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Effect of perennial ryegrass overseeding on weed suppression and sward composition

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Abstract: Pesticide bans in Canada have resulted in a requirement for municipal turfgrass managers to use cultural methods of weed control to provide a safe playing surface for athletes. A field study was conducted to determine if overseeding provides enough competition to decrease weed populations in Kentucky bluegrass athletic turf typically used in municipal parks for recreation. Perennial ryegrass was overseeded at 2, 4, and 8 kg/100 m² in May, July, or September, and all permutations of these timings in nonirrigated and irrigated trials at the Guelph Turfgrass Institute (GTI) field station in Guelph, and on in use soccer fields at the University of Guelph campus and in the town of Oakville, Ontario, Canada over 2 yr. Plant cover by species was recorded every other month using a randomized point quadrat method throughout the growing seasons of 2005 and 2006. Weed populations were not affected by overseeding in 2005, a dry growing season. However, when weed populations were high and normal growing conditions existed in 2006, overseeding applications in May/July/September at 4 and 8 kg/100 m² decreased perennial weed cover, specifically white clover in the irrigated trial and dandelion in the nonirrigated trial at the GTI. An increase in perennial ryegrass was observed in all plots that received an overseeding treatment. Treatments applied on the in-use soccer fields in Oakville and Guelph, which included May/September and May only overseedings, had no effect on weed populations or perennial ryegrass populations

compared to the weedy control. Over the short term, high-rate and frequent overseeding with perennial ryegrass appears to provide competition against perennial weeds when weed cover is high and should be considered an important part of a weed management program for municipal turfgrass managers.

Nomenclature: 2,4-D; mecoprop; dicamba; dandelion, *Taraxacum officinale* G. H. Weber ex Wiggers; white clover, *Trifolium repens* L.; perennial ryegrass, *Lolium perenne* L. 'Edge' and 'Futura 3000'; Kentucky bluegrass, *Poa pratensis* L.

Key words: Turf, cultural weed control.

Introduction

Nonchemical weed management on athletic fields and in municipal parks is becoming increasingly important as chemical weed control becomes unavailable due to municipal legislation and changing public perception. Currently, over 115 municipalities in Canada have banned or introduced legislation to restrict the use of herbicides; this affects over 11 million Canadians (Coalition for a Healthy Ottawa 2006). Turfgrass managers must turn to cultural practices and optimize their efficacy to develop an effective integrated pest management (IPM) program that decreases or eliminates the need for herbicides (Busey 2003). In addition, frequent-wear stress has become a major problem on municipal athletic turf; bare-ground patches occur from overuse, resulting in an increased probability of weed infestation (Cereti et al. 2004; Larsen and Fischer 2005). IPM programs with a focus on weed management are important in delivering a good quality and safe playing surface for user groups.

Overseeding, the practice of seeding a desirable turf species into an established turfgrass stand, is typically used in coolseason climates to fill in turf thinned from overuse, and to stabilize soil, to create a uniform playing surface for athletes. Current overseeding practices generally use perennial ryegrass and Kentucky bluegrass to create a vigorous, wear-tolerant playing surface. Establishment of Kentucky bluegrass and perennial ryegrass mixtures from seed have been studied and results indicated that turf quality is best when Kentucky bluegrass composes the majority of the stand (Niehaus 1976). Kentucky bluegrass, however, is slow to germinate and is therefore

difficult to establish on athletic fields when used in an overseeding program. Perennial ryegrass cultivars used for overseeding blend well with the more desirable Kentucky bluegrass because they have similar color, texture, and growth rate (Beard 1973). Perennial ryegrass can be susceptible to winter kill; however, and there are concerns that repeated overseeding will allow perennial ryegrass to dominate a mixed turfgrass stand (Ebdon et al. 2002; Rajashekar et al. 1983). Preliminary studies by Rossi (2004) on weekly, high-rate overseeding with perennial ryegrass for highly worn turfgrass noted a reduction (unquantified) in weed invasion. Due to input costs, time restrictions, and increased use of facilities, weekly overseeding for multiuse athletic fields in a municipality is unlikely to be adopted, and overseeding for weed suppression at this intensity is not practical. Larsen et al. (2004) observed a significant decrease in weed populations in a study on athletic fields treated by vertical cutting followed by overseeding and topdressing, but the effect of overseeding alone was not investigated.

The objectives of this experiment were to test the effect of perennial ryegrass overseeding rates and timings on weed suppression, and to determine the effect of overseeding on species composition in an established Kentucky bluegrass stand.

Materials and Methods

Guelph Turfgrass Institute Field Trials. A field study was conducted at the Guelph Turfgrass Institute (GTI), Guelph, Ontario, Canada. Two trials were set up on April 18, 2005, one irrigated and one nonirrigated, in established Kentucky bluegrass on a very fine sandy loam (55 to 60% sand, 28 to 34% silt, 10 to 11% clay). Plots measured 2 m by 3 m, with four replicates of each of 25 treatments. A 10 m by 24 m buffer area separated the nonirrigated and irrigated trials.

Mowing of the turfgrass began on April 29, 2005, using a rotary mower¹ at a height of 50 mm. Plots were subsequently mown at a height of 64 mm every 7 d commencing May 9, 2005. Plots were fertilized in 2005 and 2006 with 100 kg actual N/ha (SCU 31-0-0) split into two equal applications in early May and late October. Phosphorus and potassium were applied in October of the 2005 and 2006 growing

seasons based on a soil test and applied according to OMAFRA guidelines (OMAFRA 2006).

Beginning May 17, 2005, perennial ryegrass (*Lolium perenne* L. cv. 'Edge') was overseeded at 3 rates (2, 4, and 8 kg/100 m²) and seven application timings (May [M], July [J], September [S], May + July [M/J], May + September [M/ S], July + September [J/S], and May + July + September [M/ J/S]) for a total of 21 overseeding treatments. Seed was broadcast in each treatment using a hand shaker. In addition, four other treatments were added for comparison: a weedy control (WC) received no weed control measures and served to indicate the maximum weed potential at each site; a conventional (CN) herbicide treatment of 2,4-D at 1,050 g ai/ha plus mecoprop at 550 g ai/ha plus dicamba at 100 g ai/ ha was applied in May and September; and a spot-spray (SS) of the same herbicide mixture was applied when weed coverage exceeded 15%, to determine the potential of target-specific herbicide application. Finally, a hand-weeded (HW) treatment was included when weeds covered more than 15%, and served to indicate maximum weed control without herbicide-induced phytotoxicity. The threshold level of 15%, which is within the recommendations for athletic fields and municipal parks by OMAF (OMAF 2003), was chosen to obtain a level of weed cover that would be considered acceptable to various types of sports fields. All herbicide applications were performed using a battery powered backpack sprayer² calibrated to deliver 300 L/ha.

Baseline plant community compositions for the irrigated and nonirrigated trials were recorded on May 4 and May 6, 2005, respectively, using point quadrat methods. Point quadrats measured 60 cm by 60 cm with 25 points on 10- cm centers in each quadrat, applied four times for a total of 100 points in each plot. Plant species (Kentucky bluegrass, perennial ryegrass, or weed species) was recorded at each point. Community composition was assessed using the same method once in June, August, and October after the overseeding treatments of May, July and September.

Overseeding treatments and plant community surveys were performed again in 2006 following the same plan as in the 2005 season except that 'Futura 3000', a blend

of perennial ryegrass cultivars ('Fiesta 3', 'Cutter', and 'Express') was used instead of cv. 'Edge', which was not available.

Table 1. Soil type and texture analysis of athletic field overseeding trials as determined by an independent laboratory analysis of particle size distribution.

Location	Irrigation	Soil Types	% Sand	% Silt	% Clay
Shell Park	Yes	Fine sandy loam	69.8	18.2	12
Hopedale	No	Clay loam	33.2	39.6	27.2
Westbrook	No	Loam	50.0	30.7	19.3
Campus South	No	Loam	47.7	40.6	11.7
Campus North	No	Loam	48.3	40.2	11.5

Plant community composition data from each growing season were assessed using the mixed procedure in SAS (SAS 2006). The statistical analysis was completed using a repeated measures model to investigate the change in weed cover over time due to treatments with block set as the random variable. Square-root transformations were used to normalize the data. Data were sorted by month and least square means were computed in order to conduct a means comparison between treatments and the weedy control with an alpha value set at $P < 0.05$. Analysis of both the irrigated and nonirrigated trials at GTI indicated a treatment by month interaction. Regression analysis was performed on the data using the reg procedure in SAS (SAS 2006). Data were sorted by month, and linear, quadratic, and cubic models were tested to reveal if a relationship existed between the rate of seed applied and weed reduction.

In-Use Field Trials. A field study was conducted on three athletic field sites (Shell Park, Hopedale, and Westbrook) in the town of Oakville, Ontario, Canada, and two sites ("Campus South" and "Campus North") located at the University of Guelph, Ontario, Canada. Four nonirrigated trials and one irrigated trial of established mixed Kentucky blue and perennial ryegrass were set up on May 9, 2005. The soil types of each location are summarized in Table 1.

Plot size was 4 m by 10 m with the exception of Hopedale which, due to area restrictions, measured 3 m by 8 m. Westbrook, Campus South, and Campus North all had four replicates, Hopedale had six replicates, and Shell Park had three replicates. All nonirrigated trials were mowed on a weekly basis at a height of 76 mm and the irrigated trial was mowed two to three times per week at a height of 57 mm. Fertilizers were applied by the municipality and the university according to their normal regime: fertilizer applications at Oakville consisted of 24:6:12 (N-P-K) with no more than 50 kg N/ha five times per year on Shell Park and two times per year on Hopedale and Westbrook Parks; at the University of Guelph campus a 25:3:15 (N-P-K) fertilizer was applied four times in 2005 and three times in 2006 at a rate of 10 kg N/ha. Past overseeding procedures in Oakville consisted of seeding perennial ryegrass on nonirrigated fields in the spring at a rate of 2 kg/100 m², followed by a fall application of a mixture containing 80% Kentucky bluegrass and 20% perennial ryegrass at 2 kg/100 m². Similarly, on irrigated fields, overseeding was performed between three and five times per year, primarily with perennial ryegrass, but also including the bluegrass:ryegrass mixture in the fall. Fall overseeding applications on both nonirrigated and irrigated fields were typically followed by topdressing.

Table 2. Mean percent weed cover in the irrigated trial 2005 and 2006 at the Guelph Turfgrass Institute. Values are back-transformed and the mean of four replications

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
WC ^a	15	13	19	23	14	15	36	16
M 2 kg	7*	10	14	30	18	21	28	14
M 4 kg	15	13	18	30	14	13	32	14
M 8 kg	10	10	15	21	14	14	24*	16
J 2 kg	14	17	24	28	19	22	33	23
J 4 kg	10	8	12	14	9	8*	24*	9
J 8 kg	19	14	19	27	19	16	29	14
S 2 kg	11	11	13	21	10	13	30	12
S 4 kg	11	10	16	20	11	12	33	16

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
S 8 kg	15	14	20	26	11	9	27	9
M/J 2 kg	12	8	18	24	14	13	28	12
M/J 4 kg	11	12	15	22	15	14	23*	14
M/J 8 kg	8*	9	9*	19	8*	6*	16*	9*
M/S 2 kg	8*	10	15	18	10	10	25*	14
M/S 4 kg	14	13	16	18	13	11	29	15
M/S 8 kg	10	16	17	18	11	11	21*	11
J/S 2 kg	9	9	13	18	6*	8*	22*	12
J/S 4 kg	9	13	16	20	17	14	20*	15
J/S 8 kg	10	10	13	19	7*	5*	14*	10
M/J/S 2 kg	12	15	18	28	17	13	28	13
M/J/S 4 kg	12	10	14	22	10	8*	21*	11
M/J/S 8 kg	12	9	15	21	10	10	19*	13
CN	5*	1*	1*	0*	0*	0*	0*	0*
SS	14	12	6*	15	7*	8*	28	12
HW	8	11	12	23	13	11	34	16

^a WC, weedy control; SS, spot spray; HW, hand weeded; CN, conventional; and overseeding in May (M), July (J), and September (S) at rates of 2, 4, and 8 kg/100 m².

* Indicates means are significantly different from the weedy control at $P < 0.05$.

Overseeding with perennial ryegrass 'Futura 3000' began May 17, 2005. Four overseeding treatments were applied using a ProTurf SS-2 stainless steel drop spreader³; a fifth treatment was a nonseeded check (WC). Overseeding treatments included 2, 4, and 8 kg/100 m² May + September, and 8 kg/100 m² in May only. The irrigated trial on Shell Park had replicate 1 and 2 placed in the end zone of soccer field #1 and replicate 3 placed in the end zone of soccer field #2. These areas of the field received play because they were the training areas for soccer camps and warm-up areas for soccer games to be played on each of the fields. The nonirrigated trial on Westbrook Park had replicates 1 and 4 in the end zone areas and replicates 2 and 3 on

the sidelines inside the field of play. A further nonirrigated trial on Hopedale had replicates 1 and 6 in the end zone areas, and replications 2, 3, 4, and 5 were directly on the field of play. The nonirrigated trials at the University of Guelph campus had all four replicates side by side in warm-up and intramural play areas. Both areas received soccer play during each growing season.

Baseline plant populations were recorded from May 10 to 13, 2005, with five randomized point quadrats measuring 100 cm by 120 cm with 20 points in each quadrat, 20 cm apart, for a total of 100 points in each plot. Plant species was recorded at each point. Populations were further assessed in June, August, and October.

Plant population measurements and overseeding treatments were continued in the 2006 growing season following the 2005 regime, with exception of the Campus South location.

The Campus South location was unintentionally treated with herbicide in the spring of 2006, and therefore overseeding treatments and weed counts were not performed during the 2006 growing season. Furthermore, the Campus North location received excessive play after heavy rainfall in September and October of 2006, leaving the site unsuitable for data collection in October 2006. Plant community composition data from each growing season were assessed using the same statistical analysis for data from the GTI.

Results and Discussion

GTI Field Trials. Overseeding treatments were successful in reducing weed cover in Kentucky bluegrass turf under certain conditions. This effect was more pronounced when overseeding treatments were applied more than once per season and at the higher seeding rates. There was no reduction in weed cover that could be attributed to overseeding treatments in the 2005 season with the exception of a 10% reduction in the May/July overseeding at 8 kg/100 m² treatment (Table 2). This however could have been due to low initial weed cover. In August 2006, weed cover in the WC plots more than doubled compared to the May and June 2006 measurements. Weed cover also increased in overseeded plots, but at a lower rate than in WC plots. Overseeding

treatments in July/ September and May/July/September at rates of 4 and 8 kg/ 100 m² reduced weed cover by 15 to 22% compared to the WC (Table 2). Weed cover declined afterward to reach only 16% in the WC, whereas the average for the overseeded plots was 13%. None of the overseeding treatments reduced weed cover significantly at that time except for the May/July at 8 kg/100 m².

Rate of overseeding as well as frequency were important in reducing weed cover. Applying ryegrass at 4 or 8 kg/100 m² reduced weed cover more often than application at 2 kg/ 100 m². Multiple applications also had greater effect than single applications in May, July or September. The highest reduction in weed cover occurred with the May/July, July/ September, and May/July/September timings at 8 kg/100 m² (Table 2). Overseeding prevented large weed population increases when the conditions were favorable for weed growth. This is essential in athletic fields because reduced wear tolerance of weedy species leads to increased bare spots and potential injuries.

The CN herbicide application of 2,4-D/mecoprop/dicamba in May and September of each year completely removed weeds (Table 2). Application of the same herbicides as a SS treatment reduced weed cover compared to WC plots in August 2005 and May and June 2006. The threshold HW treatment did not reduce weed cover compared to WC. This may be due to the fact that plots often had weed cover under the 15% threshold, so no hand weeding was performed. However, the level of weed infestation was high enough that when conditions favored weed growth over that of the turf, as was experienced in July and August of 2006, weed cover increased in HW and WC plots.

Table 3. Mean percent weed cover in the nonirrigated trial 2005 and 2006 at the Guelph Turfgrass Institute. Values are back-transformed and the mean of four replications.

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
WC ^a	13	17	10	18	11	6	18	8
M 2 kg	10	15	12	17	13	7	22	15
M 4 kg	12	14	10	17	12	7	16	9
M 8 kg	10	15	8	16	10	6	11*	7

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
J 2 kg	15	17	8	17	13	6	16	8
J 4 kg	12	22	9	16	11	4	13	10
J 8 kg	10	13	13	17	13	5	14	6
S 2 kg	9	16	9	18	12	6	13	4
S 4 kg	13	15	7	12	11	5	11	5
S 8 kg	14	18	10	15	11	5	12	6
M/J 2 kg	14	21	6	13	7	4	12	7
M/J 4 kg	16	18	11	18	12	7	15	9
M/J 8 kg	10	16	8	13	10	3	11	5*
M/S 2 kg	20	19	5	11*	9	3	11	8
M/S 4 kg	15	17	7	14	11	5	13	5*
M/S 8 kg	19	19	10	13	10	5	16	5
J/S 2 kg	13	19	12	23	11	7	18	9
J/S 4 kg	9	17	8	14	9	4	10*	4
J/S 8 kg	11	17	7	11*	9	3	12	7
M/J/S 2 kg	15	17	8	16	12	5	18	9
M/J/S 4 kg	14	19	9	14	11	4	8*	6
M/J/S 8 kg	17	20	12	17	11	4	10*	6
CN	13	2*	0*	1*	0*	0*	0*	0*
SS	19	17	6*	12	10	4*	21	11
HW	13	17	3	13	9	3	13	8

^a WC, weedy control; SS, spot spray; HW, hand weeded; CN, conventional; and overseeding in May (M), July (J), and September (S) at rates of 2, 4, and 8 kg/100 m² .

* Indicates means are significantly different from the weedy control at P < 0.05.

In the nonirrigated trial, weed cover prior to the initiation of treatments ranged between 9 and 20%, and there was no difference among treatments (Table 3). Weed cover varied slightly over the 2005 season to reach 18% in the WC plots by October 2005. At this time, only the May/September application at 2 kg/100 m² and the

July/September application at 8 kg/100 m² reduced weed cover (Table 3). Weed cover remained low throughout 2006, peaking at 18% in August. Only the applications in July/September at 4 kg/ 100 m² and in May/September at 4 and 8 kg/100 m² reduced weed cover compared to the WC. As in the irrigated trial, weed cover in the nonirrigated trial was high in August 2006 at 18% and decreased to 8% in October (Table 3).

As in the irrigated trial, the May and September CN herbicide treatment reduced weed cover such that there was no weed cover in those plots in 2006 (Table 3). The SS application reduced weed cover in August 2005 and June 2006 but not at the other sampling times. Similarly, the threshold HW plots did not reduce weeds compared to the WC plots. Because weed populations in the nonirrigated trial were relatively low and often under the threshold level of 15%, the SS and HW treatments were not applied.

The predominant weed species observed at the GTI were dandelion and white clover. More detailed counts of these two species were done at the August 2006 sampling, when overseeding treatments had the greatest effects on weed cover in either the irrigated and nonirrigated trials. Interestingly, the species responded differently depending on the trial. The four overseeding treatments that reduced weed cover in the irrigated trial did so through their effect on white clover (Figure 1). White clover cover was greater than 25% in the WC and was reduced by approximately 15% in plots with overseeding treatments. Dandelion cover was 7% in the WC and was not reduced by overseeding. In contrast, dandelion cover in the nonirrigated trial reached 14% in the WC plots and was reduced by half by overseeding in May/July/ September at 4 and 8 kg/100 m² (Figure 2). White clover presence in that trial was very low at 1% cover. The drought conditions of 2005 had a strong effect on white clover, causing most of the plants in the nonirrigated trials to die. The grass species, however, were able to survive because they became dormant. Their growth resumed as rainfall recommenced later in the season. Gaps in turf cover appeared to have been colonized by dandelion that would have germinated in the fall. This would explain its high presence in the nonirrigated trial in 2006. In contrast, white clover was able to survive in the irrigated trial and there was less opportunity for dandelion seedlings to establish in the fall of

2005, explaining the greater presence of white clover compared to dandelion in the irrigated trial in 2006.

Figure 1. Percent cover as determined by randomized point quadrat of dandelion and white clover in the irrigated trial as a function of time of application and seeding rate (August 2006). Means (+/- SE) are back transformed of four replications ($P < 0.05$). Treatments include weedy control, May (M), July (J), and September (S) at rates of 4 and 8 kg/100 m².

Figure 2. Percent cover as determined by randomized point quadrat of dandelion and white clover in the nonirrigated trial as a function of time of application and seeding rate (August 2006). Means (+/- SE) are back transformed of four replications ($P < 0.05$). Treatments include weedy control, May (M), July (J), and September (S) at rates of 4 and 8 kg/100 m².

Establishment of perennial ryegrass was slow in 2005; however, by October all treatments in both trials with a September overseeding had greater establishment than the WC (Tables 4 and 5). In the irrigated trial, perennial ryegrass establishment was variable in 2005. By August 2006, all overseeding treatments increased the perennial ryegrass populations, a trend that continued into October of 2006 (Table 4).

In the nonirrigated trial, many of the May and July overseeded plots were unsuccessful in establishing a perennial ryegrass stand in 2005 (Table 5). In August of 2006, all overseeding treatments exhibited an increase in perennial ryegrass, except for the May overseeding at 2 kg/100 m² compared to the control. By October 2006 only the July overseeding at 2 kg/100 m² was not different from the control. At the completion of the experiment in October 2006, establishment of perennial ryegrass at the 4 and 8 kg/100 m² rates applied in May/July/September were not different from each other.

Increasing the perennial ryegrass seeding rate increased the percentage of perennial ryegrass cover by August and October 2006 for most overseeding regimes (Tables 4 and 5). However, regression analyses performed on October 2006 data in the irrigated trial failed to reveal relationships between seeding rate and final perennial ryegrass cover except for a linear relationship ($y = 4.04 + 1.25x$; $r^2 = 0.78$) with the July/September application timing and a quadratic relationship ($y = 20.55 + 2.79x - 0.22x^2$; $r^2 = 0.86$) with the July seeding. Similarly, in the nonirrigated trial, linear relationships were found for the May/September ($y = 4.48 + 1.46x$; $r^2 = 0.59$) and July/September ($y = 4.10 + 1.54x$; $r^2 = 0.66$) overseeding regimes, whereas there was a quadratic relationship with the May/July/September ($y = 5.71 + 1.04x - 0.08x^2$; $r^2 = 0.75$) regime.

The greatest impact of overseeding on weed cover was observed by August 2006. In the irrigated trial, weed cover was reduced the most in plots with the highest

perennial ryegrass cover. The most important impact on weed cover occurred after ryegrass cover had reached 45% or higher (Tables 2 and 4). This observation was less clear in the nonirrigated trial, but the highest reductions were obtained with perennial ryegrass cover of at least 46% (Tables 3 and 5).

In-Use Field Trials. Statistical analysis of the irrigated in-use trial (Shell Park) revealed no differences between treatments and the control plots for weed cover (Figures 3 and 4). The in-use field trials in Oakville and on the University of Guelph campus had previously been subjected to overseeding with perennial ryegrass and therefore already had an established population before the experiment began (Figures 5 and 6). Perennial ryegrass populations fluctuated depending on season; however, no differences were found between the overseeded treatments and the control plots in percent establishment for the duration of the experiment.

Sources of error in the experiment could include inaccurate detection of weed and turfgrass population changes due to improper quadrat size and number of quadrats per plot. Furthermore, although every measure was taken to inform the municipality of the plots and locations, overseeding applications by municipal workers might have taken place on the plots without our knowledge.

Table 4. Mean percent perennial ryegrass cover in the irrigated trial 2005 and 2006 at the Guelph Turfgrass Institute. Values are back-transformed and the mean of four replications.

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
WC ^a	0	0	3	3	8	5	5	9
M 2 kg	0	1	5	7*	10	14*	21*	23*
M 4 kg	0	1	3	4	9	16*	20*	40*
M 8 kg	0	1	3	5	5	25*	24*	57*
J 2 kg	0	2	2	6	9	6	20*	18*
J 4 kg	0	2	5	17*	18*	23*	31*	50*
J 8 kg	0	5	3	12*	12	15*	32*	58*

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
S 2 kg	0	2	2	13*	8	18*	15*	26*
S 4 kg	3*	2	4	17*	12	22*	17*	40*
S 8 kg	0	1	4	34*	23*	34*	27*	62*
M/J 2 kg	0	0	3	6*	9	17*	24*	44*
M/J 4 kg	0	2	3	10*	12	22*	30*	56*
M/J 8 kg	1	2	3	15*	15*	32*	49*	70*
M/S 2 kg	0	5*	5	15*	13	22*	22*	42*
M/S 4 kg	0	4	4	25*	13	29*	30*	59*
M/S 8 kg	0	3	3	36*	20*	35*	33*	72*
J/S 2 kg	0	1	5	14*	13	22*	27*	39*
J/S 4 kg	0	0	2	26*	16*	26*	36*	58*
J/S 8 kg	0	0	2	37*	22*	32*	45*	69*
M/J/S 2 kg	0	1	4	19*	15*	28*	31*	60*
M/J/S 4 kg	0	1	5	27*	20*	31*	42*	64*
M/J/S 8 kg	0	1	4	35*	20*	38*	48*	69*
CN	0	1	2	3	5	6	4	6
SS	1	2	4	3	8	10	9	12
HW	0	0	2	1	5	4	4	6

^a WC, weedy control; SS, spot spray; HW, hand weeded; CN, conventional; and overseeding in May (M), July (J), and September (S) at rates of 2, 4, and 8 kg/100 m².

* Indicates means are significantly different from the weedy control at $P < 0.05$.

Table 5. Mean percent perennial ryegrass cover in the nonirrigated trial 2005 and 2006 at the Guelph Turfgrass Institute. Values are back-transformed and the mean of four replications.

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
WC ^a	1	1	5	7	14	11	15	21

Treatment	May 2005	June 2005	August 2005	October 2005	May 2006	June 2006	August 2006	October 2006
M 2 kg	0	1	9	11	16	20*	18	44*
M 4 kg	0	1	8	14	17	21*	25*	48*
M 8 kg	0	3	4	8	14	28*	40*	58*
J 2 kg	0	3	6	11	14	16	25*	31
J 4 kg	0	2	4	11	16	19*	28*	33*
J 8 kg	0	2	2	11	12	14	38*	42*
S 2 kg	0	2	3	19*	19	17	22*	54*
S 4 kg	1	2	5	33*	17	27*	24*	59*
S 8 kg	0	3	6	45*	15	33*	31*	67*
M/J 2 kg	0	2	10	18*	18	22*	31*	52*
M/J 4 kg	1	0*	7	12	12	21*	32*	55*
M/J 8 kg	0	3	3	11	13	26*	46*	73*
M/S 2 kg	0	1	8	31*	14	25*	27*	49*
M/S 4 kg	0	3	6	38*	13	30*	38*	72*
M/S 8 kg	0	2	7	52*	15	43*	40*	76*
J/S 2 kg	0	2	5	23*	16	18*	26*	46*
J/S 4 kg	0	2	5	35*	23*	31*	46*	69*
J/S 8 kg	0	1	6	55*	24*	38*	50*	74*
M/J/S 2 kg	0	2	6	22*	19	24*	32*	56*
M/J/S 4 kg	0	3	4	36*	18	41*	49*	73*
M/J/S 8 kg	0	1	8	50*	23*	42*	56*	76*
CN	0	2	3	8	9	10	12	10*
SS	0	2	8	16	21	19	17	11*
HW	0	1	7	12*	17	16*	17	33*

^a WC, weedy control; SS, spot spray; HW, hand weeded; CN, conventional; and overseeding in May (M), July (J), and September (S) at rates of 2, 4, and 8 kg/100 m² .

* Indicates means are significantly different from the weedy control at P < 0.05.

Figure 3. Percent weed cover in the in-use irrigated trial 2005 and 2006. Values are back-transformed and the mean of three replications. Treatments include weedy control, and overseeding in May (M) and September (S) at rates of 2, 4, and 8 kg/100 m².

Perennial Ryegrass Competition. The lack of weed suppression due to overseeding treatments at the GTI in 2005 was most likely due to an establishment phase needed for the perennial ryegrass to cause direct competition on weeds. In addition, the months of July and August in 2005 had many days with high temperatures and no rain that decreased white clover cover and might have affected perennial ryegrass seedling survival in the nonirrigated trial. Daytime temperatures in the month of October 2005 were consistently above 20 C until the time of cover counts, allowing plant growth to continue until the end of the month, which is reflected in an increase of the total percent weed cover (Tables 2 and 3). In 2006, droughty conditions slowed plant growth in May and June but changed in July when moderate temperatures and timely rainfalls prevented turf dormancy for the duration of the growing season.

When weed pressure was high, competition due to frequent overseeding (two or three times per season) at high rates (4 or 8 kg/100 m²) reduced weed cover. Alternatively, when weed pressure was low, differences in weed cover between over seeded and nonoverseeded plots were not observed. These results agree with what

was previously observed when increasing crop density and uniformity of wheat. As wheat plant density increased, weed suppression was observed when weed pressure was high but not when weed pressure was low (Weiner et al. 2001).

The ability of perennial ryegrass to compete against dandelion in the nonirrigated trial was probably due to this weed species' low establishment success, which is typically around 1 to 3% of the total number of seeds shed (Honek et al. 2005). Dandelion spreads through seeds, has a large taproot, and takes longer to establish compared to other weeds (Uva et al. 1997). Dandelion populations fluctuated seasonally and decreased in the nonirrigated trial as the stand thickened in 2006, which might have been a reflection of the dandelion's inability to establish or compete at the seedling stage (Honek et al. 2005) (Figure 2). Over this short-term experiment, however, established dandelion plants probably did not decrease in numbers due to their taproot reserves allowing for persistence despite competition from overseeded perennial ryegrass. Spandl et al. (1999) found that dandelion density did not decrease until the end of the second year in forage crops that are interseeded at low rates with perennial grasses, including Kentucky bluegrass, and therefore competition effects from overseeding on established perennial weed species in turfgrass might not be visible in the first 2 yr.

Figure 4. Percent weed cover in the in-use nonirrigated trial 2005 and 2006. Values are back-transformed and the mean of 14 replications. Treatments include weedy control, and overseeding in May (M) and September (S) at rates of 2, 4, and 8 kg/100 m².

Figure 5. Percent perennial ryegrass establishment by treatment rate (2, 4, and 8 kg/100 m²) and frequency of application (May [M], July [J], and September [S]) at the in-use and Guelph Turfgrass Institute (GTI) irrigated field trials over the two growing seasons of 2005 and 2006.

Figure 6. Percent perennial ryegrass establishment by treatment rate (2, 4, and 8 kg/100 m²) and frequency of application (May [M], July [J], and September [S]) as determined by randomized point quadrat at in-use and Guelph Turfgrass Institute (GTI) nonirrigated field trials over the two growing seasons of 2005 and 2006.

The persistence of white clover in the irrigated trial might be due to its method of propagation. White clover multiplies primarily through stolons and can spread up to 18 cm per year (Uva et al. 1997), which would account for the increase of this species in the irrigated weedy control plots. White clover, however, was killed out during the drought in the nonirrigated trial in 2005 and did not re-establish. In the irrigated overseeded plots, we suggest that turf cover was dense enough to prevent white clover spread while it was actively growing in the WC plots in August 2006 (Figure 1). Seasonal peaks of *Trifolium* species, similar to those observed in this experiment, were also noted by Cereti et al. (2004) on soccer fields in Italy.

Analysis of weed cover within the in-use trials showed that the mean weed pressure was typically below 12% for the irrigated site and below 20% for the nonirrigated sites. As was the case in the GTI trials, weed suppression due to

competition from overseeding might be observed only when weed pressure is high, and differences might not be visible when weed pressure is low. Cereti et al. (2004) observed that weed cover around 12% was not reduced under normal wear on athletic fields; however, on the side strips, a reduction in white clover is attributed primarily to heavy wear incurred on that area of the field. In addition to weed pressure, the limited number of treatments selected for observation on the in-use fields due to space and time restrictions did not show significance in the GTI trials, and therefore could confirm that in the short term, overseeding in May only at 8 kg/ 100 m² or May/September at 2, 4, and 8 kg/100 m² might not have a direct effect on weed cover.

Variable establishment of perennial ryegrass at the GTI was probably a result of the high temperatures and drought during the summer of 2005. This drought could have prevented germination and growth or in the case of May-overseeded plots, germination occurred but seedlings died during the summer due to high temperatures and lack of rainfall. Perennial ryegrass was also observed to increase in all control plots in both trials, which might have been due to transfer by mowing overseeded plots in close proximity or to heavy rains washing seed into the edges of the plots. The CN and SS herbicide treatments had less perennial ryegrass establishment than the WC in the nonirrigated trial, which might have been due to turf seedling susceptibility to the herbicide applied (Table 5). Label recommendations state that the product should not be applied to seedling turf until after the third mowing and that new seeding should not take place until 2 wk after an application.

Trends of perennial ryegrass establishment were examined by plotting a line of best fit for frequency by rate of each treatment in both trials. Single applications (M, J, S) had the lowest establishment, two overseeding applications (M/J, M/S, J/S) had midrange establishment, and three applications per season (M/J/S) had the most establishment at each of the three rates (Tables 4 and 5). It is also interesting to note that many of the treatments had similar establishment to the 8 kg/ 100 m² by October 2006, which could suggest that there might be other overseeding treatments that could be effective for competition against weeds if given enough time to establish the population. These data from overseeding treatments applied three times per year

suggests that frequent overseeding will give a better chance for seed survival and establishment in a mixed stand. In addition, winterkill was evident in all treatments that included a September overseeding when comparing percent cover from October 2005 and May 2006 (Tables 4 and 5). Considering the maturity of the seedlings from the September overseeding, it is granted that there would be some dieback due to the winter season. Overseeding treatments occurring in May or July did not show the same decrease in perennial ryegrass populations from the 2005 growing season to the 2006 growing season, suggesting that the seedlings were mature enough to overwinter.

Fluctuations in turfgrass populations throughout the growing season occurred in both the GTI and in-use trials, and similar results were observed by Richmond et al. (2006) in both perennial ryegrass and tall fescue species. No change in perennial ryegrass populations on the in-use plots might have been a result of initial populations existing on the fields, or due to wear from use of the fields. Similarly, after starting an overseeding program on athletic fields, Cereti et al. (2004) detected an initial increase in perennial ryegrass populations, but observed little fluctuation in the population after it reached 45%, even though they continued to overseed each spring. Thinning of the turfgrass due to wear is one of the reasons why municipalities must overseed an athletic field. Over this short-term experiment, however, fields appeared to have good cultural management of the turfgrass including fertility, mowing, and proper scheduling of play to prevent excessive degradation of the field. These management practices could have allowed the existing turfgrass to thrive and prevent establishment of new seedlings from the overseeding applications. An establishment phase was observed in 2005 at the GTI but was not observed in plots located on in-use fields. By the end of 2006, however, GTI plots with the same overseeding treatments as the in-use fields had only 10 to 20% more establishment than in-use plots. Perennial ryegrass populations in the in-use plots fluctuated little throughout both years (Figures 5 and 6). The results from GTI demonstrate that only 2 yr of overseeding would be needed to achieve a perennial ryegrass population similar to in-use fields if excessive wear is kept to a minimum (Figures 5 and 6). In addition, Figures 5 and 6 show wear on in-use fields appears to prevent the perennial ryegrass population from dominating the Kentucky bluegrass stand. If long-term observations indicate that perennial ryegrass populations similar to

those found on in-use plots compete with weeds, then municipalities that adopt an overseeding program would need to apply seed for a minimum of 2 yr before any benefit would be apparent.

Frequent high rate overseeding of perennial ryegrass decreases weed cover when weed populations are high in both irrigated and nonirrigated situations. The impact on weeds is species-specific and is obviously related to the interaction between the environmental conditions and the species' biological characteristics. This was illustrated by the differential impact of overseeding on white clover and dandelion in the GTI irrigated and nonirrigated trials (Figures 1 and 2). Overseeding decreased white clover populations in the irrigated trial and dandelions in the nonirrigated trial in August 2006.

Perennial ryegrass cover increased in all overseeding treatments at the GTI. In addition, only treatments with a September application had reduced populations in the following spring due to winter-kill; however, additional damage can occur during a more severe winter. At the conclusion of the experiment, all overseeding treatments applied three times per year had similar percent cover. These results suggest that low-rate, frequent overseeding programs are as beneficial in reducing weed cover as high-rate, frequent overseeding. In-use plots had an initial perennial ryegrass population due to a history of overseeding on the fields. No differences were observed between the overseeded plots and the control. These results warrant concerns that frequent overseeding with perennial ryegrass can dominate undisturbed Kentucky bluegrass stands. This project demonstrates that overseeding is useful for weed suppression; however, longterm effects are still unknown and merit further investigation.

Sources of Materials

¹ John Deere GT275 riding mower, Deere and Company, One John Deere Place, Moline IL 61265–8098.

² SBR-010 backpack sprayer, Rittenhouse, 402 Fourth Ave., R.R. #3, St. Catharines, Ontario, Canada L2R 6P9.

³ ProTurf SS-2 stainless steel drop spreader, Agrium Advanced Technologies, 10 Craig St., Brantford, Ontario, Canada N3R 7J1.

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