Effect of Trinexapac-ethyl on Zoysiagrass Quality under a Shade Condition

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그늘 지역에서의 Zoysiagrass에 미치는 Trinexapac-ethyl의 효과

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ABSTRACT

'Meyer' zoysiagrass(*Zoysia japonica* Steud.) is a popular turfgrass species used for transition zone golf course fairways and tees in mid U.S.A golf courses because it is generally winter hardy while providing an excellent playing surface with minimal chemical and irrigation inputs. However, its functionality declines easily in many of the shaded areas of these courses. Reduced irradiance causes excessive shoot elongation, reduced tillering, and weak plants that are poorly suited to tolerate or recover from traffic and devoting. Trinexapac-ethyl (TE) effectively reduces gibberellic acid (GA) biosynthesis and subsequent shoot cell elongation.

This study was initiated to evaluate TE effect on shoot elongation and stand persistence under two levels of shade in 'Meyer' zoysiagrass. A mature stand of 'Meyer' was treated with all combinations of three levels of shade(0%, 79%, and 92%) and three levels of monthly TE [0, 48 g·ha^{-1} a.i(0.5x) and 96 g·ha^{-1} a.i(1x)]. In full sun, the TE at 48 g·ha^{-1} a.i reduced clipping yield by 18% over a four-week period and, whereas the TE at 96 g·ha^{-1} a.i by 30% to 38%. Monthly application of TE at the 96 g·ha^{-1} a.i increased 'Meyer' tiller density in full sun and under 79% shade. Both rates of TE consistently reduced shoot growth under shade relative to the shaded control.

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Only the monthly applications of the TE at 96 g·ha^{-1} a.i consistently delayed loss of quality under 79% shade. Our results indicate TE can be an effective management practice to increase 'Meyer' zoysiagrass persistence in shaded environments.

Key words : clipping yield, shade, tiller density, trinexapac-ethyl(TE), zoysiagrass

INTRODUCTION

It is estimated that 20 to 25% of turfgrasses are grown under low light conditions. 'Meyer' zoysiagrass is the premier warm-season turfgrass for golf course tees and fairways in transition zone of the America because of its dense growth habit, adaptation to low mowing heights, and tolerances to cold, traffic and drought, and relative lack of insect and disease problems. Unfortunately, Meyer zoysiagrass is not shade tolerant. A considerable amount of time and money are spent by golf course superintendents to maintain zoysiagrass in shade(Dudeck and Peacock, 1992; Kephart et al., 1992; Qian and Engelke, 1999; Qian et al., 1998). Traffic and shade reduce zoysiagrass quality to the point where it must be resodded or replaced entirely with a more shade-tolerant species which, unfortunately, does not offer the same functional or aesthetic performance.

Shade causes a number of morphological and physiological changes in turfgrasses. For instance, leaf length and plant heights increase most likely due to the inactivation of phytochrome by far-red light and the production of excessive levels of gibberellic acid. GA is a plant hormone that is primarily responsible for leaf blade elongation. Elongated leaves are thinner and higher in tissue moisture contents(Gawronska et al., 1995; Tan and Qian, 2000). Photosynthesis decreased with shade resulting in decreased carbohydrate reserves and reduced growth in root, rhizome, and tiller. The overall result is thin, poor quality turf that will not stand up to traffic and other stress.

Trinexapac-ethyl is a plant growth regulator that reduces leaf elongation by direct inhibition of producing of GA(Adams et al., 1992; Ervin and Koski, 1998; Fagemess and Penner, 1998; Johnson, 1993, 1994; Wiecko, 1997). A 4-year test at a live oak [*Quercus virginiana*(Mill.)] site in Texas providing up to 90% shade indicated that *Z. matrella* genotypes maintained 52% to 75% cover, while the commercial standard(*Z. japonica* 'Meyer') maintained only 27% cover(Riffell et al., 1995). Given this information, our hypothesis was that TE by inhibiting shade-induced GA production and unneeded leaf

growth, will conserve photosynthate and result in increased shade tolerance.

This research was initiated to determine whether or not applications of TE to zoysiagrass experimental fairway will enhance quality under two levels of shade.

MATERIALS AND METHODS

This study was conducted on a mature 'Meyer' zoysiagrass experimental fairway. It was maintained at 16 mm and irrigated once a week to replace 100% of evapotranspiration. Uniform applications of N at 49 kg · ha^{-1}(urea) were applied in August, 1998 and in May, 1999.

The study consisted of two factors and four replications arranged in randomized complete block designs. The two factors were: light level and trinexapac-ethyl application. There were three levels of light: full sun, 79% shade cloth, and 92% shade cloth. Such dense levels in shade are common in nature. Each shade structure covered a plot area of 3.25 m^2. Each plot was separated from its neighbor by 1.52 m borders to the east and west and 0.91 m borders on the north and south.

Shade and TE treatments began on 14 August, 1998. Three rates of TE consisting of 0, 48 g · ha^{-1} a.i(0.5x-rate) and 96 g · ha^{-1} a.i(1x-rate) were applied on 14 August and 13 September, 1998. Shade structures were removed after leaf fall and put back in May, 1999 when monthly TE treatments were resumed on May 28, 1999. Weekly golf cart traffic pressure(10 passes/plot) was initiated in June and continued during the study.

Data include weekly clipping yield(%), tiller density and visual turf quality. To determine clipping yield, a 0.6-m^2 swath was cut weekly with a standard reel-type greens-mower at 16 mm, clippings were collected, dried for 24h at 70°C, and weighed. Weekly clipping data are presented, in g · m^{-2}, as the deviation from that of the full sun control. Visual turf quality was assessed monthly on a 1(poorest) to 9(best) scale in which ratings of less than 6 were unacceptable. Tiller number was determined after removing two cores per plot with a core sampler(70 mm in diam.) on 17 Aug., 1998, 2 June, and 9 Aug., 1999. Cores were cut along the soil/thatch interface and tiller numbers were counted.

Analysis of variance was conducted on clipping dry weight, tiller number and turf quality data for this standard 3 x 3 factorial with the Michigan State Statistical Program v. 2.10(MSTAT-C, 1993). Treatment means were separated using Fisher's protected least significant difference(LSD).

RESULTS AND DISCUSSION

Average irradiance levels were in full sun and under both 79% and 92% shade from 11 AM to 2 PM on a cloud free day(14 June, 1999). They were 1,665 μmol m^{-2} s^{-1}(0% shade), 351 μmol m^{-2} s^{-1}(79% shade), and 130 μmol m^{-2} s^{-1}(92% shade).

Clipping yield demonstrated three predictable responses of zoysiagrass to TE, shade, and their combination. First, TE did reduce vertical shoot growth. In full sun with the 96 g · ha^{-1} a.i of TE reduced clipping yield by 30 to 40% over each four week application cycle, while the 48 g · ha^{-1} a.i reduced clipping yield by only about 1 to 18%(Table 1). Second, shade increased vertical shoot growth probably due to increased GA biosynthesis induced by the reduced light conditions. The 79% and 92% shade treatments without TE had increased clipping yield relative to the untreated full sun plots(8 to 54%). Third, TE's inhibition of GA production functioned to overcome or counteract most shade-induced increases in vertical shoot growth.

Table 1. Clipping yield of 'Mayer' zoysiagrass affected by shade and trinexapac-ethyl.

Treatments[z]	Clipping yields(%)[y]		
	1998		1999
	14 Aug to 13 Sept.	13 Sept to 11 Oct.	28 May to 25 June
Full sun + no TE(Control)	0	0	0
0% Shade + 0.5x TE	-17	-18	-1
0% Shade + 1x TE	-38	-36	-30
79% Shade + no TE	+42	+18	+20
79% Shade + 0.5x TE	+10	-13	+5
79% Shade + 1x TE	-9	-31	0
92% Shade + no TE	+54	+8	+8
92% Shade + 0.5x TE	-4	-15	+23
92% Shade + 1x TE	-11	-16	-16

[z]TE: Trinexapac-ethyl, 0.5x: TE at 48 g · ha^{-1} a.i, 1x: TE at 96 g · ha^{-1} a.i
[y]Clipping yields: percentage above or below the control averaged over 4 weeks

Clipping yield in shaded plots with TE was either just slightly above or below that of the full-sun untreated control. Such a response of TE-treated zoysiagrass in the shade implies most likely a conservation of energy compared with the shaded zoysiagrass without TE. The 96 g · ha^{-1} a.i of TE gave the most consistent reduction of shoot growth at both levels in shade. This rate was also most effective during periods of vigorous zoysiagrass growth(Aug. to Sept., 1998 and June, 1999).

Prior to shade and TE treatment initiated on 17 Aug., 1998, there were no tiller density differences among the plots(Table 2). Also at the beginning of the shade and TE treatments on 2 June, 1999, there was also no tiller density difference. However,

Table 2. Tiller density of 'Mayer' zoysiagrass affected by shade and trinexapac-ethyl.

Treatments[z]	Tiller density(no. dm^{-2})		
	1998	1999	
	17 Aug.	02 June	09 Aug.
Full sun + no TE(Control)	204.8	227.6	301.0b
0% Shade + 0.5x TE	222.5	256.4	270.3b
0% Shade + 1x TE	244.0	232.8	338.0a
79% Shade + no TE	251.6	231.4	45.4d
79% Shade + 0.5x TE	231.4	203.4	63.3cd
79% Shade +1x TE	211.3	207.9	89.3c
92% Shade + no TE	241.1	222.0	3.3e
92% Shade + 0.5x TE	232.9	249.6	9.3e
92% Shade + 1x TE	231.8	199.8	30.6de
LSD(0.05)	NSy	NS	36.1

[z]TE: Trinexapac-ethyl, 0.5x: TE at 48 g · ha^{-1} a.i, 1x: TE at 96 g · ha^{-1} a.i
[y]NS: *Nonsignificant*

following two months of treatments, greater differences were observed with the 96 g · ha^{-1} a.i of TE treatments providing the greatest maintenance of tiller density.

Energy conservation in the shade due to TE should result in the retention of higher quality(or a slower loss in quality)when compared with the shaded zoysiagrass without TE application in study. Preliminary quality ratings in Table 3 indicated that this is, in fact, the case. They also indicated that the 96 g · ha^{-1} a.i of TE provided the best quality under both levels of shade. By 18 July in 1999, zoysiagrass thinning under 92 percent was severe with almost no grass left on plots untreated with TE and those that only receive the 48 g · ha^{-1} a.i each month. At the end of the trial(29 September, 1999), turfgrass quality was not significant in the unshaded plots, while the 96 g · ha^{-1} a.i of TE under 79% shade had resulted in the greatest maintenance of

Table 3. Visual quality of 'Mayer' zoysiagrass affected by shade and trinexapac-ethyl.

Treatments[z]	Quality rating(1-9, 9=best)			
	1998	1999		
	09 Oct.	18 June	18 July	29 Sept.
Full sun + no TE(Control)	7.5a	6.9a	6.0a	6.9a
0% Shade + 0.5x TE	7.5a	6.9a	5.6a	7.0a
0% Shade + 1x TE	7.4a	6.8a	6.3a	6.9a
79% Shade + no TE	5.1de	4.9c	3.3c	2.3c
79% Shade + 0.5x TE	6.3bc	5.1bc	3.4c	3.9b
79% Shade + 1x TE	6.5b	5.8b	4.5b	4.0b
92% Shade + no TE	4.3e	4.5c	1.6e	1.0d
92% Shade + 0.5x TE	5.6cd	5.0bc	1.9de	1.3cd
92% Shade + 1x TE	6.4b	5.3bc	2.5d	1.6cd
LSD(0.05)	0.8	0.8	0.6	1.1

[z]TE: Trinexapac-ethyl, 0.5x: TE at 48 g · ha^{-1} a.i, 1x: TE at 96 g · ha^{-1} a.i

quality when compared to all other shaded plots.

This study has shown that greater zoysiagrass quality and density can be maintained under dense shade with monthly applications of TE at 96 g · ha^{-1} a.i. It must be stressed that this is a preventive treatment. TE will not necessarily help to fill-in zoysiagrass that has already been thinned by shade and traffic, but it will slow down the thinning process. Depending on the level of shade and the amount of traffic, TE's effects may enable a fairway or tee area to remain playable for another season or indefinitely. Superintendents may wish to experiment with more frequent applications of the same or lower rates tested in this study.

국문요약

'Meyer' zoysiagrass(*Zoysia japonica* Steud.)는 일반적으로 미국 중부지역에서 골프장 페어웨이 또는 티에 일반적으로 많이 쓰이는 잔디로 적은 시비와 관수와 함께 좋은 플레이를 제공한다. 하지만 그늘 지역에서의 생육이 저하되어 품질을 떨어뜨린다. 감소되어진 광량은 잔디 잎의 웃자람을 일으키며 밀도가 저하되고 약한 잔디 생육과 함께 답압이나 디보트에 따른 재생을 저하시킨다.

이 실험의 목적은 TE의 처리가 그늘 지역에서의 잔디의 웃자람을 억제하고 품질을 향상 시키는가를 알아보기 위함에 있다. 이 실험에서 두 가지 처리는 차광 조건(0%, 79%, 92% 차광막) 과 TE [0, 48(0.5x), 96g · ha^{-1} a.i(1x)]로 적용하였다. 무 차광 처리 시, 0.5x-비율로 TE 처리에서 4 주후 무 처리구에 비해 18%의 잔디 예초물의 감소를 보였고 1x-비율의 TE 처리는 30~38%의 예초물 감소를 보였다. 매달 1x-비율의 TE 처리 시 무 차광 처리와 79% 차광에서 zosiagrass의 밀도를 증가 시켰다. 무 처리에 비해 두 TE 비율의 처리가 잔디의 웃자람을 감소시켰으며 1x-비율로 TE 처리 시 79% 차광에서 잔디 품질이 저하되는 것이 지연되었다. 이 실험에서 그늘진 지역에서의 TE 처리가 zoysiagrass 의 웃자람을 줄이고 잔디 품질을 향상 시킨다는 것을 알 수 있었다.

주요어 : 밀도, 분얼경, 예지물, 차광, trinexapac-ethyl(TE), 한국잔디

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