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

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Summary

Three year 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 and grass weeds in turfgrass. Within each of the cities two sites were tested. At the Calgary sites, two pre-trial applications of the herbicide, Killex 500 (active ingredients 2-4D 385.25g/l, mecoprop 75 g/l and dicamba 18.75 g/l) were applied, while the other sites did not receive pre-trial applications. Various rates of four agricultural by-products, corn gluten, soybean and mustard meal as well as sugar beet extract, were compared against untreated and treated controls. Data were collected for weed counts, turfgrass colour and density.

At Calgary the pre-trial herbicide applications almost completely eliminated the dandelion (*Taraxicum officinale)* populations at both sites. Treatments included three rates of corn gluten applied in the spring, the fall and the spring and fall. As well, applications of Killex 500 were applied as a spring only treatment or as a fall only treatment.

Following the initial applications of herbicide, populations of the dandelions increased from less than 1 weed per m^2 to 32.5 m^2 between 6 Sept 02 and 25 July 03. This would indicate that dandelions either germinated from seed that was present in the soil or developed from taproots that recovered after the initial herbicide applications.

All treatments, either herbicide or corn gluten, were significantly better than the untreated control on all three rating dates in 2003. The registered herbicide applications showed a level of suppression (60-80% reduction) on only one occasion and did not control (over 80% reduction) on any of three rating dates in 2003. When comparing the spring and fall herbicide treatments, the fall application was significantly better than the spring herbicide application on the same rating dates.

Corn gluten applied in the spring and fall at the high rate (937 g/m^2) controlled weeds on all three rating dates in 2003. At the mid-rate (625 g/m^2) dandelions were controlled on the spring rating and suppressed on the other two occasions. The spring and fall low rate (62.5 g/m^2) applications showed unacceptable reductions (less than 60%) on the three rating dates.

Corn gluten applied at the low rate in the spring showed unacceptable reduction on all three rating dates in 2003. The mid-rate showed suppression on the spring rating only while the high rate showed suppression on all three rating dates. Fall application of corn gluten at the low rate showed suppression on the spring rating only. The mid-rate and high rate showed control on the spring rating date and unacceptable reductions on the other two rating dates. From this data it would appear that the fall application of the corn gluten was more effective than the spring application but that it did not carry through for the summer and fall.

The low rate fall application of corn gluten meal was as effective as the spring herbicide application, but less effective than the fall herbicide application. The mid and high rates of corn

gluten were significantly better than the spring herbicide application and comparable to the fall applied herbicide.

Although there were some trends at the other three sites, additional data is needed.

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 proposed a ban on pesticide use in residential and other public areas. Development of alternative tools for weed control in home lawns and gardens, 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 meal can, inhibit weed seed germination but has no effect on established root systems (Liu, 1994). Based on this mode of action, a corn gluten meal 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 (Statistic 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 meal 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 meal required could be 41,000 tonnes. If considering other provinces, the required agricultural by-products for weed control will be much greater.

Corn gluten meal 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 meal 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 meal, 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 meal 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:

(1) 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
(2) Determine the most effective rate and timing of application of the material
(3) Compare the effectiveness with a standard chemical pesticide control product

(4) Determine the biology and ecology of various weeds with respect to germination and development in these climates

Research Methodology - Calgary Trial

Field testing of corn gluten meal for weed control

This three year study to examine the effects of corn gluten meal (Nutrite Organic Lawn Food with Corn Gluten 8-2-4) on weed control was established on two sites within the Calgary Parks system in June, 2002. Plots were sprayed twice in late spring, one week apart on June 16 and 23, prior to the initiation of the trial with Killex 500 at a rate of 3.25 l/ha. Three application rates of corn gluten were applied each year in the spring, the fall, and in the spring and fall. The corn gluten was compared with spring and fall applications of Killex 500. Plots were established on sites that had a consistent infestation of turfgrass weeds, in particular, dandelion. Applications of the products were applied twice in 2002, on June 27 and September 6 and again on May 21 and September 10, 2003. Applications are being made twice each year for the duration of the study. Plot sizes are 1 X 5 m and are replicated four times.

Applications of the corn gluten meal were applied with a Gandy (Model 100) drop spreader calibrated to apply the appropriate quantities, while the Killex 500 was applied with a compressed CO2 propelled plot sprayer (nozzles Teejet VS 11002) with an effective boom width of 1.5metres.

Weed species and weed 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. 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. In future, density will be combined with colour to determine quality ratings.

All data were analyzed using MSTAT. Weed counts were adjusted using a co-variant analysis.

Table 1 Treatment list and schedule

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 meal - 1.0X rate 62.5 g/m^2
5) Spring treatment corn gluten meal – 10.0X rate 625 g/m^2
6) Spring treatment corn gluten meal – 15.0X rate 937 g/m^2
7) Spring and fall treatment corn gluten meal - 1.0X rate 62.5 g/m^2
8) Spring and fall treatment corn gluten meal – 10.0X rate 625 g/m^2
9) Spring and fall treatment corn gluten meal – 15.0X rate 973 g/m^2
10) Fall treatment corn gluten meal - 1.0X rate 62.5 g/m^2
11) Fall treatment corn gluten meal – 10.0X rate 625 g/m^2
12) Fall treatment corn gluten meal – 15.0X rate 974 g/m^2

Methodology for Regina Study

1. Field testing of various products for weed control: Three products are being tested over a three year study established on two sites within the Regina Parks system that have a high natural infestation of weeds. Corn gluten meal, soybean meal and sugar beet extract are being evaluated for their ability to control weeds in turf. Plot sizes are 1 x 3 m and are laid out in a randomized fashion with four replications. Three different rates of the products are being compared. Applications, which commenced in July 2002, are being made twice per season for corn gluten and soybean meal, and three times for the sugar beet extract during the growing season. Occurrence of weed species is being recorded and the number of weed is being counted three times a year for the duration of the trial. Data is analyzed using MSTAT.

Treatment Schedule

1) Control
2) Killex 500 32.5 ml/100m^2 - spring only
3) Killex 500 32.5 ml/100m^2 - fall only
4) Application of Corn Meal (8% N)at the 1X Rate (62.5g/m^2)
5) Application of Corn Meal (8% N)at the 10X Rate (649g/m^2)
6) Application of Corn Meal (8% N)at the 15X Rate (973g/m^2)
7) Application of Soybean Meal (7.5% N) at the 1X Rate (66.5g/m^2)
8) Application of Soybean Meal (7.5% N)at the 10X Rate (665g/m^2)
9) Application of Soybean Meal (7.5% N)at the 15X Rate (1000g/m^2)
10) Application of Sugar Beet Extract (7% N)at the 1X Rate (20mls/m^2)
11) Application of Sugar Beet Extract (7% N)at the 2X Rate (40mls/m^2)
12) Application of Sugar Beet Extract (7% N)at the 4X Rate (80mls/m^2)

Methodology for Kelowna and Penticton

1. Field testing of various products for weed control: A number of agricultural by-products is being tested over a two year study established on two sites within the Penticton and Kelowna Parks system. Corn gluten meal, soybean meal, sugar beet extract, and mustard meal are being evaluated for their ability to control weeds in turf. The experiments were initiated in May 2003 and are being conducted at two sites within the parks system on areas that have a high natural infestation of weeds. Plot sizes are 3 m^2 and are laid out in a randomized fashion with four replications. Different rates of the products are being compared and are applied either two (corn gluten, soybean and mustard meals) or three times (sugar beet extract) during the growing season. Occurrence of weed species are being recorded and the number of each weed species is being counted three times a year for the duration of the trial.

Treatment Schedule

Site 1 - Kelowna and Penticton

1) Untreated
2) Application of Corn Meal (8% N)at the 1X Rate (62.5g/m^2)
3) Application of Corn Meal (8% N)at the 10X Rate (649g/m^2)
4) Application of Corn Meal (8% N)at the 15X Rate (973g/m^2)
5) Application of Sugar Beet Extract (7% N)at the 1X Rate (20mls/m^2)
6) Application of Sugar Beet Extract (7% N)at the 2X Rate (40mls/m^2)
7) Application of Sugar Beet Extract (7% N)at the 4X Rate (80mls/m^2)

8) Application of Soybean Meal (7.5% N) at the 1X Rate (66.5g/m^2)
9) Application of Soybean Meal (7.5% N)at the 10X Rate (665g/m^2)
10) Application of Soybean Meal (7.5% N)at the 15X Rate (1000g/m^2)

Site 2 - Kelowna and Penticton
1) Untreated Control
2) Sugar Beet Extract (7%N) at the 1X rate (20mls/m^2)
3) Sugar Beet Extract (7%N) at the 2X rate (40mls/m^2)
4) Sugar Beet Extract (7%N) at the 4X rate (80mls/m^2)
5) Soybean meal (7.5% N) at the 1X rate (66.5g/m^2)
6) Soybean meal (7.5% N) at the 10X rate (665g/m^2)
7) Soybean meal (7.5% N) at the 15X rate (1000g/m^2)
8) Mustard Meal (4% N) at the 1X rate (125g/m^2)
9) Mustard Meal (4% N) at the 4X rate (500g/m^2)
10) Mustard Meal (4% N) at the 8X rate (1000g/m^2)
11) Corn gluten (8% N) at the 1X rate (62.5g/m^2)
12) Corn gluten (8% N) at the 10X rate (649g/m^2)
13) Corn gluten (8% N) at the 15X rate (973g/m^2)

Results and Discussion Calgary 2002-03

Colour and Density

There was an improvement in colour and density for the treatments that had corn meal applied to the plots (Tables 1 and 2). Generally, as the rate of corn gluten increased colour and density increased and the twice a year application produced the highest ratings.

Table 1 – Turfgrass colour ratings for corn gluten meal trial combined sites Calgary, 2002-03.

Treatment (corn gluten)	**Sept.6 2002**	**May 21 2003**	**July 25 2003**	**Sept 10 2003**
Untreated Control	4.75 F	4.50 D	3.50 DE	4.00 BC
Spring Herbicide	4.75 F	4.50 D	3.38 E	4.25 ABC
Fall Herbicide	4.50 F	4.13 D	3.63 CDE	3.63 C
Spring 62.5 g/m^2 Rate	5.75 DE	5.00 C	3.50 DE	3.75 C
Spring 625 g/m^2 Rate	7.00 BC	6.00 B	4.38 A	4.50 AB
Spring 937 g/m^2 Rate	7.63 AB	6.63 A	4.13 ABC	4.88 A
Fall 62.5 g/m^2 Rate	4.88 EF	5.00 C	3.38 E	3.88 BC
Fall 625 g/m^2 10X Rate	4.50 F	7.00 A	3.75 BCDE	4.25 ABC
Fall 937 g/m^2 Rate	4.88 EF	7.00 A	3.88 ABCDE	4.50 AB
Spring & Fall 62.5 g/m^2 Rate	6.25 CD	5.63 B	3.63 CDE	4.00 BC
Spring & Fall 625 g/m^2 Rate	7.88 AB	6.75 A	4.00 ABCD	4.75 A
Spring & Fall 937 g/m^2 Rate	8.00 A	7.00 A	4.25 AB	4.88 A
$LSD_{0.05}$ =	0.91	0.48	0.60	0.67

Table 2 - Turfgrass density ratings for corn gluten meal trial combined sites Calgary, 2002-03.

Treatment (corn gluten)	**Sept.6 2002**	**May 21 2003**	**July 25 2003**	**Sept 10 2003**
Untreated Control	4.25 D	4.13 F	3.75 C	4.88 FG
Spring Herbicide	4.63 D	4.13 F	3.75 C	4.75 G
Fall Herbicide	4.38 D	4.13 F	3.88 C	4.88 FG
Spring 62.5 g/m^2 Rate	5.88 C	4.50 EF	4.63 B	4.88 FG
Spring 625 g/m^2 10X Rate	6.50 BC	5.63 C	6.00 A	5.63 BCD

Spring 937 g/m^2 Rate	7.00 AB	6.38 B	6.38 A	6.00 AB
Fall 62.5 g/m^2 Rate	4.63 D	4.63 E	4.63 B	5.25 DEF
Fall 625 g/m^2 10X Rate	4.38 D	6.88 A	6.25 A	5.375 CDE
Fall 937 g/m^2 Rate	4.50 D	7.00 A	6.00 A	5.75 BC
Spring & Fall 62.5 g/m^2 Rate	6.00 BC	5.13 D	4.75 B	5.13 EFG
Spring & Fall 625 g/m^2 Rate	7.88 A	6.75 AB	6.00 A	5.63 BCD
Spring & Fall 937 g/m^2 Rate	7.88 A	6.88 A	6.38 A	6.25 A
$LSD_{0.05}$ =	1.03	0.48	0.54	0.48

Efficacy of Products Calgary - 2003

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 week control, the degree of control should consistently reach a level which is considered commercially acceptable.’ However, the term ‘commercially acceptable’ is not defined, and it may be different for chemical pesticides in comparison to biopesticides, which have a reduced-risk designation.

The only weed species that was present at the Calgary sites was dandelion. Both sites had natural infestations of the weeds and it was not necessary to introduce additional seed.

Initially two applications of Killex 500 were applied which almost completely controlled the dandelions as populations were reduced by more than 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. This might indicate that a second application increases the efficacy of the product significantly.

Following the initial application of herbicide, populations of the dandelions increased from less than 1 weed per m^2 to 32.5 m^2 between 6 Sept 02 and 25 July 03. This would indicate that dandelions either germinated from seed that was present in the soil or developed from taproots that recovered after the initial herbicide applications. On the 6 Sept 02 rating date dandelions counts were very low, although close observation was not conducted. In future, it will be important to more closely tract the development and determine if dandelions are developing from seed or recovering from the taproot.

All treatments, either herbicide or corn gluten, were significantly better than the untreated control on all three rating dates in 2003. However, when considering the PMRA guidelines for registration many of the treatments did not suppress or control the dandelions.

For example, the chemical herbicide applications showed a level of suppression (60-80% reduction) on only one occasion and did not control (over 80% reduction) on any of three rating dates in 2003. Spring herbicide application reduced dandelion population 51% on 21 May 03, 24% on 25 July 03 and 30% on 10 Sept 03, all unacceptable reductions, while the fall application reduced populations by 75% on 21 May 03, 36% on 25 July 03, and 53% on 10 Sept 03.

When comparing the spring and fall herbicide treatments, the fall application was significantly better than the spring herbicide application on all three rating dates in 2003 (Table 3). This was even more significant when taking into consideration that the spring herbicide was applied twice, once in 2002 and once in 2003, while the fall application was applied once in the fall of 2002 and once after weed counts in 2003! Additional years of study will give us a better indication whether fall applications of herbicide are more effective than spring applications in the Calgary climate.

Corn gluten applied in the spring and fall at a rate of 937 g/m^2 controlled weeds on all three rating dates in 2003. It showed 96% control on 21 May 03, 86% control on 25 July 03 and 83% control on 10 Sept 03. At the 625 g/m^2 rate dandelions were controlled on 21 May (94% reduction), and suppressed on the other two occasions (63% on 25 July and 71% on 10 Sept). The spring and fall 62.5 g/m^2 rate applications did not control or suppress weed populations on any of the three 2003 rating dates (33% reduction on 21 May, 30% reduction on 25 July and 37% reduction on 10 Sept).

Corn gluten applied at the 62.5 g/100m^2 rate in the spring showed a 47% weed reduction on 21 May, a 14% reduction on 25 July, and a 20% on 10 Sept. None of these would be considered acceptable. The 625 g/m^2 rate reduced weeds 69% on 21 May, 53% on 25 July and 49% on 10 Sept, while the 937 g/m^2 rate showed a reduction of 77% on 21 May, 72% on 25 July and 75% on 10 Sept. This high rate showed suppression on all three rating dates.

Fall application of corn gluten at the 62.5 g/m^2 showed a reduced weeds by 65% on 21 May, 28% on 25 July and 29% on 10 Sept 03. This showed fall applied corn gluten at the regular fertilizer rate suppressed dandelions the following spring. There was not an acceptable reduction on the other two rating dates. The 625 g/m^2 rate showed weed reductions of 81% on 21 May, 41% on 25 July and 53% on 10 Sept. The 936 g/m^2 rate reduced weeds by 80%, 47% and 47% on the three rating dates respectively.

From this data it would appear that the fall application of the corn gluten was more effective than the spring application when comparing the 62.5 g/m^2 rate. The two higher rates applied in the fall showed greater weed reductions the following spring but on the summer and fall rating date the spring applied product was more effective.

At the low rate (62.6 g/m^2), the fall application was as effective as the spring and fall application. However, at the higher rates there seemed to be a residual effect with the two applications and they were more effective.

The 62.5 g/m^2 fall application of corn gluten meal was as effective as the spring herbicide application, but less effective than the fall herbicide application. However, these two products applied in the fall only showed suppression of weeds on the first rating date the following spring. The 625 g and 937 g/m^2 rates were significantly better than the spring herbicide application and comparable to the fall applied herbicide.

Table 3 – Weed count for corn gluten meal trial combined sites Calgary, 2002-03.

Dandelion Counts Weeds / m^2	**June 26 2002**	**Sept 6 2002**

Untreated Control	23.88	0.12
Spring Herbicide	20.25	1.05
Fall Herbicide	16.75	0.60
Spring 62.5 g/m^2 Rate	22.75	2.26
Spring 625 g/m^2 Rate	27.13	1.19
Spring 937 g/m^2 Rate	21.00	0.41
Fall 62.5 g/m^2 Rate	24.75	1.36
Fall 625 g/m^2 Rate	26.13	1.71
Fall 937 g/m^2 Rate	27.00	0.95
Spring & Fall 62.5 g/m^2 Rate	23.75	1.12
Spring & Fall 625 g/m^2 Rate	27.50	0.07
Spring & Fall 937 g/m^2 Rate	21.75	0.40
LSD = 0.05	N/S	N/S

Dandelion Counts Weeds/m^2	**May 21 2003**	**July 25 2003**	**Sept 10 2003**
Untreated Control	17.58 G	32.47 K	20.80 F
Spring Herbicide	8.60 E	24.98 I	14.63 D
Fall Herbicide	3.72 B	20.68 FG	9.68 C
Spring 62.5 g/m^2 Rate	9.24 E	28.02 J	16.68 E
Spring 625 g/m^2 Rate	5.49 CD	14.51 D	10.68 C
Spring 937 g/m^2 Rate	3.99 BC	8.99 B	5.21 AB
Fall 62.5 g/m^2 Rate	6.20 D	23.29 HI	14.73 D
Fall 625 g/m^2 Rate	3.38 B	18.99 EF	9.79 C
Fall 937 g/m^2 Rate	3.51 B	17.07 G	10.96 C
Spring & Fall 62.5 g/m^2 Rate	11.85 F	22.78 GH	13.21 D
Spring & Fall 625 g/m^2 Rate	1.06 A	11.95 C	6.10 B
Spring & Fall 937 g/m^2 Rate	0.76 A	4.63 A	3.54 A
$LSD_{0.05}$ =	1.55	2.10	1.82

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). He 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^{o}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 21 May 03 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 3).

It is expect that the maturation of dandelions occur more slowly in cold weather, 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 at that time. It may also indicate that there was some residual pre-emergent control to the herbicide. However, in turf it is thought that most of the herbicide is intercepted by the foliage of the grass, which may indicate that there would be little herbicide that would come into contact with the soil. Weed counts indicate that there was no establishment of dandelions between July 25 and September 6.

However, this single year of observation may simply tell us that some germination will occur when moisture and temperature are adequate. Further observation and study is necessary.

The research literature also points out that dandelions can recover from the taproot. There was evidence of this at Regina during the Sept 03 rating. Our observations at the Calgary sites in the Sept 02 were not sufficient to conclude whether dandelions germinated or whether they recovered from the taproot.

Discussion of Calgary Results

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 is to evaluate weed reductions over the long term.

When effective, the above treatments would provide long term control. However, when comparing pre-emergent versus post-emergent herbicides, we would expect post-emergent to provide good initial control that may decline over time, while pre-emergent control may have poor initial control but better long term control.

When examining the herbicide treatments, the fall application was significantly better than spring application on all three rating dates in 2003. As mentioned above, this might indicate that germination had occurred just prior to the herbicide application and the dandelions were easily controlled at that time.

Results of the Other Studies

The results of the other studies from 2003 were inconclusive due in part to the severe drought conditions in Regina and the preliminary nature of the studies in Kelowna and Penticton.

In Regina, the 30 July rating date was the only time when there were significant differences between treatments. The spring application of herbicide was the only treatment to effectively control the dandelions. Further evaluations, under conditions of normal precipitation are required.

Table 4 – Weed count for agricultural by-products study combined sites Regina, 2003.

Treatments and rates	May 30	July 30	Sept 11
Control	10.75	16.00 AB	11.75
Spring Herbicide Application	14.25	2.75 A	4.00
Late Summer Herbicide Application	7.50	9.75 AB	11.75
Corn Meal 1X Rate (62.5g/m^2)	14.75	15.25 AB	11.50
Corn Meal 10X Rate (649g/m^2)	15.00	18.00 B	12.25
Corn Meal 15X Rate (973g/m^2)	15.00	18.75 BC	13.25
Soybean Meal 1X Rate (66.5g/m^2)	23.25	32.75 C	32.00
Soybean Meal 10X Rate (665g/m^2)	13.00	12.00 AB	12.25
Soybean Meal 15X Rate (1000g/m^2)	8.25	10.00 AB	8.00
Sugar Beet Extract 1X Rate (20mls/m$^{2)}$	15.25	16.00 AB	15.25
Sugar Beet Extract 2X Rate (40mls/m^2)	12.75	14.50 AB	12.50
Sugar Beet Extract 4X Rate (80mls/m^2)	9.75	10.50 AB	11.25
$LSD_{0.05}$ =	N/S	14.06	N/S

At Belgo Park in Kelowna there were high infestations of Speedwell (*Veronica spp).* On 9 July the best treatments were corn gluten at the two high rates, sugar beet extract at the high rate and soybean meal at the high rate. These corn gluten treatments reduced speedwell by just over 40%, while the high rate of sugar beet extract reduced speedwell by 45% and the high rate of soybean meal reduced the population by 72%. During the 22 Sept rating treatments were not significantly different, although the high rates of sugar beet and soybean meal reduced the weed percentage by 47% and 30% respectively. There was not an initial herbicide application in this trial.

Table 5 – Adjusted speedwell percentage cover Belgo Park Kelowna, 2003.

Treatments and rates	July 9	Sept 22
Untreated Control	74.31 E	77.03
Corn gluten 1X rate (62.5g/m^2)	58.10 BCDE	68.04
Corn gluten 10X rate (649g/m^2)	43.94 ABC	62.35
Corn gluten 15X rate (973g/m^2)	42.41 ABC	66.33
Sugar Beet Extract 1X rate (20mls/m^2)	66.16 CDE	75.08
Sugar Beet Extract 2X rate (40mls/m^2)	51.62 BCDE	74.69
Sugar Beet Extract 4X rate (80mls/m^2)	41.16 AB	41.33
Soybean meal 1X rate (66.5g/m^2)	70.09 DE	71.17
Soybean meal 10X rate (665g/m^2)	46.07 BCD	67.66
Soybean meal 15X rate (1000g/m^2)	21.16 A	53.83
$LSD_{0.05}$ =	24.82	N/S

Although there were no statistical differences between treatments at Lions Park in Kelowna, it appeared that there was a trend where dandelion numbers declined as application rates increased for the corn gluten, the sugar beet extract and the soybean meal on the 22 Sept rating date (Table 6). The mustard meal did not appear to have the same effect.

Table 6 - Adjusted dandelion weed counts Lions Park, Kelowna 2003.

Treatment and rate	July 9	Sept 22
Untreated Control	64.53	65.52
Corn gluten 1X rate (62.5g/m^2)	67.85	60.36
Corn gluten 10X rate (649g/m^2)	64.25	65.58
Corn gluten 15X rate (973g/m^2)	44.86	48.42
Sugar Beet Extract 1X rate (20mls/m^2)	52.06	69.36
Sugar Beet Extract 2X rate (40mls/m^2)	63.22	63.05
Sugar Beet Extract 4X rate (80mls/m^2)	53.07	53.74
Soybean meal 1X rate (66.5g/m^2)	62.76	57.97
Soybean meal 10X rate (665g/m^2)	59.31	67.36
Soybean meal 15X rate (1000g/m^2)	60.89	46.19
Mustard meal 1X rate (125g/m^2)	58.10	61.57
Mustard meal 4X rate (500g/m^2)	60.97	50.55
Mustard meal 8X rate (1000g/m^2)	71.62	56.83
$LSD_{0.05}$ =	N/S	N/S

A similar pattern existed for the percent clover. For all materials tested, as the rate increased the clover percentage decreased (Table 7).

Table 7 - Adjusted clover percentage area cover Lions Park, Kelowna 2003.

Treatments and rate	July 9	Sept 22
Untreated Control	0.54	5.00 ABC
Corn gluten 1X rate (62.5g/m^2)	0.45	7.15 BCD
Corn gluten 10X rate (649g/m^2)	0.00	2.05 AB
Corn gluten 15X rate (973g/m^2)	0.55	0.40 ABC
Sugar Beet Extract 1X rate (20mls/m^2)	0.23	4.39 ABC
Sugar Beet Extract 2X rate (40mls/m^2)	1.05	3.42 ABC
Sugar Beet Extract 4X rate (80mls/m^2)	0.80	2.40 ABC
Soybean meal 1X rate (66.5g/m^2)	0.65	7.94 CD
Soybean meal 10X rate (665g/m^2)	0.27	5.61 ABC
Soybean meal 15X rate (1000g/m^2)	0.27	1.59 AB
Mustard meal 1X rate (125g/m^2)	0.98	11.89 D
Mustard meal 4X rate (500g/m^2)	0.20	4.62 ABC
Mustard meal 8X rate (1000g/m^2)	0.03	2.05 AB
$LSD_{0.05}$ =	N/S	5.79

Discussion of the Other Sites

Unlike the Calgary site, the three trial sites in Kelowna, Penticton and Regina did not have a post-emergent application of herbicide applied to the plots prior to the initiation of the treatments. Expectations are that if the products were effective pre-emergent controls, that weed numbers and percent would decrease over time. As a result, it may take a longer period of time before treatment differences are noted.

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