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Research Articles

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Evaluating Various Potassium Sources for Kentucky Bluegrass Growth

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ABSTRACT. Potassium (K) is one of the essential nutrients for plants but is not a constituent of any plant compound. K is substances for activation of many enzymes and influences the process that the enzymes are involved in catalyzing. Although experimental results associated with the K effects with both benefits and no effects on turfgrass growth were reported, the limited research results of K effects on turfgrass among K sources are available in Korea. The objectives of the study was conducted to evaluate responses of Kentucky bluegrass (*Poa pratensis* L.) treated by fertilizer treatments with six K sources. There were six fertilizer treatments as K sources applied to Kentucky bluegrass which were potassium nitrate (13-0-44, PN), potassium chloride (0-0-60, PC), potassium sulfate (0-0-50, PS), polymer-coated potassium sulfate (0-0-45, PPS), potassium thiosulfate (0-0-25, PT), and potassium sulfate granulated with methylene urea (20-0-25, PSU). Potassium of 8 g m^{-2} and N of 5 g m^{-2} was applied 4 times giving a total 20 and 30 g m^{-2}, respectively. Although significant differences were found for turfgrass color, quality, chlorophyll index, and clipping dry weight, no consistent results among K sources were found during the one year study. Overall, K treatments didn't affect turfgrass growth in this study.

***Key words*:** Chlorophyll Index, Clipping Dry Weight, Potassium, Kentucky Bluegrass, Turfgrass Color, Turfgrass Quality

Introduction

Potassium (K) is one of the essential nutrients for plants and plays important roles for activation of many enzymes and influences the process that the enzymes are involved in catalyzing (Carrow et al., 2001). However, because K is not a constituent of any plant compound, scientists often refer K as a cofactor (Christians, 2011). This means that K is required for plant constituents and many processes for plant growth although it is not a part of plant constituents. Several research results regarding no effect on turfgrass were reported from the former researches. Shearman and Beard (1975) investigated the effects of nitrogen (N) and K on cool-season turfgrass wear tolerance. They found N increased wear tolerance and total cell wall content in creeping bentgrass, while K had no effect on total cell wall content. They also reported that shoot density, verdure, leaf tensile strength, and moisture percentage increased with N fertilization although K had no effects on creeping bentgrass. Trenholm et al. (2001) had similar results that wear tolerance, shoot density, and shoot growth increased with N from 92 to 392 kg ha^{-1} yr^{-1}, while response to K was minimal. Fry et al. (1989) studied phosphorus (P) and K effects on turfgrass grown on calcareous sand. They found P effects on turfgrass quality, but K effects were not founded for turfgrass quality because of high K level of the sands.

In contrast, the benefits of K were also reported from the previous researches. K is required for photo synthesis and carbohydrate production (Blevins, 1985; Christians, 2011; Huber et al., 1985; Weber, 1985). K is also required for disease resistance. K deficient grass is less resistant to plant disease than K containing optimum K (Goss, 1969; Tisdale and Nelson, 1975). In the early 1980s, the K ratio in analysis was lower than current K ratio in analysis because the past researches indicated that the lower K produced the maximum shoot growth at the limited levels. In the present, however, the part of K in analysis is much greater than the past because many research reports were reported for the benefits of K regarding stress management. Several researches reported that K is highly required for stress management such as heat, drought, and wear stress (Beard and Rieke, 1966; Caroll and Petrovic, 1991; Cook and Duff, 1976; Juska, and Murray, 1974; Nus, and Sandburg, 1991; Sandburg and Nus, 1990; Schmidt and Brueninger, 1981).

Experimental results associated with the K effects with both benefits and no effects on turfgrass exist. However, the limited research results of K effects on turfgrass among K sources are available in Korea. The objectives of the study was conducted to evaluate responses of Kentucky bluegrass (*Poa pratensis* L.) treated by fertilizer treatments with six K sources.

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Table 1. Treatments showing nitrogen and potassium sources and application frequency.

Treatment	K Rate ($g\ m^{-2}\ yr^{-1}$)	N Rate ($g\ m^{-2}\ yr^{-1}$)	Application frequency for N and K			
			5/27	6/24	7/22	9/2
Control	0	20	N[y]	N	N	N
PN	32	20	NK[x]	NK	NK	NK
PC	32	20	NK	NK	NK	NK
PS	32	20	NK	NK	NK	NK
PPS	32	20	NK	NK	NK	NK
PT	32	20	NK	NK	NK	NK
PSU	32	20	NK	NK	NK	NK

[z] PN: Potassium Nitrate (13-0-44), PC: Potassium Chloride (0-0-60), PS: Potassium Sulfate (0-0-50), PPS: Polymer-coated potassium sulfate (0-0-45), PT: Potassium thiosulfate (0-0-25), PSU: Potassium sulfate granulated with methylene urea (20-0-25)
[y] N indicates a single application of 5 g N m^{-2}, N source was urea.
[x] NK indicates a single application of 5 g N m^{-2} and 8 g K_2O m^{-2}.

Materials and Methods

There were six fertilizer treatments as K sources applied to Kentucky bluegrass which were potassium nitrate (13-0-44, PN), potassium chloride (0-0-60, PC), potassium sulfate (0-0-50, PS), polymer-coated potassium sulfate (0-0-45, PPS), potassium thiosulfate (0-0-25, PT), and potassium sulfate granulated with methylene urea (20-0-25, PSU). Potassium of 8 g m^{-2} and N of 5 g m^{-2} was applied 4 times giving a total 20 and 30 g m^{-2}, respectively, during 6 month research period. When N and K were applied, additional N was applied to make balance of the amount of K in each plot. Fertilizer treatments for N and K in detail were described in Table 1. Urea was used as a N source. The research plots were established at the Birdwood Golf Club located in Byungchun, Chungchungnam-Do, Korea. Plot size was 1.5×2.0 m and plots were mowed weekly at 7 cm. Fertilizer treatments were applied with a hand shaker container. Irrigation was applied at 3 cm water per week depending on precipitation. Turfgrass color was measured by visual evaluation weekly from July to November, 2011 using a scale of 1 to 9 (1 = straw brown, 6 = acceptable, and 9 = excellent). Turfgrass quality was measured by visual evaluation weekly from July to November, 2011 using a scale of 1 to 9 (1=worst, 6=acceptable, and 9=best). Field Scout CM-1000 Chlorophyll Meter manufactured by Spectrum Technologies was used to quantify turfgrass color throughout the treatments. The clippings collected were oven-dried at a temperature of 67°C for 72 h and weighed.

The experimental design was a randomized complete block design with 4 replications. 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., 2000).

Results and Methods

No significant K source effect for turfgrass color was found for the study except the observation date of May, 27 (Table 2). When the significant effect for turfgrass was found, PT had the highest or equal to the highest turfgrass color rating. The turfgrass color rating on all dates and with all K treatments were greater than an acceptable turfgrass color rating of six. The reason of greater turfgrass color rating than six during the research period may result from not K source treatments but N application. This is similar result reported by Fry et al. (1989). On the study, overall, K

Table 2. Mean turfgrass color for potassium source main effect.

Treatment[z]	Date									
	5/27	6/10	6/24	7/8	7/22	8/5	8/19	9/2	9/16	10/30
Control	6.1[y] c[x]	5.9 b	6.8	6.0	6.0	6.0	6.0	6.1	7.3	6.1
PN	6.9 b	6.2 b	7.1	6.3	6.3	6.3	6.2	6.1	7.0	6.0
PC	7.2 ab	6.1 b	7.0	6.0	6.0	6.0	6.0	6.3	7.3	6.1
PS	6.5 c	5.8 b	7.1	6.1	6.1	6.1	6.1	6.3	7.1	6.3
PPS	6.9 b	6.0 b	7.0	6.0	6.0	6.0	6.1	6.4	7.3	6.1
PT	7.4 a	6.8 a	7.3	6.0	6.0	6.1	6.0	6.4	7.0	6.0
PSU	6.7 b	6.0 b	7.1	6.2	6.0	6.0	6.0	6.1	6.5	6.3

[z] PN: Potassium Nitrate (13-0-44), PC: Potassium Chloride (0-0-60), PS: Potassium Sulfate (0-0-50), PPS: Polymer-coated potassium sulfate (0-0-45), PT: Potassium thiosulfate (0-0-25), PSU: Potassium sulfate granulated with methylene urea (20-0-25)
[y] Mean turfgrass color was measured by visual evaluation using 1 to 9 scale (1=straw brown, 6=acceptable, and 9=dark green).
[x] Means with the same letters or no letter are not significantly different according to Fisher's LSD (P=0.05).

Table 3. Mean turfgrass quality for potassium source main effect.

Treatment[z]	Date									
	5/27	6/10	6/24	7/8	7/22	8/5	8/19	9/2	9/16	10/30
Control	7.0[y] b[x]	6.8 b	7.0	5.9 b	6.0	6.7	6.5	6.8	6.6 c	6.0 c
PN	7.0 b	6.8 b	6.8	6.0 b	5.9	7.0	7.0	6.8	7.0 bc	6.4 c
PC	7.1 b	6.8 b	7.0	6.0 c	6.0	6.8	6.5	7.0	7.6 a	7.4 a
PS	7.3 ab	7.0 b	7.0	6.3 a	6.5	7.0	7.5	7.0	7.4 ab	7.2 b
PPS	6.9 b	6.8 b	7.0	6.0 b	6.1	7.0	7.0	6.5	7.2 b	7.2 b
PT	7.7 a	7.2 a	7.0	6.0 b	6.1	7.0	6.8	6.5	7.0 b	6.3 c
PSU	7.1 b	7.0 b	6.9	5.8 c	6.0	6.5	7.0	6.3	6.7 c	6.3 c

[z] PN: Potassium Nitrate (13-0-44), PC: Potassium Chloride (0-0-60), PS: Potassium Sulfate (0-0-50), PPS: Polymer-coated potassium sulfate (0-0-45), PT: Potassium thiosulfate (0-0-25), PSU: Potassium sulfate granulated with methylene urea (20-0-25)
[y] Mean turfgrass quality was measured by visual evaluation using 1 to 9 scale (1=worst, 6=acceptable, and 9=best).
[x] Means with the same letters or no letter are not significantly different according to Fisher's LSD (P=0.05).

Table 4. Mean chlorophyll index for potassium source main effect.

Treatments[z]	Date				
	6/10	7/8	8/5	9/2	10/30
Control	324[y] c[x]	299	229	278	312
PN	327 bc	298	278	285	307
PC	331 b	257	282	288	328
PS	328 bc	279	251	267	318
PPS	332 b	235	268	279	307
PT	352 a	274	292	268	312
PSU	318 c	231	279	281	319

[z] PN: Potassium Nitrate (13-0-44), PC: Potassium Chloride (0-0-60), PS: Potassium Sulfate (0-0-50), PPS: Polymer-coated potassium sulfate (0-0-45), PT: Potassium thiosulfate (0-0-25), PSU: Potassium sulfate granulated with methylene urea (20-0-25)
[y] Mean chlorophyll index was measured by chlorophyll meter.
[x] Means with the same letters or no letter are not significantly different according to Fisher's LSD (P=0.05).

Table 5. Mean clipping dry weight for potassium source main effect.

Treatments[z]	Date			
	6/10	7/22	9/2	10/30
Control	18.5[x] c[y]	17.3 b	21.7 c	20.6
PN	23.5 b	34.3 a	38.1 a	34.7
PC	20.3 bc	19.1 b	32.5 b	32.0
PS	21.9 bc	23.6 b	31.8 b	30.3
PPS	23.3 b	22.5 b	30.8 b	26.1
PT	28.5 a	25.2 b	33.3 b	21.4
PSU	23.8 b	22.9 b	31.8 b	27.2

[z] PN: Potassium Nitrate (13-0-44), PC: Potassium Chloride (0-0-60), PS: Potassium Sulfate (0-0-50), PPS: Polymer-coated potassium sulfate (0-0-45), PT: Potassium thiosulfate (0-0-25), PSU: Potassium sulfate granulated with methylene urea (20-0-25)
[y] Clipping dry weight units are g m^{-2}.
[y] Means with the same letters or no letter are not significantly different according to Fisher's LSD (P=0.05).

source had no effects for turfgrass color for one year of the study. There was a significant K source effect for turfgrass quality on four out of 10 rating dates (Table 4). PT had the greatest or equal to the greatest turfgrass quality for May, 27 and June, 10. No significant K source effects were found for turfgrass quality from June, 24 to September, 2 except July, 8. PC had the the greatest or equal to the greatest turfgrass quality for September, 16 and October, 30. PSU had no difference with the control for turfgrass quality for the research period except rating dates of July, 8. In July, 8, turfgrass quality treated by PSU was lower than the control with no K application. Among treatments, only PSU had lower turfgrass quality rating than an acceptable turfgrass quality rating of six. K effects on photosynthesis and carbohydrate production were reported although K is not a constituent of any turfgrass compound (Christians, 2011). However, these effects were not greater than N effects on turfgrass quality because plots treated by K application had no difference with control treated with no K. No consistent results were found among K treatments during the study. Although there were significant K treatment effects for turfgrass quality, turfgrass quality is more affected by N treatments than K treatments like turfgrass color. A high positive correlation was found between chlorophyll content in a given type of photocenosis and the photosynthetic productivity (Voronin et al., 2004). Chlorophyll index can be used to measure physiological characteristic for quantitative estimation of the photosynthetic productivity. There were no significant effects for chlorophyll index except June, 10 (Table 4). PT had the highest chlorophyll index when a significant difference was found for chlorophyll index. It is similar result with turfgrass color and quality. There were no significant K source effects for clipping dry weigh (Table 5). In June, PT had the highest clipping yield, and control plot treated by no K had the lowest clipping yield. PN had the highest clipping yield for July and August which is a period of relatively high temperature. However, other K treatments had no differences with control plot for July and August.

Although significant differences were found for turfgrass color, quality, chlorophyll index, and clipping dry weight, no consistent results among K sources were found during the one year study. Overall, K treatments didn't affect to turfgrass growth in this study, and turfgrass growth found was affected from N application as many similar research results were reported (Fry et al., 1989; Shearman and Beard, 1975; Trenholm et al., 2001). Among K treatments, differences for turfgrass color and quality were found, but no significant differences were found for clipping dry weight. It also had no consistent results. Interaction between K and N treatments may exist. However, K had no effects for Kentucky bluegrass growth and no differences were found among K sources for one year study.

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켄터키블루그래스의 생육을 위한 칼륨의 유형별 효과

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요 약: 칼륨(K)은 식물체 성장을 위한17가지 필수 영양소중의 하나이지만 식물체를 구성하는 필수 구성물질은 아니다. 그러나 칼륨은 식물체내에서 여러가지 효소작용과 효소와 관련된 여러가지 대사과정에 관여를 하는 중요한 영양소이다. 칼륨이 잔디의 성장에 영향이 있는 경우와 없는 경우의 결과들이 많은 연구결과를 통해서 보고가 되었음에도 불구하고, 우리나라에서는 다양한 칼륨의 종류에 따른 잔디의 생육에 관한 연구결과가 부족한 것이 현실이다. 본 실험의 목적은 6종류의 칼륨에 따른 켄터키블루그래스의 생육을 조사하기 위하여 수행되었다. 실험에 사용된 칼륨의 종류로 potassium nitrate (13-0-44, PN), potassium chloride (0-0-60, PC), potassium sulfate (0-0-50, PS), polymer-coated potassium sulfate (0-0-45, PPS), potassium thiosulfate (0-0-25, PT), potassium sulfate granulated with methylene urea (20-0-25, PSU) 등 6종류가 사용이 되었다. 실험을 위해 질소와 칼륨이 각각 20와 30 g m^{-2} yr^{-1} 의 양이 4번에 나누어 실험구에 적용되었다. 칼륨의 종류에 따른 처리에 의해 잔디의 색, 품질, 엽록소 지수, 예지물 생산량등에 있어서 부분적으로 유의성이 발견되었지만, 일관성 있는 결과는 나타나지 않았다. 본 실험에서 칼륨의 종류에 따라 켄터키블루그래스의 생육에 미치는 영향은 발견되지 않았다.

주요어: 엽록소지수, 예지물생산량, 잔디 색, 잔디 품질, 칼륨, 켄터키블루그래스