (Nature's Feed, Greener Pastures, Oakdale, Minnesota 7% nitrogen) were evaluated for their ability to control dandelions in turf. Unlike study 1, the dandelions were not eradicated with herbicide prior to the initiation of the study. Therefore, a goal of this study was to determine if the products would be able to reduce dandelion numbers over time through natural plant mortality if seed germination was controlled.

Plot sizes were 1 by 3 metres and were laid out in a randomized block design with four replications. Three different rates of each product were compared (Table 2). Applications, which commenced in July 2002, were made twice per season for corn gluten and soybean meal, and three times for the sugar beet extract during the growing season. The dandelion numbers were recorded in spring, summer and fall for the duration of the trial.

Table 2. List of treatments used in study 2.

Treatments
1) Control
2) Corn gluten - 1X Rate (62.5g/m^2)
3) Corn gluten - 10X Rate (649g/m^2)
4) Corn gluten - 15X Rate (973g/m^2)
5) Soybean meal - 1X Rate (66.5g/m^2)
6) Soybean meal - 10X Rate (665g/m^2)
7) Soybean meal - 15X Rate (1000g/m^2)
8) Sugar beet extract - 1X Rate (20mls/m^2)
9) Sugar beet extract - 2X Rate (40mls/m^2)
10) Sugar beet extract - 4X Rate (80mls/m^2)

Data was analyzed using MSTAT. When analysis of variance (ANOVA) indicated the presence of significant treatment differences, mean separation was conducted using least significant difference (LSD).

Study 3: Field testing of corn gluten and mustard meal for weed control.
This two year study was conducted at one site in Penticton BC and one site in Kelowna BC. Two products corn gluten and mustard meal (Demeter Agro, Minneapolis, Minnesota 4% nitrogen) were evaluated for their ability to control dandelions in turf.

Plot sizes were 1 by 3 metres and were laid out in a randomized block design with four replications. Three different rates of each product were compared (Table 3). Applications, which commenced in July 2002, were made twice per season. The dandelion numbers were recorded in spring, summer and fall for the duration of the trial.

Table 3. List of treatments used in study 3.

Treatments
1) Control
2) Corn gluten - 1X Rate (62.5g/m^2)
3) Corn gluten - 10X Rate (649g/m^2)
4) Corn gluten - 15X Rate (973g/m^2)
5) Mustard meal - 1X rate (125g/m^2)
6) Mustard meal - 4X rate (500g/m^2)
7) Mustard meal - 8X rate (1000g/m^2)

Data was analyzed using MSTAT. When analysis of variance (ANOVA) indicated the presence of significant treatment differences, mean separation was conducted using least significant difference (LSD).

RESULTS AND DISCUSSION

Control and Suppression of Weeds

The Pesticide Management Regulatory Agency (PMRA) has defined control as at least 80% reduction in weed stand or growth when compared to untreated control plots (PMRA, 2002). Suppression is considered to be a minimum of 60% reduction, and less than 60% is defined as being unacceptable. In order to support a label claim for weed control, the PMRA guidelines state that the degree of control should consistently reach a level which is considered ‘commercially acceptable’. However, the term ‘commercially acceptable’ is not defined, and the term may take on a different meaning when comparing chemical pesticides with bio-pesticides, which have a reduced-risk designation.

Study 1: Field testing of corn gluten for weed control

Control of dandelions in establishment year

Initially, in spring 2002, two applications of Killex 500 were applied which almost completely eradicated the dandelions (Table 4). The June 26 weed counts represent the initial dandelion population and the September 6 rating showed that the dandelion populations were very low and had been reduced by 99% in the untreated control plots. This complete eradication created an equal starting point for all the products in this study. It was interesting to note that the two applications seemed to give more effective control than the single applications that were applied later in 2003 or 2004. This would indicate that a second application may increase the effectiveness of the product.

Table 4 – Dandelion counts for corn gluten meal trial for combined sites in 2002.

	Dandelions (#/m²)	
Treatment	June 26[1]	Sept 6
Untreated Control	24a	0.1a
Spring Herbicide	20a	1.0a
Fall Herbicide	17a	0.6a
Spring corn gluten 1x	23a	2.3a
Spring corn gluten 10x	27a	1.2a
Spring corn gluten 15x	21a	0.4a
Fall corn gluten 1x	25a	1.4a
Fall corn gluten 10x	26a	1.7a
Fall corn gluten 15x	27a	1.0a
Spr & fall corn gluten 1x	24a	1.1a
Spr & fall corn gluten 10x	28a	0.1a
Spr & fall corn gluten 15x	22a	0.4a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Dandelion counts in 2003 and 2004.

Dandelion was the only weed species that was present at the Calgary sites. As both sites had natural infestations from surrounding areas, it was not necessary to introduce additional seed. Generally, throughout the trial dandelion numbers were lower at the Silver Springs Gate site than at Spring Hill Park (Table 5). Mowing frequencies were lessened at Silver Springs Gate which may have reduced weed counts.

In the untreated control plots, dandelion populations increased from less than 1 weed per m^2 on Sept 2002 to 9 weed per m^2 by Sept 2004. This would indicate that dandelions either germinated from seed that was present in the soil or recovered from root stock.

Application of the corn gluten provided levels of control comparable to the herbicide application (Table 5). The use of the higher rates and particularly the combination of higher rate and multiple application of the corn gluten provided levels of control superior to that of the herbicide. However, when considering the PMRA guidelines for registration many of the treatments did not suppress or control the dandelions.

When comparing the spring and fall herbicide treatments, the fall application was generally better than the spring herbicide application. The fall herbicide treatment was more likely to meet the PMRA criteria for weed suppression (i.e. 60% reduction). However, the differences between the spring and fall herbicide treatments were usually not significant.

Application of the corn gluten during the fall produced a consistently lower dandelion population although the numbers were not significantly different. Increasing the rate and the number of applications also increased efficacy. The greatest impact on the dandelion population was provided by the use of the corn gluten at the 15x rate applied in both spring and fall. At all rating periods in 2003 and 2004, this treatment exceeded the PMRA criteria for weed control (at least 80% reduction).

Table 5. Dandelion counts over a two year period at two sites in Calgary.

	Dandelions (#/m²)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Spring Hill Park (SH)	3a	10a	5a	7a	3a	6a
Silver Springs Gate (SS)	1b	3b	3a	4b	1b	2b
Treatment						
Control	6a	11a	7a	10a	9a	9a
Spring herbicide	3bc	8abc	5abcd	8a	5bcd	4bcd
Fall herbicide	1cde	6cde	3bcde	4cde	5bcde	3bcd
Spring corn gluten 1x	3bc	9ab	6ab	9a	5bcde	6ab
Spring corn gluten 10x	2bcde	5bcde	4bcde	5bcd	2cdef	5bc
Spring corn gluten 15x	1cde	3de	2de	3de	1ef	2cd
Fall corn gluten 1x	2bcde	8abc	5abc	8ab	6abc	4bcd
Fall corn gluten 10x	1cde	7abcd	3bcde	3de	2cdef	3bcd
Fall corn gluten 15x	1cde	6abcd	4abcde	4de	3bcdef	3bcd
Spr & fall corn gluten 1x	4ab	8abc	4abcd	7abc	6ab	5abc
Spr & fall corn gluten 10x	1de	5cde	2cde	3de	2def	2cd
Spr & fall corn gluten 15x	0e	1e	1e	1e	0f	1d

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

When discussing control and suppression within the guidelines of the PMRA, it should be pointed out that control is based upon ratings following application that are 7-14, 21-35 and 42-56 days after treatment with the products. In our situation, from May 21 to July 25 would be a rating period of 65 days and from July 25 to September 10 would be 47 days after treatment. If this trial was rated at the two shorter rating periods, greater weed reductions may have been recorded. However, our objective was to evaluate weed reductions over the long term.

Dandelion Seed Production, Germination and Establishment

In order to develop effective pre-emergent control products for dandelions a further understanding of seed production, germination and establishment is necessary.

Generally, it is felt that peak production of dandelion seed in the Canadian Prairie Provinces is in the spring of the year, typically from late April until mid-June. However, some of the research literature also points out that seed production can occur in late summer and early fall (Vavrek et al, 1997). They also mentioned that the time to maturation for most dandelion seed is anywhere from 2 to 12 days and seed viability is quite high at this time. If optimum moisture and temperature conditions are present, it is thought that a seed dormancy period is not necessary (Stewart-Wade et al., 2002) and that the longevity of seed viability is short. However, Watson et al., (2001) found that seed could remain viable for up to four years.

There is evidence that dandelion seed will germinate over a wide range of temperatures, possibly as variable as 5 to 35^{o}C (Stewart-Wade et al., 2002). Watson et al., (2001) found an optimum temperature for germination to be 23°C. Watson also found that germination is high in spring and fall. A high establishment in the fall would suggest that dandelion plants will be very competitive the following spring when moisture conditions are adequate (Vavrek et al., 1997).

When dandelions were observed at the two Calgary sites on May 21, 2003 it was thought that the youngest dandelions were three to four weeks old and the others were somewhat older. When comparing the two sites, dandelion populations at Spring Hill Park were more fully developed than at Silver Springs Gate. Spring Hill is a southerly exposure, while Silver Springs Gate is a flat site, which may indicate that dandelions developed earlier on a southerly exposure and that germination occurred around the spring rating date at Silver Springs Gate (Table 5).

It is expected that the maturation of dandelions occurs more slowly in cold temperatures, which could indicate that the youngest dandelions were older than three to four weeks. The fact that there was sufficient moisture just prior to the fall herbicide application may be further evidence of late summer and early fall germination. The fact that the fall herbicide application was more effective than the spring application might indicate that some germination had occurred around the time of the fall application and that the young seedlings were easily controlled. In the fall, there is also greater likelihood of the herbicide being translocated into the roots.

Turf Quality

The use of corn gluten improved both turf colour (Table 6) and turf density (Table 7). This is likely due to the impact of improved fertility as the corn gluten contains 8% nitrogen. However, it is important to note that even at the higher rates, there was a positive rather than a negative impact on turf quality.

Table 6. Turf colour over a two year period at two sites in Calgary.

	Colour (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Spring Hill Park (SH)	6.0a	2.4b	3.0b	6.6a	6.5a	6.2a
Silver Springs Gate (SS)	5.5b	5.2a	5.6a	6.2a	6.4a	6.2a
Treatment						
Control	4.5d	3.5de	4.0bc	4.9d	5.0d	4.9c
Spring herbicide	4.5d	3.4e	4.3abc	5.1d	5.0d	5.0c
Fall herbicide	4.1d	3.6cde	3.6c	4.9d	5.3d	5.5bc
Spring corn gluten 1x	5.0c	3.5de	3.8c	5.3cd	6.1c	5.4bc
Spring corn gluten 10x	6.0b	4.4a	4.5ab	6.9b	7.8a	6.9a
Spring corn gluten 15x	6.6a	4.1abc	4.9a	6.9b	7.9a	7.4a
Fall corn gluten 1x	5.0c	3.4e	3.9bc	5.4cd	5.1d	5.1c
Fall corn gluten 10x	7.0a	3.8bcde	4.3abc	8.0a	7.1b	6.9a
Fall corn gluten 15x	7.0a	3.9abcde	4.5ab	7.9a	6.9b	7.0a
Spr & fall corn gluten 1x	5.6b	3.6cde	4.0bc	5.8c	6.1c	6.0b
Spr & fall corn gluten 10x	6.8a	4.0abcd	4.8a	7.9a	7.6a	7.3a
Spr & fall corn gluten 15x	7.0a	4.3ab	4.9a	7.8a	7.6a	7.3a

1Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Table 7. Turf density over a two year period at two sites in Calgary.

	Density (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Spring Hill Park (SH)	5.6a	4.9a	4.5b	5.1a	6.0b	5.3a
Silver Springs Gate (SS)	5.4a	5.5a	6.2a	5.3a	7.0a	5.5a
Treatment						
Control	4.1f	3.8c	4.9fg	4.5de	6.3de	5.0de
Spring herbicide	4.1f	3.8c	4.8g	4.3e	6.3de	4.6e
Fall herbicide	4.1f	3.9c	4.9fg	4.3e	6.1e	5.0de
Spring corn gluten1x	4.5ef	4.6b	4.9fg	4.5de	6.5bcd	5.1cd
Spring corn gluten 10x	5.6c	6.0a	5.6bcd	5.5abc	6.9a	5.5abc
Spring corn gluten 15x	6.4b	6.4a	6.0ab	5.8ab	6.6abc	5.9a
Fall corn gluten 1x	4.6e	4.6b	5.3def	5.1bcd	6.4cde	5.1cd
Fall corn gluten 10x	6.9a	6.3a	5.4cde	6.1a	6.5bcd	5.8ab
Fall corn gluten 15x	7.0a	6.0a	5.8bc	5.9a	6.5bcd	5.9a
Spr & fall corn gluten 1x	5.1d	4.8b	5.1efg	5.0cd	6.6abc	5.4bcd
Spr & fall corn gluten10x	6.8ab	6.0a	5.6bcd	6.0a	6.6abc	5.9a
Spr & fall corn gluten 15x	6.9a	6.4a	6.3a	5.8ab	6.8ab	5.9a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Study 2: Field testing of corn gluten, soybean meal and sugar beet extract for weed control. In this study, the weeds were not controlled with herbicide prior to the start of the experiment. Therefore, decreases in the dandelion population would typically be due to environmental factors or plant mortality. Therefore, it would be expected that over time, the dandelion population in the control plots would increase, while a product that was successful in preventing germination would reduce the population. Perhaps over a longer period of time, there might be a decrease in the dandelion population due to plant mortality. However, that would probably require longer than the two years of this study. For example, dandelion life spans of 10-13 years have been reported as being common (Stewart-Wade et al, 2002).

Dandelion numbers were consistently lower at the Regina Kings Road Park site and higher at Kelowna Lions Park and Penticton Cenetaph Park (Table 8). The study was initiated in 2003 and there were no significant treatment differences until 2004 (Table 8). Soybean meal at the 15x rate produced dandelion populations that were significantly lower than the control at all three rating periods. The corn gluten produced a lower dandelion population relative to the control, but the results were only statistically different at the September 2004 rating date. In contrast, the sugar beet treatments did not significantly reduce the dandelion population on any rating date when compared to the control.

Table 8. Dandelions counts over a two year period, Regina, Kelowna and Penticton.

	Dandelions (#/m^2)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Regina Caens Park	13b	1b	0c	19a	23a	18ab
Regina Kings Road Park	5c	6b	5bc	6b	8c	8c
Kelowna Lions Park	24a	20a	20a	18a	14b	23a
Penticton Cenataph Park	21a	17a	25a	20a	22a	25a
Penticton Skaha Beach Pk.	15b	2b	8b	10b	7c	11bc
Treatment						
Control	14a	8a	12a	15bc	16bc	21b
Corn gluten 1x	18a	11a	13a	20a	18b	20b
Corn gluten 10x	16a	10a	11a	12bcd	13cd	14cd
Corn gluten 15x	14a	8a	10a	11cd	12cd	11d
Soybean 1x	16a	11a	14a	20a	19b	20b
Soybean 10x	18a	8a	11a	13bc	14bcd	16bc
Soybean 15x	15a	8a	9a	9d	11d	11d
Sugar beet 1x	14a	8a	13a	15bc	14bc	17bc
Sugar beet 2x	14a	9a	13a	16bc	15bc	20bc
Sugar beet 4x	15a	7a	11a	14bc	15bc	18bc

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Based on these results, sugar beet extract will probably not be included in future experiments. However, the soybean meal looked very promising and compared favorably with the corn gluten.

One concern is that the 15x rate was required to produce a significant effect for both the soybean and corn gluten when the dandelion population was not reduced with herbicide prior to the initiation of the study. Also, the percent reduction even for soybean meal at the high rate was not enough to meet the PMRA criteria for suppression (60% reduction).

In this study, there were populations of veronica and clover in Kelowna and plantain at one site in Penticton. There was no significant impact of corn gluten, soybean meal or sugar beet extract in controlling these weeds (data not shown). However, since there was only data from one site for each weed, and there was a lot of variability within the plots, the true impact of the amendments was hard to assess.

Turf colour (Table 9) and density (Table 10) were not negatively impacted by the use of any of the amendments. The slight improvements in colour and density associated with the use of soybean and corn gluten are undoubtedly due to the impact of fertility.

Table 9. Colour ratings over a two year period, Regina, Kelowna and Penticton.

	Colour (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
<u>Location</u>						
Regina Caens Park	3.0d	1.0d	1.0d	3.7c	5.3b	5.5b
Regina Kings Road Park	5.0c	3.7c	4.5c	4.4c	5.4b	6.2ab
Kelowna Lions Park	6.8a	7.8a	7.8a	6.7a	6.3a	6.9a
Penticton Cenataph Park	7.0a	6.3b	7.0b	6.1b	6.1a	6.1ab
Penticton Skaha Beach Pk.	6.1b	6.4b	7.1b	5.6b	5.8ab	6.3ab
<u>Treatment</u>						
Control	5.7a	5.0a	5.5a	4.9c	5.5b	6.1a
Corn gluten 1x	5.6a	4.8a	5.2a	4.9c	5.6b	6.1a
Corn gluten 10x	5.6a	5.1a	5.6a	5.7b	6.2a	6.4a
Corn gluten 15x	5.6a	5.2a	5.7a	5.8ab	6.2a	6.2a
Soybean 1x	5.6a	5.0a	5.4a	4.9c	5.5b	6.2a
Soybean 10x	5.4a	5.3a	5.6a	5.9ab	6.1a	6.4a
Soybean 15x	5.7a	5.5a	5.8a	6.1a	6.2a	6.4a
Sugar beet 1x	5.7a	5.1a	5.4a	5.2c	5.5b	6.3a
Sugar beet 2x	5.6a	5.1a	5.5a	4.9c	5.5b	6.1a
Sugar beet 4x	5.3a	5.0a	5.5a	4.9c	5.4b	6.1a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Table 10. Density ratings over a two year period, Regina, Kelowna and Penticton.

	Density (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Regina Caens Park	3.0d	3.0b	1.0c	3.3c	5.1c	4.9b
Regina Kings Road Park	4.2c	4.2c	5.1b	5.0b	6.7a	6.1a
Kelowna Lions Park	5.3b	7.3a	7.3a	5.3ab	5.8b	6.2a
Penticton Cenataph Park	6.1a	6.2b	6.8a	5.7a	5.8b	6.1a
Penticton Skaha Beach Pk.	5.4b	5.6b	5.6b	5.6ab	5.6bc	5.6ab
Treatment						
Control	4.8a	5.3a	5.1a	4.9bcde	5.5de	5.6cd
Corn gluten 1x	4.7a	5.2a	5.1a	4.8cde	5.4e	5.5d
Corn gluten 10x	4.8a	5.3a	5.2a	5.1abc	6.1a	5.9abc
Corn gluten 15x	4.9a	5.4a	5.2a	5.2ab	6.0abc	5.9abc
Soybean 1x	4.9a	5.2a	5.1a	4.7e	5.7de	5.6cd
Soybean 10x	4.7a	5.1a	5.1a	5.3ab	6.1ab	6.1ab
Soybean 15x	5.0a	5.5a	5.4a	5.3a	6.0abc	6.2a
Sugar beet 1x	4.8a	5.3a	5.3a	5.0abcd	5.7bcd	5.8bcd
Sugar beet 2x	4.7a	5.4a	5.3a	4.8bcde	5.7cde	5.6cd
Sugar beet 4x	4.8a	5.0a	5.0a	4.7de	5.7cde	5.7bcd

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Study 3: Field testing of corn gluten and mustard meal for weed control.

The main goal of this study was to compare mustard meal with corn gluten for the control of dandelions. Unfortunately, there was no benefit of the mustard meal over the corn gluten (Table 11). In addition, while the mustard meal, particularly at the higher rates did not negatively impact turf colour (Table 12) or density (Table 13), there was a concern that there was a negative impact on turf area cover (data not shown). For these reasons, the mustard meal will not be included in further studies.

Table 11. Dandelions counts over two years, Kelowna and Penticton.

	Dandelions (#/m^2)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Kelowna Lions Park	24a	21a	20a	18a	15a	23a
Penticton Skaha Beach Pk.	15b	2b	8b	10b	8a	9b
Treatment						
Control	17a	11a	15a	12bc	11a	18a
Corn gluten 1x	24a	15a	17a	21a	15a	19a
Corn gluten 10x	20a	12a	14a	13bc	10a	17a
Corn gluten 15x	16a	6a	11a	9c	8a	11a
Mustard meal 1x	22a	13a	16a	17ab	14a	17a
Mustard meal 4x	20a	11a	11a	16ab	14a	16a
Mustard meal 8x	21a	12a	14a	12bc	9a	18a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Table 12. Colour monitored over two years, Kelwona and Penticton.

	Colour (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Kelowna Lions Park	6.9a	7.8a	7.8a	6.8a	6.3a	6.8a
Penticton Skaha Beach Pk.	6.1b	6.4b	7.2b	5.6b	5.9a	6.3a
Treatment						
Control	6.5a	6.9bc	7.4a	6.4a	5.9b	6.6a
Corn gluten 1x	6.4a	6.6c	7.0a	6.4a	6.1ab	6.8a
Corn gluten 10x	6.6a	7.3ab	7.6a	6.0a	6.1ab	6.5a
Corn gluten 15x	6.6a	7.4ab	7.8a	6.1a	6.4a	6.5a
Mustard meal 1x	6.1a	6.9bc	7.3a	6.3a	6.0b	6.5a
Mustard meal 4x	6.9a	7.5a	7.8a	6.1a	5.9b	6.5a
Mustard meal 8x	6.4a	7.1abc	7.6a	6.0a	6.4a	6.6a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

Table 13. Density monitored over two years, Kelowna and Penticton.

	Density (1-9 Scale)					
	2003			2004		
Source of Variation	May[1]	July	Sept	May	July	Sept
Location						
Kelowna Lions Park	5.4a	7.4a	7.4a	5.0a	5.7a	5.9a
Penticton Skaha Beach Pk.	5.5a	5.7b	5.8b	5.5a	5.5a	5.5a
Treatment						
Control	5.3bc	6.4bc	6.4bc	5.3a	5.6a	5.8a
Corn gluten 1x	4.9c	6.1c	6.0c	5.1a	5.4a	5.6a
Corn gluten 10x	5.5abc	6.6abc	6.8abc	5.4a	5.9a	5.8a
Corn gluten 15x	5.9ab	6.9ab	7.0ab	5.3a	5.5a	5.9a
Mustard meal 1x	5.3bc	6.3c	6.3bc	5.3a	5.6a	5.6a
Mustard meal 4x	6.0a	7.1a	7.3a	5.4a	5.6a	5.6a
Mustard meal 8x	5.4abc	6.6abc	6.6abc	5.3a	5.6a	5.4a

[1]Within a column and for each source of variation, means followed by the same letter are not significantly different at p=0.05.

CONCLUSIONS

- Use of corn gluten to control dandelions was most effective when the established weeds were first killed with herbicide applications.
- Fall application, increasing the rate and multiple applications of corn gluten all increased efficacy.
- When the dandelions were not eliminated with an initial herbicide application, corn gluten and soybean meal maintained dandelion population numbers while dandelion populations increased in untreated control plots.
- At the 15x rate, the corn gluten and soybean meal slightly reduced the dandelion population.
- At the 1x rate, the dandelion population increased slightly.
- Even at the 15x rate, the corn gluten and soybean meal was not able to reduce the dandelion population enough to meet PMRA guidelines for suppression. This is not unexpected as dandelions can live for several years so it would take several years for plant mortality to reduce the existing population.
- The use of corn gluten and soybean meal had a slight beneficial impact on turf quality, probably due to enhanced fertility.
- None of the products were effective at controlling clover, veronica or plantain. However, these weeds were only present at one site and there was a lot of variability within the trial that may have obscured any effect of the amendments.
- Soybean meal was at least as effective as corn gluten and should be studied further.
- Sugar beet extract and mustard meal were not as effective as the corn gluten and soybean meal.

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