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# Mesotrione and Seeding Rate Effects to Recover Kentucky Bluegrass Contaminated by Creeping Bentgrass

**Sang-Kook Lee***

*Research Institute for Basic Sciences, Hoseo University, Asan 336-795, Korea*

**ABSTRACT.** Creeping bentgrass (*Agrostis stolonifera* L.) is one of the highest maintained turfgrass but often problematic especially for Kentucky bluegrass fairway. Mesotrione is one of selective herbicide that is firstly registered for corn (*Zea mays* L.) and provides preemergence and postemergence control of broadleaf and annual grassy weeds. Although mesotrione is effective to eradicate area contaminated by creeping bentgrass, protracted time is required to recover damaged area by rhizome extension of Kentucky bluegrass. Overseeding is typically used to fill bare or damaged areas using appropriate turf species to create a uniform turfgrass surface. The objectives of this study were to evaluate mesotrione and seeding rate effects to recover Kentucky bluegrass contaminated by creeping bentgrass. Six treatments consisted of three mesotrione rates and two Kentucky bluegrass seeding rates. The mesotrione rate were 0, 0.05 and 0.10 m ml$^{-2}$. Two seeding rate of to Kentucky bluegrass 'Midnight' were 15 and 30 g m$^{-2}$. Mesotrione application and Kentucky bluegrass overseeding at the same time is helpful to damage creeping bentgrass but not for establishment of Kentucky bluegrass to refill damaged area. To maximize mesotrione effects, temperature above 20°C would be recommended based on this study.

***Key words*:** Creeping bentgrass, Kentucky bluegrass, Mesotrione, Overseeding

## Introduction

Creeping bentgrass (*Agrostis stolonifera* L.) is one of the highest maintained turfgrass used for high-quality playing surface such as putting green on golf courses. However, it surrounds and often encroaches adjacent areas of Kentucky bluegrass (*Poa pratensis* L.). Thus creeping bentgrass is often problematic especially for Kentucky bluegrass fairway in golf courses. Creeping bentgrass is difficult to control as a weed in Kentucky bluegrass lawn because it has stoloniferous growth and interrupts turfgrass uniformity (Branham et al., 2005). The most widely used methods of removing creeping bentgrass from Kentucky bluegrass are physical removal and the use of non-selective herbicide. Non-selective herbicide is usually not recommended because it may not completely eliminate creeping bentgrass with a single application and may require overseeding (Dernoeden et al., 2008). Instead of non-selective herbicides, selective herbicide would be effective in the circumstance of removal creeping bentgrass out of Kentucky bluegrass. Mesotrione is one of selective herbicide that is firstly registered for corn (*Zea mays* L.) and provides preemergence and postemergence control of broadleaf and annual grassy weeds. Mesotrione was developed by suppressing 4-hydroxyphenylpyruvate dioxygenase (HPPD) to reduce carotenoids leading to bleach plant leaves and subsequent death (Mitchell et al., 2001). Previous researches have reported the effects of mesotrione to control creeping bentgrass in other cool-season grasses. Mesotrione is known for phytotoxicity to creeping bentgrass (Askew et al., 2003; Bhowmik and Riego, 2003). Beam et al. (2005) investigated the effects of selective herbicides with imazaquin, isoxaflutole, and mesotrione to control creeping bentgrass in Kentucky bluegrass and perennial ryegrass. They found isoxaflutole and mesotrione injured Kentucky bluegrass and perennial ryegrass less than 20% with controlled creeping bentgrass. In contrast, imazaquin injured Kentucky bluegrass and perennial ryegrass greater than 50%. Jones and Christians (2007) reported that one application of mesotrione controlled 7 to 43% of creeping bentgrass in Kentucky bluegrass, two applications of mesotrione controlled 39 to 88% as rates increased from 0.07 and 0.11 g m$^{-2}$ a.i. Mesotrione was found for safety on newly seeded cool-season grasses except creeping bentgrass (Hart et al. 2007). Beam et al. (2006) applied mesotrione twice at 0.03 g m$^{-2}$ a.i. or three times at 0.01 and 0.02 g m$^{-2}$ a.i. All mesotrione treatments provided 92% creeping bentgrass control in whole study period. Many results from previous researches have reported the safety of mesotrione use compared to bensulide, dithiopyr, prodiamine, ethofumesate, primisulfuron and bisbyribac sodium (Dernoeden, 2000; Reicher et al., 2000; Shortell et

*Corresponding author; Sang-Kook Lee
Tel: +82-41-5401-5879, Fax: +82-41-540-5882
E-mail: sklee@hoseo.edu
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al., 2005; Hart and McCullough, 2007). Branham et al. (2005) applied two or three times of mesotrione at 0.03 to 0.04 g $m^{-2}$ a.i. They found inconsistent levels of creeping bentgrass control ranged from 13 to 92%. When mesotrione of 0.04 g $m^{-2}$ a.i. was treated three times, creeping bentgrass was controlled by 92 to 100%. The suitable application rate and timing is critical for successful creeping bentgrass control depending on the soil pH because the soil persistence of mesotrione can be relatively short (Dyson et al., 2002).

Although mesotrione is effective to eradicate area contaminated by creeping bentgrass, protracted time is required to recover damaged area by rhizome extension of Kentucky bluegrass. Overseeding is typically used to fill bare or damaged areas using appropriate turf species to create a uniform turfgrass surface. Current overseeding practices usually use perennial ryegrass (*Lolium oerenne*) or Kentucky bluegrass to form uniform turfgrass. Turfgrass overseeded needs moisture and nutrients for germination and to compete with existing species (Miltthorpe, 1961; King, 1971). Existing species also interrupted a species which is newly overseeded to reach soil (Keeley et al., 2006). Dernoeden and Pigati (2008) investigated Kentucky bluegrass establishment following overseeding to creeping bentgrass treated by mesotrione applications. They found that Kentucky bluegrass seedlings began to emerge in about 12 days and Kentucky bluegrass cover was initiated 15 day after seeding. Although the benefits of mesotrione effects have been reported, overseeding may be needed for quick recover. However, there were limitations for the results of experimental studies regarding quick establishment of damaged turf species destroyed by mesotrione to kill creeping bentgrass. The objectives of this study were to evaluate mesotrione and seeding rate effects to recover Kentucky bluegrass contaminated by creeping bentgrass.

## Materials and Methods

The study was initiated in October 1, 2012 at the Hoseo Turfgrass Research Center on the campus of Hoseo University. Six treatments consisted of three mesotrione rates and two Kentucky bluegrass seeding rates. The mesotrione rates were 0, 0.05 and 0.10 m $ml^{-2}$. Two seeding rates of to Kentucky bluegrass ‘Midnight’ were 15 and 30 g $m^{-2}$. The first application with mesotrione and seeding was treated to creeping bentgrass ‘Penncross’. Additional application with mesotrione rates was treated one week after the first application. For the complete list, treatments were described in Table 1. Four weeks before the first application, creeping bentgrass sods were planted on the plastic containers which are sizes of 0.3×0.6 m. The rate of 5 g N $m^{-2}$ was applied for creeping bentgrass establishment. Dong-Bu Turf-Fertilizer (12-7-5, Dong-Bu Han-Nong, Seoul) as N source was used.

**Table 1.** List of treatments.

| Treatment | Seeding rate[z] (g $m^{-2}$) | Mesotrione rate (ml $m^{-2}$) | |
|---|---|---|---|
| | | 10/1 | 10/8 |
| Low seeding + No mesotrione | 15 | 0.00 | 0.00 |
| High seeding + No mesotrione | 30 | 0.00 | 0.00 |
| Low seeding + Low mesotrione | 15 | 0.05 | 0.05 |
| High seeding + Low mesotrione | 30 | 0.05 | 0.05 |
| Low seeding + High mesotrione | 15 | 0.10 | 0.10 |
| High seeding + High mesotrione | 30 | 0.10 | 0.10 |

[z] Kentucky bluegrass ‘Midnight’ was used for seeding to existing creeping bentgrass.

Fertilizer treatments were applied with a hand shaker container. Mesotrione was applied as liquid solution with $CO_2$ pressurized backpack sprayer equipped with a flat-fan nozzle and calibrated to deliver 96 ml water $m^{-2}$ at 207 kPa. Irrigation was applied four times per day to ensure wet soil for proper germination.

All data were measured by visual evaluation based on National Turfgrass Evaluation Program (NTEP) guideline. Turfgrass color was visually rated on a scale of 1 to 9 (1 = straw brown, 6 = acceptable, and 9 = excellent). Turfgrass quality was visually rated on a scale of 1 to 9 (1 = poor, 6 = acceptable, and 9 = best). The rates of creeping bentgrass damaged were measured by percent (%). In this study germination counts were made initially at 2 day intervals, but the counting interval increased to everyday after two weeks. The experimental design was a randomized complete block design with 3 replications with 6 treatments. Data were analyzed using analysis of variance (PROC GLM). Mean separation was performed by Fischer’s protected least significant difference (LSD) at a 0.05 significance level. All statistical analyses were performed by SAS (SAS Inst., 2001).

## Results and Discussion

There was a significant mesotrione rate by seeding rate interaction on turfgrass color only for 17 DAT (day after treatment) (Table 2). Significant differences for mesotrione rate effects on turfgrass color were found throughout the study period (Table 3). No mesotrione treatments had the highest turfgrass color and produced higher turfgrass color rating than an acceptable color rating of six throughout the study. Low rate of mesotrione produced acceptable turfgrass color rating for 8 and 17 DAT. However, low rate of mesotrione had lower turfgrass color than an acceptable turfgrass color rating of six after 17 DAT. High mesotrione rate had lower turfgrass color than an acceptable turfgrass

**Table 2.** Analysis of variable table for turfgrass color, quality, and creeping bentgrass damaged.

| Source | df | 8 DAT[z] | 17 DAT | 26 DAT | 35 DAT |
|---|---|---|---|---|---|
| | | ---------- Turfgrass color ---------- | | | |
| Mesotrione rate (MR) | 2 | ** | ** | ** | ** |
| Seeding rate (SR) | 1 | NS | NS | NS | NS |
| MR × SR | 2 | NS | * | NS | NS |
| | | ---------- Turfgrass quality ---------- | | | |
| Mesotrione rate (MR) | 2 | ** | ** | ** | ** |
| Seeding rate (SR) | 1 | NS | NS | NS | NS |
| MR × SR | 2 | NS | NS | NS | NS |
| | | ---------- Creeping bentgrass damaged area ---------- | | | |
| Mesotrione rate (MR) | 2 | NS | * | ** | ** |
| Seeding rate (SR) | 1 | NS | NS | NS | NS |
| MR × SR | 2 | NS | NS | * | NS |

[z] Days after treatment
* indicates significance at P = 0.05.
** indicates significance at P = 0.01.
NS indicates not significant at P = 0.05.

color rating of six throughout the study except 8 DAT. Differences between low and high mesotrione were found after 17 DAT. The lower color ratings were resulted from whitening symptoms due to mesotrione applications. In the case of low and high rate mesotrione application, whitening symptoms was induced after 8 and 17 DAT, respectively.

There was a significant mesotrione rate main effect for turfgrass quality, but no significant differences were found among Kentucky bluegrass seeding rates and interaction between mesotrione and Kentucky bluegrass seeding rate (Table 2). No mesotrione treatments had the highest turfgrass quality and produced higher turfgrass quality rating than an acceptable quality rating of six throughout the study (Table 3). Low and high mesotrione rates had unacceptable quality rating after 8 DAT. Significant difference between low and high mesotrione rates were found after 17 DAT. There was a significant mesotrione rate by seeding rate interaction on the rate of creeping bentgrass damaged only for 26 DAT, and significant difference for mesotrione rate effects were found throughout the study period except 8 DAT (Table 2). No damage on creeping bentgrass was found on no mesotrione application (Table 3). High mesotrione rate produced the greatest damages or equal to the greatest damage on creeping bentgrass. The high rate of mesotrione took 35 days to produce 43% damage on creeping bentgrass. Difference between low and high mesotrione effects on the rate of creeping bentgrass damaged was found on one of four rating dates (35 DAT). The germination of Kentucky bluegrass seeding was not found throughout the study period (data not shown).

Based on the results, mesotrione rates influenced to turfgrass color, quality, and creeping bentgrass growth. Leaf bleaching or whitening is well-known symptoms with no necrosis occurring when mesotrione is used to turfgrass

**Table 3.** Mean turfgrass color, quality, and creeping bentgrass damaged for mesotrione rate main effect.

| Mesotrione rate | 8 DAT[z] | 17 DAT | 26 DAT | 35 DAT |
|---|---|---|---|---|
| | ---------- Turfgrass color ---------- | | | |
| 0.00[y] | 8.6[x] a[w] | 9.0 a | 9.0 a | 9.0 a |
| 0.05 | 6.6 b | 6.2 b | 4.5 b | 3.5 b |
| 0.10 | 6.6 b | 5.8 b | 3.7 c | 2.8 c |
| | ---------- Turfgrass quality ---------- | | | |
| 0.00 | 8.5[v] a | 9.0 a | 9.0 a | 9.0 a |
| 0.05 | 6.8 b | 5.5 b | 4.0 b | 3.3 b |
| 0.10 | 6.8 b | 5.7 b | 3.0 c | 2.5 c |
| | ---------- Creeping bentgrass damaged ---------- | | | |
| 0.00 | 0.0[u] | 3.0 b | 0.0 b | 0.0 c |
| 0.05 | 0.0 | 10.0 a | 15.0 a | 30.0 b |
| 0.10 | 0.0 | 7.5 a | 21.7 a | 43.0 a |

[z] Days after treatment
[y] The unit of mesotrione rate is ml $m^{-2}$.
[x] Turfgrass color was rated from 1 to 9 (1 = straw brown, 9 = dark green, and 6 = acceptable).
[w] Means in a column followed by the same letter are not significantly different according to Fisher's LSD ($P = 0.05$).
[v] Turfgrass quality was rated from 1 to 9 (1 = worst, 9 = excellent, and 6 = acceptable).
[u] The rate of creeping bentgrass damaged is percent (%).

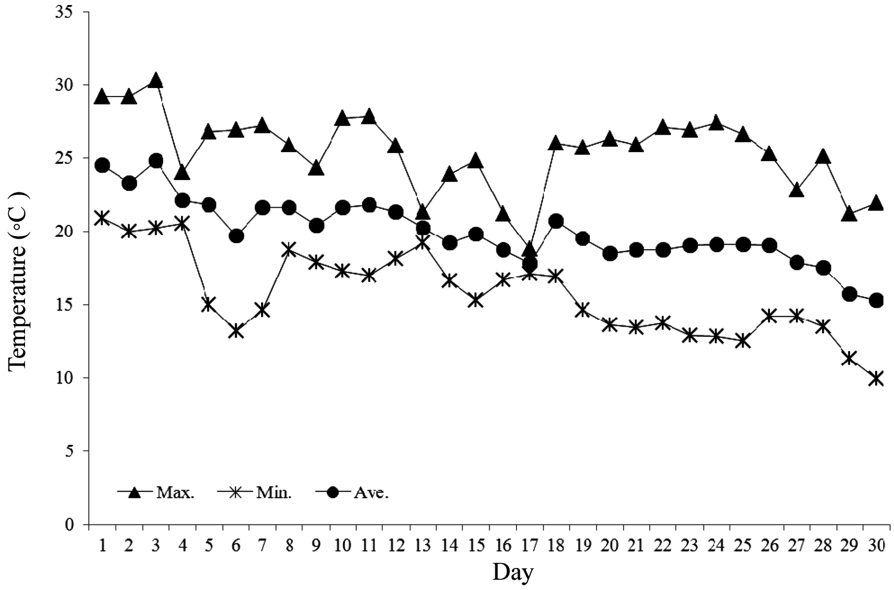


**Fig. 1.** Daily air temperature of maximum, minimum and average recorded in Cheonan and Asan city area for October, 2012.

species (McElroy and Breeden, 2007). In the case of turfgrass color, bleaching or whitening symptoms influenced turfgrass color particularly after 8 DAT. Turfgrass quality was affected by bleaching and the rate of creeping bentgrass damaged. Jones and Christians (2006) found that creeping bentgrass treated with mesotrione showed phytotoxicity 67% greater than no mesotrione treatment 7 days after the first application. In the study, it took longer time than 7 days to observe mesotrione effects on creeping bentgrass. Compared to their results, mesotrione effects on creeping bentgrass may be regarded to weather condition especially temperature. Jones and Christians (2006) made the first application of mesotrione on July 27, 2005. However, the first application of this study was made on October 1, 2012. Average temperature of October 2012 for the study area was 20ºC (Fig. 1). This temperature may be not appropriate to maximize mesotrione effects. This result is supported by Dernoeden et al. (2008). They found poor creeping bentgrass control was provided with cooler temperature while 92 to 100% control was provided with higher temperature. Temperature would be needed above 20ºC to maximize mesotrione effects. No germination from Kentucky bluegrass overseeding was found in this study. The optimum temperature of Kentucky bluegrass germination is 15 to 30ºC (Samples and Sorochan, 2007). The temperature during the study was appropriate for Kentucky bluegrass germination. However, existing creeping bentgrass was a barrier for Kentucky bluegrass seed to reach soil. The low rate of Kentucky bluegrass germination has been reported. Kraft et al. (2004) investigated overseeding of Kentucky bluegrass to perennial ryegrass for conversion. They found just 1% of Kentucky bluegrass establishment for 6 months when overseeding was conducted in fall. In conclusion, mesotrione application and Kentucky bluegrass overseeding at the same time is helpful to damage creeping bentgrass but not for establishment of Kentucky bluegrass to refill damaged area. It is only from mesotrione effects. To maximize mesotrione effects, temperature above 20ºC would be recommended based on this study.

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# Creeping bentgrass 에 침입된 Kentucky bluegrass 회복을 위한 Mesotrione 과 Kentucky bluegrass 덧파종 효과

**이상국***

호서대학교 기초과학연구소

**요 약**: Creeping bentgrass 는 골프장의 티나 퍼팅그린 그리고 경기장과 같이 집중관리가 요구되는 곳에 가장 많이 사용되는 잔디의 종류중 하나이기도 하지만 Kentucky bluegrass에 침입하는 방제하기 어려운 잡초이기도 하다. Mesotrione은 선택성 제초제이며 처음에 옥수수를 위해 등록이 되었으며, 광엽잡초를 방제하기 위한 발아전 혹은 발아후 제초제로 이용이 되고 있다. Mesotrione가 creeping bentgrass를 방제하기 위한 효과는 많은 선행연구에 의해 보고가 되어 왔다. Mesotrione이 creeping bentgrass 방제에 효과가 있어도 방제가 된 후 피해가 발생한 곳의 회복은 Kentucky bluegrass의 지하부와 rhizome 등에 의해 회복되기 까지는 시간이 오래 걸린다. 덧파종은 일반적으로 피해를 입은 곳을 회복 시키거나 밀도를 높이기 위해서 사용이 된다. 실험의 목적은 mesotrione과 덧파종이 Kentucky bluegrass에 침입한 creeping bentgrass를 방제하고 회복하기 위한 효과를 조사하기 위해서 수행이 되었다. 0, 0.05 and 0.10 m $ml^{-2}$ 의 세가지 mesotrione농도와 15와 30 g $m^{-2}$두가지의 Kentucky bluegrass 덧파종량의 총 6가지 처리가 적용이 되었다. Mesotrione 과 Kentucky bluegrass 덧파종을 동시에 처리 하는 것은 creeping bentgrass 방제에는 효과가 있으나 Kentucky bluegrass 회복에는 효과가 나타나지 않았다. Creeping bentgrass방제 효과는 mesotrione의 처리에 의한 것이며 덧파종에 의한 것은 아닌 것으로 나타났다. Mesotrione의 효과를 극대화 하기 위해서는 본 실험결과 20°C 이상일때가 더 효과가 좋은 것으로 판단된다.

**주요어**: 덧파종, Creeping bentgrass, Kentucky bluegrass, Mesotrione