INCREASED POTASSIUM FERTILIZATIONS FOR ENHANCED STRESS RESISTANCE OF PERENNIAL RYEGRASS GROWN ON A SAND ROOT ZONE SPORTS FIELD

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October 28, 1994

I. SUMMARY

Fertilization of turfgrasses with relatively large amounts of potassium (K) has been associated with resistance to many stress conditions including those imposed by diseases, drought, traffic, and high and low temperatures. There is little debate about the need for K fertilization of turfgrasses grown on a sand root zone, especially if clippings are removed and the site is irrigated and fertilized to promote optimum turfgrass quality and function. The objective of this study was to determine if increasing the K component of the N/K ratio would increase traffic and drought resistance of perennial ryegrass grown on a sand root zone. Potassium treatments included N/K_2O ratios from 1/0 to 1/3 and they were applied from May 13, 1993 to July 15, 1994. From October 13 to November 29, 1993, the plots were subjected to either high (25 game equivalents) or low (12.5 game equivalents) traffic utilizing a Brinkman Traffic Simulator. Measurements that were taken during and after the traffic treatments included visual assessments of wear, traction strength of sod, and N, P, K content of crown tissue. On June 6 to 12, 1994, plugs were pulled to determine crown mass and root mass from each K treatment - traffic treatment plot and on July 18, 1994, a drought treatment was initiated. Unfortunately, the site did not dry down uniformly, therefore making unbiased measurements of drought resistance impossible.

Results showed that K treatments did not significantly affect wear tolerance of perennial ryegrass. However, upon close inspection of the data, there appeared to be a trend for higher traffic tolerance associated with higher amounts of K. Potassium treatments had a significant effect on percent K of crown tissue. Generally, higher amounts of K fertilizer resulted in higher amounts of K in the crown tissue. Potassium treatments did not significantly affect the amount of crown or root mass. It should be noted that potassium treatments had been applied for 14 months prior to sampling for plant mass.

II. INTRODUCTION

Fertilization of turfgrasses with relatively large amounts of potassium (K) has been associated with resistance to many stress conditions including those imposed by diseases, drought, traffic, and high and low temperatures. Potassium may enhance stress resistance by directly or indirectly causing increased rooting, thickened cell walls with an associated higher cellulose content, and decreased tissue hydration resulting in hardy tissue.

Data from several university studies has supported the above benefits, while data from other studies has shown no benefit. Some of this paradox can be explained by recognizing several factors that may influence the outcome of these studies: soil type (sand, clay, loam, etc.) and starting K soil levels; turfgrass species, including their respective K requirements and uptake capabilities; irrigation amount and potential K leaching, especially in sandy soils, clipping removal and thus the removal of K; N fertility rate, an example being at low N rates, K uptake may be low though there is sufficient soil-available K; and soil chemical and physical properties that influence K uptake, an example being high sodium levels in the water or soil hinder K uptake.

There is little debate about the need for K fertilization of turfgrasses grown on a sand root zone, especially if clippings are removed and the area is irrigated to promote optimum turfgrass quality and function. Potassium fertilization in relatively large amounts on many of the native California soils is debatable. However, many agronomists do stress the need for a balanced nutritional program; one that involves N, P, and K.

Potassium is one of the 16 essential elements required for plant growth, excluding carbon, hydrogen, and oxygen. The K requirement for turfgrasses ranks second only to N. Potassium is not a constituent of plant tissues nor organic compounds, such as carbohydrates, proteins, and lipids. However, K is an essential cofactor involved in carbohydrate synthesis and translocation, protein and amino acid synthesis, and enzyme activity. It is also involved in the control of transpiration, respiration, and uptake of certain nutrients such as N and magnesium. Generally, the requirement for K increases with higher N fertilizer rates, heavy irrigations, and clipping removal.

Soils having sufficient amounts of clay minerals may supply appreciable amounts of plant-available K. However, sandy soils contain much less K than clays and have considerably less ability to retain K against leaching. Potassium is very mobile and can be easily leached from plant tissue and from sandy soils. This situation is further exaggerated when clippings are removed and the site is irrigated heavily. This is a typical situation for athletic fields receiving medium to high levels of management. Sand is a popular root zone medium because it resists soil compaction from heavy traffic and because it facilitates drainage so that rainfall has the least impact on sporting events.

The objective of this study was to determine if increasing the K component of the N/K ratio would increase traffic and drought resistance of perennial ryegrass grown on a sand root zone.

III. MATERIALS AND METHODS

This study was conducted on a mature stand of Manhattan II perennial ryegrass. The root zone was a well-drained, 16-inch deep, medium textured sand with a subsurface drainage system. Potassium treatments included N/K_2O ratios ranging from 1/0 to 1/3, and they were applied from May 13, 1993 to July 15, 1994 (Tables 1, 2, and 3). From October 13 to November 29, 1993, the plots were subjected to either high or low traffic utilizing a Brinkman Traffic Simulator (Table 4). Measurements that were taken during and after the traffic treatments included visual assessments of wear, traction strength of sod, and N, P, K content of crown tissue (Table 5). On June 6 to 12, 1994, plugs were pulled to determine crown mass and root mass from each K treatment-traffic treatment plots and on July 18, 1994, a drought treatment was initiated. Unfortunately, the site did not dry down uniformly, therefore making unbiased measurements of drought resistance impossible.

Table 1. Calendar of potassium fertilizations for increased stress resistance of perennial ryegrass.

Date	Activity
May 13, 1993 to July 15, 1994	Potassium treatments applied according to schedule.
October 13 to November 29, 1993	Application of traffic treatments.
November 23 and November 30, 1993	Conducted visual assessments of wear.
December 6, 1993	Conducted traction plate measurements.
December 9, 1993	Took samples for N, P, K tissue analysis.
June 6 to June 12, 1994	Took samples for determination of above-ground and below-ground plant mass.
July 18, 1994	Initiated drought treatment.

Table 2. Materials and methods outline for potassium fertilizations for increased stress resistance of perennial ryegrass.

Cultivar

Manhattan II perennial ryegrass.

Experimental Site

A mature, sand-filled basin model sports field established at the UCR Turfgrass Research Field Laboratory in 1984. The root zone was a well-drained, 16-inch deep, medium textured sand with a subsurface drainage system. The perennial ryegrass was established in spring 1992 by sod.

Experimental Design

Strip-plot design with three replications. K treatments formed main plots (12 x 4.5 feet), while traffic treatments were stripped across main plots forming subplots (6 x 4.5 feet).

Mowing

One time per week with a walk-behind rotary mower; mower setting/actual height = 1 7/8 inches and 1 5/8 inches, respectively; clippings removed.

Irrigation

Irrigated to promote maximum turfgrass quality for the entire plot area.

K Treatments

Initiated May 13, 1993. Treatments were applied once every 2 weeks; exception was Multicote which was applied once every 4 months at a rate of 2 lb N/1,000 ft^2 (see Table 3).

Traffic Treatments

Applied with a Brinkman Traffic Simulator (BTS) equipped with football cleats. Two passes with the BTS were equivalent to one football game (see Table 4).

Drought Treatment

Initiated July 18, 1994 by withholding irrigation and rating plots visually for drought symptoms (leaf wilting and rolling, and discoloration and eventual firing). Unfortunately, the site did not dry down uniformly, therefore making unbiased measurements of drought resistance impossible. Dry-down patterns across the plot and treatments dominated the visual appearance.

Table 3. Potassium treatments for increased stress resistance of perennial ryegrass.

Fertilizer Source ($N-P_2O_5-K_2O$)	N/K_2O	Pounds/1,000 ft^2 per month N	K_2O
Urea 45 - 0 - 0	1/0	0.5	0
K-Power 13.75 - 0 - 44.5	1/3	0.5	1.6
Multicote 12 - 0 - 43	1/3	0.5	1.8
K-Power + Urea 19 - 0 - 38	1/2	0.5	1.0
K-Power + Urea 26.4 - 0 - 26.4	1/1	0.5	0.5

Table 4. Traffic treatments on perennial ryegrass utilizing a Brinkman Traffic Simulator.

Date	Number of Passes with BTS High Traffic	Low Traffic
Oct. 4	2	1
Oct. 8	2	1
Oct. 11	2	1
Oct. 15	2	1
Oct. 18	4	2
Oct. 22	2	1
Oct. 25	4	2
Oct. 29	4	2
Nov. 1	4	2
Nov. 5	4	2
Nov. 8	4	2
Nov. 12	4	2
Nov. 15	4	2
Nov. 22	4	2
Nov. 29	4	2
Total Passes	50	25
Game equivalents	25	12.5

Table 5. Measurements taken during potassium fertilizations for increased stress resistance of perennial ryegrass.

Measurements During/After Traffic Treatments

1. Visual rating of wear: 1 to 9; 1 = brown, worn turf, 9 = no wear.
2. Traction strength of sod. Taken with a traction torque apparatus equipped with a 42-kg plate with football cleats.
3. N, P, K content of crown tissue. One 2.5-inch diam. plug was taken from each K treatment main plot. Each plug was cut at the soil surface and washed to remove the remaining soil and roots. The remaining crown tissue was dried and ground in preparation for laboratory analysis.

Plant Measurements Prior to Drought Treatment

Three plugs (2 $^3/_8$ inches diam. x 6 inches deep) were taken on June 6 to 12, 1994, from each K treatment - traffic treatment subplot in order to determine crown mass and root mass in the upper 3 inches and root mass in the 3- to 6-inch depth interval.

IV. RESULTS AND DISCUSSION

Potassium treatments were applied for almost 5 months prior to traffic treatments. These treatments did not significantly affect wear tolerance of perennial ryegrass (Table 6). The K-treatment x traffic-treatment interaction was not significant. This means that K treatments responded relatively the same regardless of traffic treatment level. Therefore, as presented in Table 6, K treatments are the average of both high-and low-traffic treatments. It should be noted that traffic treatments did significantly affect the amount of wear. That is, plots receiving the high-traffic treatment were significantly more worn than plots receiving the low-traffic treatment. In summary, higher amounts of K did not significantly increase the wear tolerance of perennial ryegrass. However, upon close inspection of the data in Table 6, there appeared to be a trend for higher traffic tolerance associated with higher amounts of K.

Potassium treatments did not significantly affect sod strength (Table 7). It is also interesting to note that traffic treatments did not significantly affect sod strength. One might expect a more worn turf (high-traffic treatment) to have a lower sod strength than a less worn turf (low-traffic treatment).

Potassium treatments had a significant effect on percent K of crown tissue (Table 8). Generally, higher amounts of K fertilizer resulted in higher amounts of K in the crown tissue. Potassium treatments did not affect percent N and P of crown tissue.

Potassium treatments did not significantly affect the amount of crown or root mass (Table 9). It should be noted that potassium treatments had been applied for 14 months prior to sampling for plant mass. Traffic treatments also did not significantly affect the amount of crown or root mass. Since the site was allowed to recover for 6 months following the traffic treatments, it may not be surprising to find a nonsignificant traffic effect on plant mass. The primary purpose of this sampling was to determine the influence of potassium treatments on plant mass.

Table 6. The effect of N/K ratios and simulated traffic on visual wear measurements of perennial ryegrass grown on a sand root zone.

		Visual wear estimate[z]	
Potassium treatment	**N/K_2O**	**Nov. 23**	**Nov. 30**
Urea	**1/0**	**4.6[y]**	**4.9**
K-Power + Urea	**1/1**	**3.8**	**4.2**
K-Power + Urea	**1/2**	**5.3**	**5.6**
K-Power	**1/3**	**5.3**	**5.5**
Multicote	**1/3**	**4.9**	**5.0**
LSD P = 0.05		**1.3**	**1.4**
Strip-plot effects			
Potassium treatment		**NS**	**NS**
Traffic		*****	******
Potassium treatment x traffic		**NS**	**NS**

[z] Wear rated from 1 to 9: 1 = brown, worn turf; 9 = no wear.

[y] Means are the average of high- and low-traffic treatments.

***, **, ***, NS Significant at P=0.05, 0.01, 0.001, or nonsignificant, respectively.**

Table 7. The effect of N/K ratios and simulated traffic on the traction strength of perennial ryegrass grown on a sand root zone.

Potassium treatment	N/K_2O	Traction torque[z] (meter kilograms)
Urea	1/0	4.85[y]
K-Power + Urea	1/1	4.57
K-Power + Urea	1/2	4.67
K-Power	1/3	4.94
Multicote	1/3	4.71
LSD P = 0.05		NS
Strip-plot effects		
Potassium treatment		NS
Traffic		NS
Potassium treatment x traffic		NS

[z] Traction torque measured with a 42-kg plate with football-type cleats.

[y] Means are the average of high- and low-traffic treatments.

***, **, ***, NS Significant at P=0.05, 0.01, 0.001, or nonsignificant, respectively.**

Table 8. The effect of N/K ratios on percent N, P, K of crown tissue of perennial ryegrass grown on a sand root zone.

Potassium treatment[z]	N/K_2O	% N	% P	%K
Urea	1/0	2.073	0.110	1.217
K-Power + Urea	1/1	2.132	0.107	1.260
K-Power + Urea	1/2	2.252	0.130	1.577
K-Power	1/3	2.192	0.133	1.480
Multicote	1/3	2.271	0.150	1.770
LSD P = 0.05		NS	NS	0.393

[z] **Fertility treatments were applied for 6.5 months prior to plant collection.**

Table 9. The effect of N/K ratios and simulated traffic (followed by 6 months of recovery from the traffic) on plant mass of perennial ryegrass grown on a sand root zone.

		Mass (mg)[z]			
Potassium Treatment	**N/K_2O**	**Crown**	**Upper Roots (0 to 3 Inches)**	**Lower Roots (3 to 6 inches)**	**Plant Total**
Urea	1/0	1,020[y]	515	100	1,635
K-Power + Urea	1/1	1,008	521	105	1,634
K-Power + Urea	1/2	972	518	118	1,609
K-Power	1/3	972	564	126	1,662
Multicote	1/3	993	434	116	1,543
LSD P=0.005		NS	NS	NS	NS
<u>Strip-plot effects</u>					
Potassium Treatment		NS	NS	NS	NS
Traffic		NS	NS	NS	NS
Potassium Treatment x Traffic		NS	NS	NS	NS

[z] Three plugs (2 3/8 inches diam. x 6 inches deep) were taken from each fertility treatment-traffic treatment subplot.

[y] Means are the average of high- and low-traffic treatments.

*, **, ***, NS Significant at P=0.05, 0.01, 0.001, or nonsignificant, respectively.