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Research Article

Germination Enhancer and Wetting Agent for Quick Establishment of Kentucky bluegrass Cultivars

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Abstract

Wetting agent is designed to reduce the surface tension of the liquid and spread more easily across or penetrate into the soil against water repellency. The effect of wetting agent to seed germination is not clear. Using germination enhancer is one of the methods to increase the germination speed of turfgrass seeds and to shorten establishment period. The objective of the study was to evaluate germination enhancer and wetting agent for quick establishment of various Kentucky bluegrass cultivars. The germination enhancer was used at two levels of 0.3 and 0.6 ml kg^{-1} as low and high, respectively. Two levels of wetting agent were of 0.46, and 0.92 ml m^{-2} as low and high, respectively. Germination enhancer has no synergistic effect with wetting agent. When quick establishment is required, selection of cultivar would be more effective instead of using germination enhancer and wetting agent. Among Kentucky bluegrass cultivars, 'Award' had the greatest turfgrass coverage for establishment and the greatest turfgrass color and quality based on the result of the study. When quick establishment is required, selection of cultivar would be more effective instead of using germination enhancer and wetting agent.

Keywords: Establishment, Germination enhancer, Kentucky bluegrass, Wetting agent

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INTRODUCTION

Kentucky bluegrass (*Poa pratensis* L.) is one of the most widely used cool-season grasses golf course fairways, athletic fields and urban landscape although it require high water demand and has shallow root system (Christians, 2011). The widespread use of Kentucky bluegrass is caused by its affirmative capacity such as recovery ability from damage, high density, and excellent color and quality. However, Kentucky bluegrass seeds usually require more time to germinate than seeds of the tall fescue (*Festuca arundinacea* Schreb.) and perennial ryegrass (*Lolium perenne* L.). Kentucky bluegrass needs 14 to 21days to germinate taking several months to fully establish while it takes 3 to 7 days for germination of perennial ryegrasses (Samples and Sorochan, 2007). Quick germination of turfgrass is often required to recover area damaged by biotic or abiotic injuries. Environmental factors such as optimum range of temperature, proper light intensity, pH, sufficient

water content and appropriate oxygen level are known to affect plant seed germination (Bewley and Black, 1994; Rizzardi et al., 2009). Soil water content among factors to affect turf seed germination can be controlled to shorten germination period although the water requirements for seed germination are various based on plant species and soil types. Cano (1988) investigated water stress and seed germination of *Digitaria eriantha.* He found that if water stress is low, seeds of *Digitaria eriantha* can germinate over a wide range of temperatures, but the more water stress, the greater the reduction in germination rate. Sufficient water application is required to avoid decreasing germination rate of plant seed. Appropriate water management is one of the most critical factors for seed germination. Seed germination is essential for turf establishment. Turf establishment is defined as the root and shoot growth following seed germination or vegetative planting needed to form a mature, relatively stable turf (Beard and Beard, 2004). In addition to planting, turf establishment includes establishment period, which means the time to reach mature turf after seed germination. Site conditions, weather conditions, time of year, and turfgrass species can be factors to affect establishment period (Owen and Lanier, 2016). Kentucky bluegrass is one of the cool-season grasses to take the longest establishment period. Various chemical and physiological methods are used to shorten the establishment period, Wetting agent is designed to reduce the surface tension of the liquid and spread more easily across or penetrate into the soil against water repellency (Zontek and Kostka, 2012). Previous researches have reported the advantages of wetting agent for plant seed germination. Debano and Conrad (1974) investigated wetting agent and nitrogen fertilizer on establishment of ryegrass (*Lolium multiflorum*) and mustard (*Brassica nigra*). They reported that the application of wetting agent and nitrogen fertilizer increased total plant production of ryegrass, and the wetting agent decreased the total production of mustard and increased the number of ryegrass seedlings. Lee (2014) evaluated wetting agent and phosphorus rate for quick establishment of Kentucky bluegrass. He has reported that the medium and high rate of wetting agent at the high P rate had the greatest turfgrass coverage and took 28 days to reach 50% turfgrass coverage regardless of P application. He conclude that wetting agent is effective for fast germination and establishment of Kentucky bluegrass if sufficient phosphorus is applied. However, the results of negative effects have been reported about the wetting agent to seed germination. Miyamoto and Bird (1977) evaluated two wetting agents on germination and shoot growth of southwestern range plants. They found that the seed germination rates of *Sporobolus airoides* and *Pleuraphis jamesii* were decreased to 37 and 40% by the 400 ppm wetting agent. The 800 ppm of wetting agent decreased 60% and 44% seed germination rates of *Sporobolus airoides* and *Pleuraphis jamesii,* respectively. Burridge and Jorgensen (1971) reported that the 1% wetting agent decreased 47.3 to 82.8% seed germination of four different cultivars of British Columbia conifers, Douglas-fir (*Pseudotsuga menziesii*). The effect of wetting agent to seed germination is not clear based on the research data reported.

Turf scientists have found the way to shorten germination period of turf seed. One of the methods to increase the germination speed of turf seeds is to use germination enhancer. Potassium nitrate (KNO_3) is a material of germination enhancer to control turf seed hydration (Bradford, 1986). The benefits of using KNO_3 to increase the rate of germination have been reported in perennial ryegrass, Kentucky bluegrass, and colonial bentgrass (*Agrostis capillaris* L.) (Lush and Birkenhead, 1987). Polyethylene glycol, a different material of germination enhancer, increased 35% germination rate of perennial ryegrass (Danneberger et al., 1992). Gholami et al. (2009) found that the application of rhizobacteria is effective to improve seedling growth by coating seeds of plants.

Although the numerous research data have been reported for positive effects of germination enhancer to increase

speed and rates of seed germination, in the case of application of wetting agent, both positive and negative results for seed germination have been reported. There was no clear evidence that the effects of interaction germination enhancer and wetting agent to increase speed and rate of seed germination that lead to quick establishment of turf. Therefore, the objective of the study was to evaluate germination enhancer and wetting agent for quick establishment of various Kentucky bluegrass cultivars.

Materials and Methods

Research was conducted at the Hoseo Turfgrass Research Center on the campus of Hoseo University in Asan, Chungnam, Korea. Each plot size for the study was 0.4 by 0.4 m. The particle size distributions for the soil used were 92.4% sand, 4.2% silt, and 3.4% clay. Four cool-season turfgrasses which are Kentucky blugrass 'Award', 'Midnight', and 'Award' and perennial ryegrass 'Accent' were used for the study. Perennial ryegrass which is known for the species of the fastest seed germination was included in the study to compare the germination speed of Kentucky bluegrass. The seeding rates recommended by Christians (2011) which were 5 and 34 g m^{-2} for Kentucky bluegrass and perennial ryegrass, respectively were used for the study. The germination enhancer was used at two levels of 0.3 and 0.6 ml kg^{-1} as low and high, respectively and Take off ST® (Verdesian Life Sciences Inc., Cary, North Carolina, US) consisting of 0.75% citric acid, 0.25% glutamate, 0.25% proline, and 98.75% inert ingredients was used as a source of germination enhancer. The source of wetting agent was Hydro-Wet® (KALO, Overland Park, Kansas, US) which consist of 87.5% poloxanlene, 2-butoxyethanol, and two levels which were of 0.46, and 0.92 ml m^{-2} were applied as low and high, respectively.

Treatments of germination enhancer and wetting agent application were initiated on August, 12 after seeding. The complete fertilizer, Super21 (21-17-17, Namhae Chmistry. Inc. Yeosu, Korea), was used at the level of 8 g m^{-2} for the first fertilization. The treatment list and application timing are listed in Table 1. Irrigation of 1 cm was applied at three times per day before germination. Additional water was applied before a waterless symptom on soil surface was found. Irrigation of 1 cm was applied at one time per day after germination. Turfgrass coverage was measured for the area of seedlings to an area of whole treatment plot by visual evaluation. Measurements of turfgrass color and quality were initiated when turfgrass coverage was reached about 50% by visual evaluation. Turfgrass color is based on a visual rating scale with 1 being straw brown green, 9 being dark green, and 6 being minimum acceptable green. Turfgrass color ratings are a measure of overall plot and are collected when the turf is actively growing and is not under stress. Chlorosis and browning from necrosis are excluded for turfgrass color ratings (NTEP, 2010a). Turfgrass quality was measured by an index of turf density, leaf texture, disease resistance, mowing qualities, and stress tolerance including several stresses during winter (Beard, 1973; Turgeon, 1999). Turfgrass quality was visually rated on a scale of 1 to 9 (1 = poor, 6 = acceptable, and 9 = best).

The experimental design was a randomized complete-block design with three replications. Analysis of variance (ANOVA) was performed on transformed data using Statistical Analysis Systems design (SAS Institute Inc., 2001). Treatment differences were analyzed by the Proc Mixed procedure. When appropriate, mean separations were performed by Fischer's protected least significant difference (LSD) at a 0.05 probability level. All statistical analyses were analyzed by SAS.

Table 1. Treatment list of germination enhancer and wetting agent for each turf cultivar.

Cultivar	Application rate	
	Germination enhancer[y] (ml L^{-1})	Wetting agent[z] (ml m^{-2})
Kentucky bluegrass 'Award'	0.3	0.18
Kentucky bluegrass 'Award'	0.3	0.23
Kentucky bluegrass 'Award'	0.6	0.18
Kentucky bluegrass 'Award'	0.6	0.23
Kentucky bluegrass 'Midnight'	0.3	0.18
Kentucky bluegrass 'Midnight'	0.3	0.23
Kentucky bluegrass 'Midnight'	0.6	0.18
Kentucky bluegrass 'Midnight'	0.6	0.23
Kentucky bluegrass 'Award'	0.3	0.18
Kentucky bluegrass 'Award'	0.3	0.23
Kentucky bluegrass 'Award'	0.6	0.18
Kentucky bluegrass 'Award'	0.6	0.23
Perennial ryegrass 'Accent'	0.3	0.18
Perennial ryegrass 'Accent'	0.3	0.23
Perennial ryegrass 'Accent'	0.6	0.18
Perennial ryegrass 'Accent'	0.6	0.23

[y]Take off ST® was used for the application of germination enhancer.
[z]Hydro-Wet® was used for the application of wetting agent.

Results and Discussion

There was no significant three way interaction for turfgrass coverage except for the only rating date of 39 DAT (Day after treatment). Significant differences for turfgrass coverage main effect were found throughout the all rating dates of the study period (Table 2). Perennial ryegrass 'Accent' had the greatest or equal to the greatest turfgrass coverage throughout the research period (Fig. 1). Kentucky bluegrass 'Midnight' had the lowest or equal to the lowest

Table 2. Analysis of variance for turfgrass coverage.

Source	df	Day after treatment (DAT)							
		8 DAT	19 DAT	26 DAT	31 DAT	39 DAT	49 DAT	64 DAT	73 DAT
Germination enhancer rate (GER)	1	NS[z]	*	NS	*	NS	NS	*	NS
Wetting agent rate (WAR)	1	NS	NS	NS	*	NS	NS	NS	NS
Cultivar (CUL)	3	**	**	**	**	**	**	**	**
GER × WAR	1	NS	NS	NS	NS	*	NS	NS	NS
GER × CUL	3	NS	*	NS	NS	NS	NS	NS	NS
WAR × CUL	3	NS	NS	*	NS	NS	NS	NS	NS
GER × WAR × CUL	3	NS	NS	NS	NS	*	NS	NS	NS

*, ** indicates significance at $P = 0.05$ and $P = 0.01$, respectively.
[z]NS indicates not significant at $P = 0.05$.

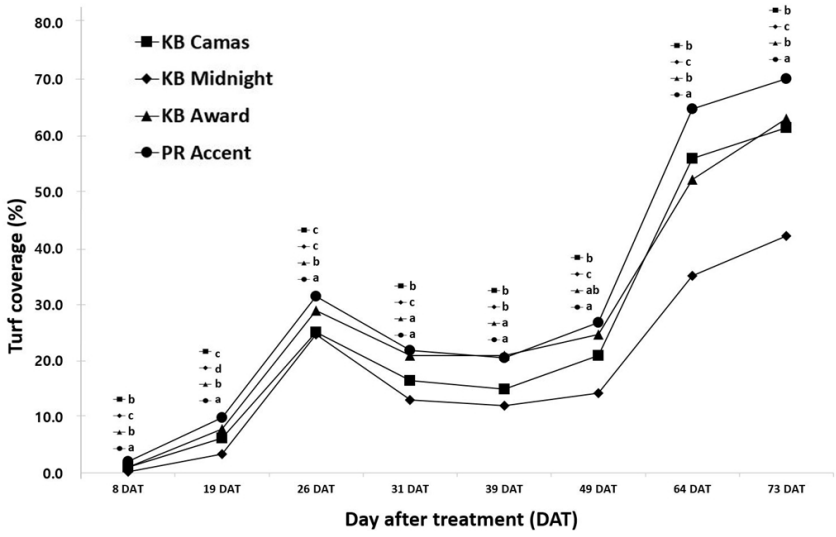

Fig. 1. Mean turfgrass coverage (%) for by turf cultivar main effect. Each mean was calculated from 12 observations (three replications × two application rates of germination enhancer × two application rates of wetting agent). Means with the same letter within each date are not significantly different according to Fisher's LSD ($P = 0.05$). KB and PR mean Kentucky bluegrass and perennial ryegrass respectively.

turfgrass coverage ratings on seven of eight rating dates. Kentucky bluegrass 'Award' had the equal to the greatest turfgrass coverage on 31, 39 and 49 DAT. Kentucky bluegrass 'Award' had greater turfgrass coverage than 'Midnight' throughout the research period. However, Kentucky bluegrass 'Award' had lower turfgrass coverage than perennial ryegrass 'Accent' on five of eight rating dates.

Among Kentucky bluegrass cultivars, 'Award' had greater turfgrass coverage ratings for the whole research period than 'Midnight'. Similar results were reported from the previous researches. Pennucci and Langille (2007) evaluated turfgrass quality, genetic color, and disease ratings for 173 Kentucky bluegrass varieties seeded in September 2000. They found that 'Award' had 16.7% more ground cover than 'Midnight' when ground cover was measured in spring 2001. However, there were the opposite results reported from the previous research. According to research report from NTEP (2010b), 'Midnight' had 5.3 % greater establishment ratings than 'Award' from the researches of seven states of the United States. From the previous research, 'Midnight' had greater establishment ratings than 'Award' during the growing season. In contrast, 'Award' had greater ground coverage than 'Midnight' when Kentucky bluegrass breaks dormancy in spring and recover damage from winter stress. 'Award' may have greater ability of ground coverage than 'Midnight' when they emerge from dormancy about mid-March. Germination rates are commonly reduced by negative effects such as seed dormancy resulted from physiological maturation and is obtained at the seed filling stage (Sinniah et al., 1998). The previous researches have been reported about relation germination rates and dormancy of plant seed. Research results concluded that the amount of ethylene production in plant seeds vary in *Xanthium pensylvanicum*, and it is effective to increase seed germination and a compound of dormancy-breaking (Gorecki et al., 1991; Saini et al., 1986; Taylorson, 1979). However, further study is required to evaluate the germination rates of 'Award' and 'Midnight' in spring when they break winter dormancy. Kentucky bluegrass 'Camas' is known for the species of fast establishment. Cross et al. (2011) evaluated 306 Kentucky bluegrass cultivars and concluded that 'Camas' had the greatest rating of establishment. Based on the results of the study, Kentucky

bluegrass 'Camas' had greater turfgrass coverage on six of eight ratings than 'Midnight'. After 39 DAT, 'Camas' had 31.3 to 32.4 % greater turfgrass coverage than 'Midnight. 'Camas' had no significant difference on turfgrass coverage compared to 'Award' after 39 DAT although 'Award' had 13.2 to 28.4% greater turfgrass coverage than 'Camas' between 19 and 39 DAT. Among Kentucky bluegrass species, there were significant differences on turfgrass coverage, perennial ryegrass 'Accent' had the greatest or equal to the greatest turfgrass coverage throughout the research period.

There was the main effect of germination enhancer rates for turfgrass coverage on three of eight ratings (Fig. 2). In 19 DAT, the high rate of germination enhancer had 7.1% greater turfgrass coverage than the low rate. In 31 and 64 DAT, the low rate had 14 and 9.9% greater turfgrass coverage than the high rate, respectively. Liu et al. (2009) support these results regarding the effect of germination enhancer to germination rates. They investigated seed germination enhancer for *Taxodium distichum*. They concluded that higher concentration (over 1%) of NaOH which is one of the materials of germination enhancer didn't increase the germination rate. However, dilute NaOH solution which is the lower rate of germination enhancer enhanced germination rate of *Taxodium distichum.* Sabongari and Aliero (2004) support the result of the study. They evaluated soaking duration on germination and seedling growth of *Lycopersicum esculentum*. They found that significant enhancement of germination by all soaking durations of 36 h treatment showed no significant difference from the control, but maximum germination rate was obtained under 24 h treatment for all the seed cultivars. High rate of germination enhancer or longer duration of soaking seeds are not effective to seed germination.

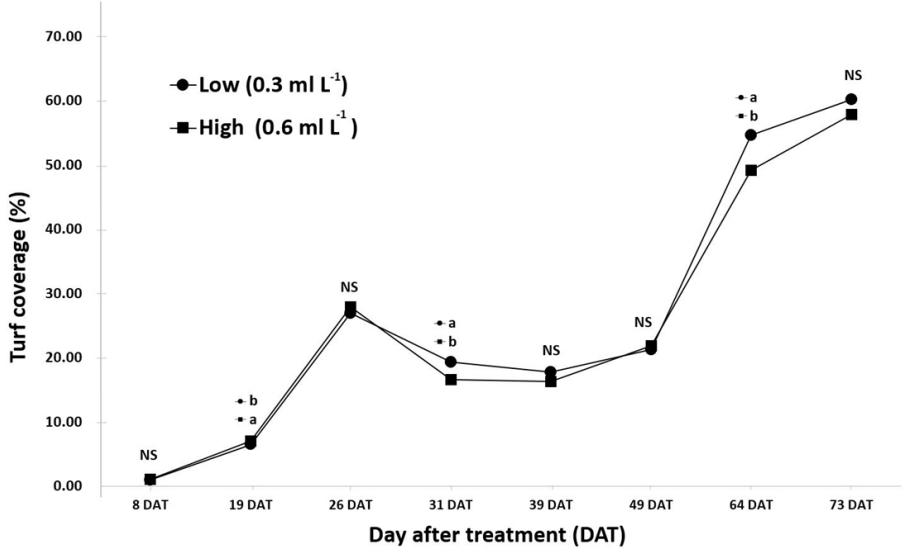

Fig. 2. Mean turfgrass coverage (%) for by the main effect of the germination enhancer rates. Each mean was calculated from 16 observations (three replications × four turfgrass cultivars × two application rates of wetting agent). Means with the same letter within each date or NS (not significant) are not significantly different according to Fisher's LSD (P= 0.05).

No three way interaction was found for turfgrass color and quality except for turfgrass quality on 64 DAT (Table 3). There were the cultivar main effects on turfgrass color and quality throughout the research period. Perennial ryegrass

'Accent' had greater turfgrass color than Kentucky bluegrass 'Camas' and 'Award' on 55 and 64 DAT (Table 4). In 73 DAT, perennial ryegrass 'Accent' had the lowest turfgrass color among all treatment. In 73 DAT (October, 24), the lowest temperature was 7.8ºC (data not shown) which is lower temperature range than optimal temperature range of cool-season grass although the lowest temperature on 55 and 64 DAT was 14.7 and 13.3ºC, respectively. According Fry and Huang (2004), perennial ryegrass is less tolerate for low temperature than Kentucky bluegrass. Range of lethal temperature is -15 to -5ºC for perennial ryegrass and -30 to -21ºC for Kentucky bluegrass. The lowest turfgrass color of perennial ryegrass 'Accent' may be resulted from tolerance ability of perennial ryegrass to low temperature. Kentucky bluegrass 'Camas' had the greatest or equal to the greatest turfgrass quality for all rating dates (Table 4). Perennial ryegrass 'Accent' had lower turfgrass quality on 73 DAT than Kentucky blegrass 'Award'. Among Kentucky bluegrass, 'Midnight' had the lowest turfgrass quality for all rating dates.

Table 3. Analysis of variance for turfgrass color and quality.

Source	df	Day after treatment (DAT)					
		55 DAT	64 DAT	73 DAT	55 DAT	64 DAT	73 DAT
		--------- Turf color --------			-------- Turf quality -------		
Germination enhancer rate (GER)	1	NS	*	NS	NS	NS	NS
Wetting agent rate (WAR)	1	NS	*	NS	NS	NS	NS
Cultivar (CUL)	3	**	*	**	**	**	*
GER × WAR	1	NS	NS	NS	NS	NS	NS
GER × CUL	3	NS	NS	NS	*	NS	NS
WAR × CUL	3	NS	NS	NS	*	NS	NS
GER × WAR × CUL	3	NS	NS	NS	NS	*	NS

*, ** indicates significance at $P = 0.05$ and $P = 0.01$, respectively.
[y]DAT means day after treatment.
[z]NS indicates not significant at $P = 0.05$.

Table 4. Mean turfgrass color and quality for the turfgrass cultivar main effect.

Cultivar[w]	Day after treatment (DAT)					
	55 DAT	64 DAT	73 DAT	55 DAT	64 DAT	73 DAT
	---------- Turf color ----------			---------- Turf quality ----------		
Award	5.9[x] b[y]	5.5 b	5.8 b	4.3[z] a	5.4 ab	5.5 ab
Midnight	5.8 b	5.5 b	6.8 a	3.3 b	3.6 c	4.8 c
Award	7.0 a	5.8 ab	6.8 a	4.6 a	5.0 b	5.8 a
Accent	6.5 a	6.1 a	4.9 c	4.7 a	5.6 a	5.0 bc

[w]Turfgrass cultivar included Kentucky bluegrass 'Award', 'Midnight', 'Award' and perennial ryegrass 'Accent'.
[x]Turfgrass color was rated from 1 to 9 (1=straw brown, 9=dark green, and 6=acceptable).
[y]Means in a column followed by the same letter are not significantly different according to Fisher's LSD ($P = 0.05$).
[z]Turfgrass quality was rated from 1 to 9 (1=worst, 9=excellent, and 6=acceptable).

Overall, germination enhance has no synergistic effect with wetting agent. No significant effects of wetting agent were found on turfgrass coverage except for the rating date on 31 DAT. Although the germination enhancer was

effective to turfgrass coverage and establishment, the difference from cultivars was more effective for the turfgrass coverage for establishment. Although significant differences among Kentucky bluegrass cultivars for turfgrass coverage were found, perennial ryegrass had the greatest turfgrass coverage for establishment. When quick establishment is required, selection of cultivar would be more effective instead of using germination enhancer and wetting agent. Among Kentucky bluegrass cultivars, 'Award' had the greatest turfgrass coverage for establishment and the greatest turfgrass color and quality based on the result of the study.

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