Growth of 'Tifway' Bermudagrass Following Application of Nitrogen and Iron with Trinexapac-ethyl

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Abstract. A field study was conducted to assess the effects of N and Fe with trinexapac-ethyl (TE) on established 'Tifway' bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) during 2 years at Griffin, Ga. There were no TE x Fe or N treatment interactions when applied in three applications at 4-week intervals each year. Combinations of Fe with TE improved turfgrass quality over TE alone at 1 to 2 weeks after each treatment. The improvement from Fe sources was 17% higher with Sprint 300 and SoluPlex, 33% higher with Ferromec and LawnPlex, and 67% higher with ferrous sulfate. Vegetative suppression of 'Tifway' bermudagrass at 14 weeks after treatment ranged from 46% in 1994 to 28% in 1995 when treated with TE at 0.1 kg·ha⁻¹ in three applications at 4-week intervals. Neither N or Fe influenced vegetative growth when applied with TE. Chemical name used: 4 (cyclopropyl- α -hydroxy-methylene)-3,5-dioxocyclohexanecarboxylic acid ethyl ester (trinexapac-ethyl).

'Tifway' bermudagrass is used as a high-quality sports turf throughout the southern United States. Maintaining a high-quality turf usually requires frequent mowings. When mowing is delayed, scalping often results in a subquality turf. Plant growth regulators (PGRs) suppress vegetative growth and prevent excessive growth during rainy periods. Trinexapac-ethyl (TE) is a relatively new PGR that suppresses growth of cool- and warm-season turfgrasses (Johnson, 1992, 1993a, 1993b, 1994). However, the success of this and other PGRs depends on consistent vegetative suppression with little or no turfgrass injury.

For PGRs to be effective, they must suppress turfgrass growth without causing an objectionable injury. When 'Tifway' bermudagrass was treated with TE at 0.2 kg·ha⁻¹, leaf discoloration was moderate (24% to 30%) with some plant necrosis (Johnson, 1992). When the 0.2 kg·ha⁻¹ rate was followed by 0.1 kg·ha⁻¹ at 2 or 3 weeks later, the injury was severe (33% to 35%) (Johnson, 1992). Even though turfgrass recovered within 4 to 5 weeks, the initial degree of injury was considered not commercially acceptable.

Nitrogen did not completely offset adverse effects from PGR treatments on 'Tifway'

bermudagrass (Johnson, 1988). However, in some instances, N at 50 kg·ha⁻¹ resulted in a higher-quality turf than did 25 kg; in others, turfgrass injury was reduced and quality improved when Fe was applied with selected PGRs (Carrow and Johnson, 1990). Hence, a study was initiated to determine if N and Fe applied with TE would reduce turfgrass injury without affecting turfgrass growth suppression when compared with the PGR alone.

Material and Methods

An experiment was conducted with combinations of N and Fe sources with TE (emulsifiable concentrate) in established 'Tifway' bermudagrass at Griffin, Ga., during 1994 and 1995. TE was applied at 0.1 kg·ha⁻¹, N at 12 kg·ha⁻¹, and Fe at 0.6 kg·ha⁻¹. The PGR was applied alone and in combination with N and Fe in three applications at the same rate on 1 June, 29 June, and 26 July $\pm$ 2 days. The PGR, N, and Fe treatments alone and combination treatments will be referred to as PGR treatments. Nitrogen source was urea. The Fe sources were Sprint 330, Ferromec, ferrous sulfate, SoluPlex, and LawnPlex. Sprint 330 (CIBA-GEIGY Corp., Greensboro, N.C.) contains 10% chelated Fe derived from technical sodium ferric diethylenetriamine pentaacetate formulation. Ferromec (PBI Gordon Corp., Kansas City, Kan.) contains 15% urea nitrogen, 3% S, and 6% Fe derived from low biuret urea and ferrous sulfate heptahydrate. Ferrous sulfate (Baker analyzed Reagent Product) contains 20% Fe derived from iron sulfate heptahydrate formulation. SoluPlex (Roots; RGB Laboratories, New Haven, Conn.) contains 4% ammonium nitrogen, 13% S, and 15% Fe derived from ammonium sulfate and ferrous sulfate formulation. LawnPlex (Roots; RGB Laboratories) contains 8% S and 8% Fe

derived from ammonium thiosulfate iron phosphate-citrate in a formulation. All treatments were applied as a broadcast spray at 375 kg·ha⁻¹ and turf was irrigated with 6 to 8 mm water $\approx$ 12 h after each application.

Soil type was an Appling loamy sand (clayey kaolinitic, thermic Typic Kanhapludult) with (g·kg⁻¹) 22 organic matter, 790 sand, 140 silt, and 70 clay. The turfgrass was fertilized each year with (kg·ha⁻¹) 50N–22P–42K in early April and again at the same rate in early September. Additional N at 50 kg·ha⁻¹ was applied in early May. When rainfall was limited, the turfgrass was irrigated to provide $\approx$ 25 mm of rainfall and irrigation per week.

'Tifway' bermudagrass was mowed at 1.6 cm with a reel mower 2–3 times weekly beginning 3 to 4 weeks before PGR treatments. Turf was mowed 1 day before treatments and once weekly at 1.6 cm after treatment.

Turf quality was visually rated weekly throughout the experiment. Ratings were based on leaf discoloration where 1 = brown and 10 = dark green with a uniform, dense stand. Vegetative growth of 'Tifway' bermudagrass was based on fresh clipping weights. Clipping masses were collected by mowing weekly (0.6 by 3 m) from 1 through 14 weeks after treatment. Percent growth suppression ratings were determined from cumulative fresh masses during the 14-week period:

$$\% \text{ suppression} = 100 - \left(\frac{\text{treated clipping mass}}{\text{untreated clipping mass}} \right)$$

The design was a randomized complete block with four replications. Plots were 1.5 x 3 m. Analysis of variance (ANOVA) using the Statistical Analysis System (General Linear Model Procedure) (SAS Institute, 1982) was carried out within and across years. There was a year x treatment interaction ($P \leq 0.05$) for turf quality and vegetative growth and means for each year were separated by the least significant difference $P \leq 0.05$. Various post-hoc contrasts were hypothesized to compare PGR alone with combinations of PGR with N or Fe.

Results and Discussion

There was no interaction from combinations of TE with N or Fe for turfgrass quality or vegetative growth during 1994 and 1995.

Turfgrass quality. Turfgrass injury and reduction in the overall turfgrass quality usually occurs within 2 weeks after PGR treatments (Johnson, 1989). This is especially true when PGR treatments are repeated on the same site at 2- to 4-week intervals (Johnson, 1992).

Nitrogen applied at 12 kg·ha⁻¹ with TE on 1 June 1994 improved turf quality of 'Tifway' bermudagrass when compared with TE alone (Table 1). Nitrogen did not have any effect on turf quality on other 1994 rating dates. Nitrogen applied alone improved turf quality compared with TE alone only following 1 June 1994 and 1995 and 28 June 1994 applications.

Iron sources. Bermudagrass response to Fe source plus TE was not consistent in either year (Table 1). Ferrous sulfate plus TE enhanced turf quality following 3 of 6 applications. In contrast, Ferromec and LawnPlex

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plus TE enhanced quality following 2 of 6 applications, Sprint 300 and SoluPlex plus TE improved quality after 1 of 6 applications. When a Fe response occurred, the quality of bermudagrass was higher for only 1 or 2 weeks following treatment with TE. By 3 weeks

following Fe and TE combination treatments, turf quality was similar following TE alone.

These results indicate that when TE was applied to 'Tifway' bermudagrass at 0.1 kg·ha⁻¹, the addition of Fe did not always improve turf quality immediately after treatment when com-

pared with TE alone. Turf response to TE plus Fe from ferrous sulfate occurred more frequently than TE plus Fe from other sources.

Vegetative suppression. The suppression of 'Tifway' bermudagrass growth for 14 weeks was similar when TE was applied at 0.1 kg·ha⁻¹ in each of three applications alone or with N and Fe (Table 2). In 1994, the suppression from TE alone ranged from 75% at 4 weeks to 46% by 14 weeks, while in 1995 it ranged from 47% at 3 weeks to 28% by 14 weeks. Hence, N did not reduce TE efficacy and these results were similar to those reported earlier when N and flurprimidol [α -(1-methylethyl)- α -[4-(trifluoromethoxy)-5-pyrimidinemethanol] were used together (Johnson, 1988).

Although results were not consistent, Fe (0.6 kg·ha⁻¹) and particularly iron sulfate, improved quality of TE-treated 'Tifway' bermudagrass compared to TE applied alone.

Table 1. Influence of N and Fe applied with trinexapac-ethyl on quality of 'Tifway' bermudagrass within 2 weeks after treatment at Griffin, Ga.

Orthogonal contrasts for treatments			Turfgrass quality rating ^z					
			Treatment dates					
			1 June		28 June		26 July	
PGR (kg·ha ⁻¹)	N (kg·ha ⁻¹)	Fe ^y sources	1994	1995	1994	1995	1994	1995
0.1	0	None	7.4	9.1	7.2	8.3	7.3	8.0
vs. 0	0	None	8.2**	9.6*	8.1	7.3**	5.7**	7.9
0	12	None	8.7**	9.7*	8.6**	7.7*	6.4*	8.0
0.1	12	None	7.9*	9.2	7.0	8.6	7.6	8.4
0.1	0	Sprint 300	7.7	9.2	7.1	8.8*	7.8	8.4
0.1	0	Ferromec	8.1*	9.5	7.5	8.9*	8.1	8.4
0.1	0	Ferrous sulfate	8.2*	9.7**	7.5	8.9*	7.8	8.5*
0.1	0	LawnPlex	8.2*	9.3	7.7	8.4	7.6	8.8*
0.1	0	SoluPlex	7.4	9.5	7.5	8.7	8.1	8.8*

^zTurfgrass quality was rated 1 to 2 weeks after each treatment on a 1 to 10 scale where 1 = brown or dead and 10 = dark green with a uniform, dense turf.

^yIron was applied at 0.6 kg·ha⁻¹.

* **Significant at $P \geq 0.05$ and 0.01, respectively.

Table 2. Influence of N and Fe applied with trinexapac-ethyl on vegetative suppression of 'Tifway' bermudagrass at Griffin, Ga.

Orthogonal contrasts for treatments ^y			Vegetative suppression (%) ^z					
			1994			1995		
			Weeks after first treatment			Weeks after first treatment		
PGR (kg·ha ⁻¹)	N (kg·ha ⁻¹)	Fe ^x sources	4	10	14	3	10	14
0.1	0	None	75	74	46	47	37	28
vs. 0	0	None	0**	0**	0**	0**	0**	0**
0	12	None	+15**	+36**	+36**	+7**	+2**	2**
0.1	12	None	67	48	39	47	34	24
0.1	0	Sprint 300	75	62	56	58	40	29
0.1	0	Ferromec	72	55	48	44	32	26
0.1	0	Ferrous sulfate	77	59	53	51	43	32
0.1	0	LawnPlex	65	51	42	47	40	28
0.1	0	SoluPlex	78	65	60	47	38	27

^zPercent vegetative suppression ratings were based on cumulative weekly fresh clippings weights as determined by 100-mass treated turf/mass untreated turf. Values preceded by + had higher clipping weights than untreated control.

^yTreatments were applied initially on 1 June $\pm$ 1d followed by applications on 28 June and 26 July.

^xIron was applied at 0.6 kg·ha⁻¹.

**Significant at $P \leq 0.01$.

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