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Flurprimidol, Paclobutrazol, and Trinexapac-ethyl Increased Lateral Development of 'Zenith' Zoysiagrass in a Shade Environment

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ABSTRACT. This study was conducted to examine the effects of plant growth regulators (PGRs) on the lateral stem growth, and the change of total nonstructural carbohydrate (TNC) status of 'Zenith' zoysiagrass under shaded conditions. Well-established turf was subjected to a full sun, 47%, and 77% shade in a field study. Three different rates of flurprimidol (FP: 0.2, 0.4, and 0.8 kg·ha^{-1}), paclobutrazol (PB: 0.16, 0.32, and 0.64 kg·ha^{-1}), and trinexapac-ethyl (TE: 0.04, 0.08, and 0.16 kg·ha^{-1}) were applied. Lateral development of 'Zenith' zoysiagrass decreased with increasing shade levels. However, compared with control plots, total stolon length and stolon number increased two fold at 0.2, 0.4 kg·ha^{-1} FP, and 0.16 kg·ha^{-1} PB under full sun. Under 77% shading, stolon number increased by 170% and total stolon length increased by 140% at 0.8 kg·ha^{-1} FP. Tiller number increased by 40% at 0.08 kg·ha^{-1} TE under full sun, and by 72% at 0.16 kg·ha^{-1} TE under 77% shading. The TNC contents of turfgrass treated with 0.8 kg·ha^{-1} FP and 0.16 kg·ha^{-1} TE increased by 50% as compared with control. Remarkably, nonstructural carbohydrates (NC) partitioning was enhanced by PGRs from leaf tissue to lateral stem tissue, which increased lateral development and may have contributed to recuperative rate. These results suggested that treatments of proper rate of PGRs could enhance the recuperative rate of 'Zenith' zoysiagrass by increasing lateral stem growth especially in shaded conditions.

***Key words*:** Flurprimidol, Paclobutrazol, Stolon, Total nonstructural carbohydrate (TNC), Trinexapac-ethyl.

Introduction

Zoysiagrass (*Zoysia japonica* Steud.) is a major warm-season turfgrass for golf course tees and fairways in Asia because of its dense sod, tolerance to - environmental stresses, low mowing heights, and traffic tolerance. However, since zoysiagrass showed a slow recovering characteristics from damage and zoysiagrass is not very shade tolerant., it is normally not used in highly trafficked football or soccer fields. Too often, the effects of traffic and shade reduce zoysiagrass quality to the point where it must be resodded or replaced entirely with a more shade-tolerant species that lacks the advantages of the zoysiagrass.

Flurprimidol (FP), paclobutrazol (PB), and trinexapac-ethyl (TE) are commonly used antigibberellic acid type plant growth regulators (PGRs) that may be used for zoysiagrass management. Turf quality has been shown to decline more slowly in PGR treated turfgrass (Qian and Engelke, 1999). However, in 'Diamond' zoysiagrass, TE treatment improved turfgrass quality under 75% and 88% shade levels, where conditions favored higher vertical growth rates, but not under 40% shade, where conditions favored slow vertical growth (Qian et al., 1998). Stier and Rogers (1996) reported that TE enhanced the turfgrass quality of tall fescue under 75% to 95% shade. Turfgrass quality increased as shoot growth resumed following PGR-induced growth suppression (Green et al., 1990)

Shade increases vertical shoot growth probably due to increased GA biosynthesis induced by the reduced light conditions. Shade levels of 86% decreased total nonstructural carbohydrate (TNC) levels of 'Diamond' zoysiagrass by 85%, which led to decreased turf density and stand persistence (Qian and Engelke, 1997). At all levels of shade, TE application reduced the canopy height of 'Diamond' zoysiagrass (Qian and Engelke, 1999). Shade treatments without TE had increased clipping yield of 'Meyer' zoysiagrass relative to the untreated full sun plot (Ok, 2006).

Increasing tiller number also has been reported in other grasses treated with gibberellin-inhibiting PGR's (Dernoeden, 1984; Watschke et al., 1992). FP treatments increased tillering but did not affect root growth of Kentucky bluegrass (Stier et al., 1999). 'Diamond' zoysiagrass in the control treatment exhibited a gradual decline in tiller number at 5 to 15 weeks after shading in the greenhouse. Grasses receiving monthly and bimonthly TE treatments had 27% more tillers than grasses in the control at 20 weeks after the initial treatment (Qian and Engelke, 1999). Tiller density of 'Meyer' zoysiagrass increased by TE treatments during 67day under 79% shading (Ok, 2006).

Rhizome production per unit of turfgrass area declined linearly with shading in 'Diamond' zoysiagrass. Treatment with TE increased rhizome mass, and the effect became more significant as light level decreased (Qian et al., 1998).

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While the effects of these compounds in biomass production and turfgrass quality have been investigated, little is known about their impact on lateral development of creeping species such as zoysiagrass.

Grasses generally accumulate assimilated carbohydrates in the lower stems and crowns. Starch and sucrose were the primary nonstructural carbohydrates extracted from 'Floratam' St. Augustinegrass stolons. Fructose and glucose were also present in significantly lower concentrations than starch and sucrose (Fry et al., 1991). Levels of TNC in grasses could be affected by PGRs (Cooper et al., 1988; Watschke, 1976). TE, FP, and PB increased the TNC content of creeping bentgrass at 2 weeks after their initial application, but TNC levels began to decrease at week 4 (Han et al., 1998).

The objective of this study was to determine the effects of PGRs on growth of lateral stems in 'Zenith' zoysiagrass as associated with shading.

Materials and Methods

The experiment was conducted in a field plot at the Crop Experiment Farm in the College of Agriculture and Life Science, Seoul National University in Suwon, Korea. Sprigs of 'Zenith' zoysiagrass were harvested in May 2002 from the nursery. The sprigs were washed and planted to plastic pots (20 cm diam. 20 cm deep), and then placed in the filed. Pots were filled with a sand/peat mix (50:50, v/v). For the determination of TNC, additional pots were established by filling plastic boxes (60 cm length×40 cm width×20 cm depth) with a sand/peat (50:50, v/v). The pots for TNC determination were seeded on 8 May 2001 with 'Zenith' zoysiagrass. A water-soluble fertilizer (N-P-K ; 6.5-4.5-49) was applied monthly at 20 kg·ha^{-1}. Plots were hand-mowed at a 3.5-cm height once to twice weekly and watered as necessary to prevent moisture stress. The main factors in the study were light level and PGRs with three replications arranged in a completely randomized block design.

Shading was imposed on 14 Aug. 2002, and maintained during the study period until 7 Oct. 2002. Three metal frame structures (120×240×80 cm height) were constructed, and two kinds of shade cloth covers that provided light-filtering of 47% and 77% were mounted on the frames at 20 cm above the turf canopy. The shade cloth was draped on all sides to prevent the effect of incline light. Light intensity was quantified in several cloud-free days by measuring irradiance under the shade of the structures with a lux meter (TES 1332, TES, Taiwan), and expressed as percentage with relative value to outside light level.

PGRs were applied on 26 Aug. 2002, at three different rates. Flurprimidol was applied at low rate (0.20 kg a.i. ha^{-1}; LFP), medium rate (0.40 kg a.i. ha^{-1}; MFP), and high rate (0.80 kg a.i. ha^{-1}; HFP). Paclobutrazol was applied at low rate (0.16 kg a.i. ha^{-1}; LPB), medium rate (0.32 kg a.i. ha^{-1}; MPB), and high rate (0.64 kg a.i. ha^{-1}; HPB). Trinexapac-ethyl was applied at low rate (0.04 kg a.i. ha^{-1}; LTE), medium rate (0.08 kg a.i. ha^{-1}; MTE), and high rate (0.16 kg a.i. ha^{-1}; HTE). After mowing to make every pot uniform, PGRs were treated with a hand sprayer, which delivered 600 L·ha^{-1}.

Clipping yield was measured at 9, 22, and 42 days after the initial treatment, whereas stolon number, stolon length, tiller number, node number, and internode length were measured at harvest. Fresh weight was measured for clipping yield. Stolon number and tiller number were counted and stolon length was measured at the end of experiments. Node number and internode length were also measured.

TNC content was determined using a 10.16 cm core from each pot 45 days after the initial treatments. Samples were washed and freeze-dried. Tissue was divided into three 100 mg replicates before analysis and ground to fine powder, weighed and nonstructural carbohydrates were extracted in 80% ethanol. Concentrations of fructose, glucose, and sucrose were determined using high performance liquid chromatography (HPLC) method described by Robbins and Pharr (1988) with minor modification that included 75% acetonitrile at a flow rate of 1.0 mL·min^{-1} as the solvent. Sugars were identified and quantified using a Zorbax NH_2 column.

Data on clipping yield, tiller number, stolon number, stolon length, and TNC were analyzed using the GLM procedure, and treatment means were separated using Duncan's Multiple Range test as appropriate (SAS Institute, 1999). Linear regression analysis was performed to determine the relationship between the measured parameters and level of shade or rate of PGRs, where shade level and rate of PGRs were the independent variables and each measured parameter was the dependent variable.

Results and Discussion

Clipping Yield

In agreement with a previous study (Qian et al., 1998), the effectiveness of PGRs in reducing clipping yields generally increased with increasing shade level (Table 1). Under full sun, significant difference was not shown in clipping yields by PGRs at 22 days after initial treatments (DAT). Under 47% shaded condition, turf treated with 0.40 kg a.i. ha^{-1} FP (MFP) and all rates of TE exhibited lower clipping yields than that of the control. Turf receiving all rates of FP, TE and 0.64 kg a.i. ha^{-1} PB (HPB) had lower clipping yields than the control at 77% shading. At 42DAT, most PGR treatments markedly decreased clipping yields under all

Table 1. Effects of PGRs on clipping yields of 'Zenith' zoysiagrass under various shade levels in the field.

Treatment		9 DAT[x]			22 DAT			42 DAT		
PGR	Appl. Rate ($kg \cdot ha^{-1}$)	% shade			% shade			% shade		
		0	47	77	0	47	77	0	47	77
Flurprimidol	0.20	2.95 a[y]	3.19 b	3.65 abc	2.36 a	1.61 ab	0.79 bcd	2.04 a	1.44 b	1.30 ab
	0.40	3.14 a	2.52 b	4.82 a	1.37 ab	0.99 bc	0.73 bcd	1.04 bc	1.41 b	0.97 bc
	0.80	2.40 ab	4.26 ab	3.56 abc	1.31 ab	1.17 abc	0.62 cd	1.12 bc	1.19 bcd	0.77 cd
Paclobutrazol	0.16	3.12 a	3.55 ab	4.56 ab	1.67 ab	1.56 ab	1.10 abc	1.46 ab	1.72 b	1.20 ab
	0.32	2.60 ab	5.52 a	4.08 ab	1.72 ab	1.35 abc	1.41 ab	1.11 bc	1.48 b	1.07 abc
	0.64	3.32 a	3.18 b	4.47 ab	1.47 ab	1.25 abc	0.82 bcd	1.12 bc	1.35 bc	1.12 abc
Trinexapac-ethyl	0.04	2.36 ab	3.13 b	3.79 abc	0.76 b	0.90 bc	0.40 cd	0.43 cd	0.87 cde	0.79 cd
	0.08	1.27 b	3.42 ab	3.21 bc	1.21 ab	0.64 c	0.31 d	0.30 d	0.69 de	0.47 de
	0.16	2.28 ab	2.77 b	2.55 c	0.65 b	0.65 c	0.40 cd	0.25 d	0.40 e	0.39 e
Control	---	2.56 ab	4.20 ab	5.10 a	1.65 ab	2.01 a	1.70 a	1.98 a	2.23 a	1.36 a
F-test		NS	NS	*	NS	*	**	***	****	****

NS, *, **, ***, **** Non-significant or Significant at 0.05, 0.01, 0.001 and 0.0001 probability levels, respectively.
[x] DAT: days after the initial treatments.
[y] Mean separation within columns by Duncan's multiple range test, 5% level.

shading condition. In addition, among the PGR treatments, TE reduced clipping yields most effectively. Under 47% shade, especially, compared with the control, 0.04 kg a.i. ha^{-1} TE (LTE), 0.08 kg a.i. ha^{-1} TE (MTE), and 0.16 kg a.i. ha^{-1} TE (HTE) resulted in a reduction of clipping yields by 69, 70, and 82%, respectively. However, 0.20 kg a.i. ha^{-1} FP (LFP) and all rates of PB increased clipping yields more than control treatment 9d after the initial treatment in natural sunlight condition. The reason for this difference in clipping yields was assumed that vertical shoot growth suppression of zoysiagrass varied with growth regulator and its rate, especially 1 week after treatment (Kim and Kim, 1999). Stier et al. (1999) reported that all rates of FP significantly reduced clipping yields beginning 3 to 4 weeks after the initial treatment.

Stolon length and Stolon number

Total stolon length and stolon number generally decreased with increasing shade level, whereas increased at low rate of PGR treatment under full sun (Table 2).

Under full sun, turfgrass treated with LFP, MFP and LPB had higher total stolon length than those of other treatments. Moreover, MFP treatment under 47% shading and HFP under 77% shading exhibited higher effect on extending total stolon length. However, Fagerness and Yelverton (1999) proposed that stolon length was reduced by paclobutrazol (0.56 kg a.i. ha^{-1}), and trinexapac-ethyl (0.11 kg a.i. ha^{-1}) had little effect on stolon length of 'Tifway' bermudagrass.

Under full sun, stolon number of turfgrass treated with PGRs increased with decreasing PGRs rate. Especially 0.16 kg a.i. ha^{-1} PB (LPB) significantly more increased stolon number than 0.32 kg a.i. ha^{-1} PB (MPB) by 190% and 90%, respectively. The MTE and 0.80 kg a.i. ha^{-1} FP (HFP) significantly increased stolon number by 230% and 170% in 47% and 77% shade, respectively. In case of 'Tifway' bermudagrass (Fagerness and Yelverton, 1999), three rates of paclobutrazol applications resulted in the increases in stolon counts by 60% at 7 wk after the initial treatment, but these stolon count increasing declined rapidly beyond 7 wk after the initial treatment.

Tiller number

Tiller number of turfgrass treated with PGRs typically increased, while that of the control became visually deteriorated with increasing shade level. The MTE increased tiller number by 42% than that of the control under full sun, and under 77% shading HTE increased it by 72% than the control (Table 3). However, tiller number was not statistically different among PGR treatments under 47% shade levels. Increasing tiller number has been reported for other turfgrasses when treated with antigibberellin PGRs (Dernoeden, 1984; Watschke et al., 1992). In Kentucky bluegrass, FP treatments increased tillering but did not affect root growth (Stier et al., 1999). The improvement of turfgrass quality under 75% and 88% shade by repeated TE applications was due mainly to a darker green color and

Table 2. Effects of PGRs on total stolon length, stolon number, and mean stolon length of 'Zenith' zoysiagrass under various shade levels in the field at 42 days after initial treatment.

Treatment		Total stolon length (cm)			Stolon number (ea)			Mean stolon length (mm)		
PGR	Appl. Rate (kg·ha^{-1})	% shade			% shade			% shade		
		0	47	77	0	47	77	0	47	77
Flurprimidol	0.20	293.9a[x]	149.4ab	68.3abc	39.0ab	20.5ab	9.0cd	75.0a	74.0ab	71.3ab
	0.40	266.5a	204.0a	89.0abc	36.5ab	25.0ab	10.0cd	77.0a	82.0a	72.0ab
	0.80	132.5b	72.9b	104.8a	19.0c	12.0b	19.0a	74.0a	63.5ab	64.0ab
Paclo-butrazol	0.16	274.5a	119.9ab	53.0bc	43.0a	16.5b	6.0d	65.0a	75.0ab	82.7a
	0.32	148.0b	73.3b	64.9abc	28.0bc	12.5b	11.0bcd	52.0a	55.0b	67.3ab
	0.64	100.0b	157.2ab	55.0bc	18.5c	24.5ab	10.0cd	53.5a	64.0ab	51.0ab
Trinexapac-ethyl	0.04	125.5b	141.6ab	95.9ab	28.0bc	27.0ab	15.0abc	44.5a	52.0b	59.0ab
	0.08	134.9b	183.8ab	50.9bc	26.0bc	36.5a	10.5bcd	55.0a	50.0b	50.7ab
	0.16	105.6b	152.4ab	68.0abc	19.0c	24.5ab	18.0ab	58.5a	61.0ab	42.7b
Control	---	98.9b	78.4b	43.1c	15.0c	11.0b	7.0d	69.0a	74.0ab	53.3ab
F-test		**	NS	**	*	NS	***	NS	NS	NS

NS, *, **, *** Non-significant or Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.
Determined at 42 DAT. DAT days after the initial treatments.
[x] Mean separation within columns by Duncan's multiple range test, 5% level.

increased tiller density (Qian et al., 1998). At 67days after initial treatments, greater differences were observed with the 96 g a.i. ha^{-1} TE providing the greatest maintenance of tiller density of 'Meyer' zoysiagrass (Ok, 2006).

Although the statistically significanct difference was not found, tiller number was maintained even higher than that of non-treated control under full sun, when turfgrass was treated with MFP, 0.32 kg a.i. ha^{-1} PB (MPB), and HTE under 47% shade levels. These suggested that PGRs could be used for maintaining tiller number under shade environment. Especially, under 77% shading, MPB and HTE treatment could be very useful to maintain acceptable quality. Stier and Rogers (1996) reported that TE enhanced the turfgrass quality of tall fescue under 75% to 95% shade. In addition, Stier et al. (1999) reported that FP maintained turfgrass quality of Kentucky bluegrass under reduced irradiance. Ok (2006) also showed that the 96 g a.i. ha^{-1} TE under 79% shade had resulted in the greatest maintenance of quality when compared to all other shaded 'Meyer' zoysiagrass.

Node Number and Internode Length

Node number of 'Zenith' zoysiagrass was significantly increased by most PGR treatments under full sun and 47% shading condition (Table 3). Under 47% shading, turfgrass with MTE showed node number three-fold as many as that of control plot. Internode length was decreased by MTE and HTE under 47% shading condition. Data showed that all TE treatments decreased internode length under full sun. It was proposed that FP and PB are favored to use on low density turfgrass, while TE is favored to use on dense turfgrass.

TNC Contents Status

TNC contents was measured with turfgrass treated with high rates of PGRs at 42 DAT. HPB and HTE treatments markedly increased TNC contents of whole plant compared to untreated turf (Fig. 1). This result is contrary to earlier study, in which single applications of FP at 0.56 kg a.i. ha^{-1}, PB at 0.28 kg a.i. ha^{-1} significantly reduced verdure TNC content of creeping bentgrass at 6 weeks after application, whereas TE at 0.28 kg a.i. ha^{-1} did not (Han et al., 1998). In addition, TNC content of the each organ varied remarkably by PGRs treatments (Fig. 1). The TNC content of the leaf treated with PGRs decreased, whereas TNC content of lateral stem and root increased unusually at harvest by PGRs. While control plot had 11% TNC of whole plant in lateral stem, HPB treatment plot had 26% TNC and HTE treatment plot had as many as 50% TNC. Qian and Engelke (1999) reported that Trinexapac-ethyl treatments significantly increased the TNC in rhizome + root tissue. 'Tifway' bermudagrass (*Cynodin dactylon*×*C. tranvaalensis*) at 2 and 6 wk after application of TE at 0.015 kg a.i. ha^{-1} showed increased TNC in root tissue (Waltz et al., 1996).

In terms of lateral stem, TNC contents increased double with HFP, two and a half-fold with HPB, and four-fold with HTE compared with the control. The rhizome is the major

Table 3. Effects of PGRs on tiller number, node number, and internode length of zoysiagrass under various shade levels in the field at 42 days after initial treatment.

Treatment		Tiller number (ea·dm^{-2})			Node number (ea)			Internode length (mm)		
PGR	Appl. Rate (kg·ha^{-1})	% shade			% shade			% shade		
		0	47	77	0	47	77	0	47	77
Flurprimidol	0.20	186.8ab^{x}	167.3a	104.0cd	179.0ab	102.0bc	37.3a	16.3a	15.2ab	17.0ab
	0.40	191.2ab	179.1a	116.7cd	191.5a	129.0ab	36.3a	13.8ab	15.9ab	18.1ab
	0.80	216.1ab	153.6a	106.1cd	112.0cde	53.0c	52.3a	11.7ab	13.7bc	15.1abc
Paclo-butrazol	0.16	208.0ab	150.3a	128.9abcd	198.5a	70.5bc	28.0a	13.8ab	17.0a	15.9ab
	0.32	166.8b	177.2a	157.3ab	119.5cd	56.0c	32.0a	12.2ab	12.4cd	19.8a
	0.64	207.0ab	134.9a	118.8bcd	76.5de	113.0abc	29.7a	12.9ab	13.9bc	16.6ab
Trinexapac -ethyl	0.04	198.4ab	147.5a	134.2abcd	141.5bc	115.5abc	52.0a	8.8b	12.2cd	14.6bc
	0.08	226.9a	139.0a	142.8abc	140.0bc	188.5a	30.7a	9.9b	9.8d	13.1bc
	0.16	216.1ab	168.0a	166.6a	125.0c	147.0ab	52.3a	8.3b	10.3d	10.9c
Control	---	160.3b	158.6a	96.9d	73.5e	48.0c	20.7a	13.3ab	16.3ab	16.1ab
F-test		*	NS	***	***	**	NS	NS	***	*

NS, *, **, *** Non-significant or Significant at the 0.05, 0.01 and 0.001 probability levels, respectively.
[x] Mean separation within parameters and columns by Duncan's multiple range test, 5% level.

organ for carbohydrate storage in rhizomatous grasses (White, 1973). Decreased shoot growth may also partially account for the carbohydrate buildup in TE treated turf (Brown and Blaser, 1965). However, 'Majestic' Kentucky bluegrass (*Poa prantesis* L.) exhibited a reduced photosynthate partitioning to roots 4 wk after the application of paclobutrazol, and flurprimidol (Hanson and Branham, 1987). Decreased shoot growth and increased lateral stem suggested that TE decreased the sink strength of the shoot and shifted limited assimilates to the lateral stem system. We supposed that the higher TNC of lateral stem in turf treated with PGRs may enhance lateral stem growth of 'Zenith' zoysiagrass under shade environment. Qian et al (1998) also stated that the higher rhizome mass and higher TNC of rhizome in TE treated turfgrass gave 'Diamond' zoysiagrass the advantages for better survival and recovery under heavy shade.

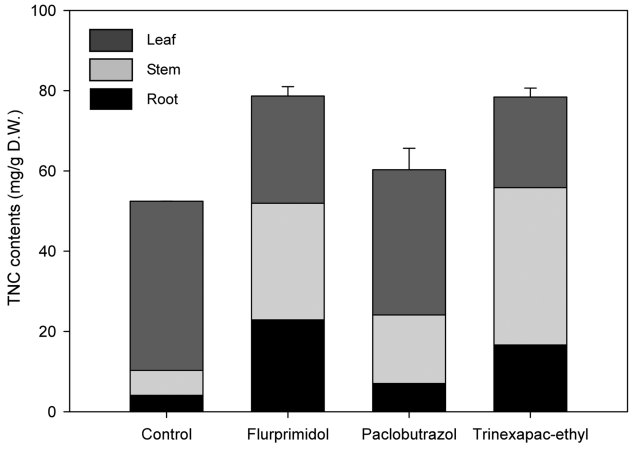

Fig. 1. Total nonstructural carbohydrate (TNC) distribution of 'Zenith' zoysiagrass treated with 0.8 kg a.i. ha-1 flurprimidol, 0.64 kg a.i. ha-1 paclobutrazol and 0.16 kg a.i. ha-1 trinexapac-ethyl under full sun in the field.

Conclusions

Shading caused by shelter of stadium or building results in excessive shoot elongation and decrease tiller number of 'Zenith' zoysiagrass, which make the maintenance of high quality turfgrass in the shade difficult. As we have shown, anti-gibberellin PGRs treatments could not only decrease clipping yields, but also enhance lateral stem growth, and increase tiller number under shade conditions. In particular, under 47% shading, 0.40 kg a.i. ha^{-1} FP and 0.08 kg a.i. ha^{-1} TE could effectively improve lateral stem growth of 'Zenith' zoysiagrass compared with untreated turf. Under full sun, 0.20, 0.40 kg a.i. ha^{-1} FP and 0.16 kg a.i. ha^{-1} PB treatment increased stolon growth compare to the control. The TNC content of turf treated with 0.64 kg·ha^{-1} PB and 0.16 kg·ha^{-1} TE increased by 22% and by 39%, respectively, as compared with control. PGR treatments changed nonstructural carbohydrates partitioning from leaf tissue to

lateral stem tissue, which increased lateral development.

Under 47% shading, 0.40 kg a.i. ha^{-1} FP and 0.08 kg a.i. ha^{-1} TE could contribute to the improvement of the recuperative rate of zoysiagrass with the increase in lateral stem growth such as stolon length and number, and tiller number. In addition, 0.80 kg a.i. ha^{-1} FP in 77% shade and 0.16 kg a.i. ha^{-1} PB in full sun could increase stolon length and number. However, it should be noted that these experiments were conducted when weather conditions favored slow growth. Further study should be undertaken to determine seasonal difference by PGR treatments when environmental conditions favored rapid growth.

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그늘조건에서 Flurprimidol, paclobutrazol, and trinexapac-ethyl 이 한국잔디 ‘Zenith’ 의 수평생장 증가에 미치는 영향

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요 약: 이번 실험은 차광조건하에서 생장조절제들이 한국잔디 ‘제니스’의 수평생장에 미치는 영향에 대하여 알아보기 위하여 수행하였다. 실험포지 잔디를 무차광, 47%와 77%의 차광조건 하에 flurprimidol(FP), paclobutrazol(PB), trinexapac-ethyl(TE) 세가지의 생장조절제를 각각 0.2, 0.4, and 0.8 kg·ha^{-1} FP, 0.16, 0.32, and 0.64 kg·ha^{-1} PB, 그리고 0.04, 0.08, and 0.16 kg·ha^{-1} (TE)씩 처리하였다. 한국잔디 ‘제니스’의 수평생장은 차광정도가 증가함에 따라 감소하였다. 무차광조건에서 0.2, 0.4 kg·ha^{-1} FP, and 0.16 kg·ha^{-1} PB를 처리한 결과 포복경의 전체 길이와 수가 대조구에 비하여 2배 정도 증가하였다. 77% 차광조건에서는 0.8 kg·ha^{-1} FP를 처리하였을 경우 포복경의 수는 170%, 전체 포복경의 길이는 140%증가하였다. 분얼경수는 무차광조건에서는 0.08 kg·ha^{-1} TE를, 77% 차광조건에서는 0.16 kg·ha^{-1} TE를 처리하였을 경우 각각 40%, 72%의 증가를 보였다. 전체 당함량은 0.8 kg·ha^{-1} FP와 0.16 kg·ha^{-1} TE 처리구에서 대조구 대비 약 50%의 증가를 보였으며, 특이한 것은 비구조성 탄수화물이 잔디의 잎에서 기는 줄기로 이동하는 것으로 나타나, 이는 한국잔디의 수평생장을 증가시켜 회복속도를 높이는데 도움이 될 것으로 판단된다. 이상의 결과를 통하여 그늘상태에서의 한국잔디의 도장과 줄기밀도의 감소를 방지시키고, 또한 포복경의 발달을 촉진시켜 회복력을 높이기 위하여 생장조절제의 처리가 매우 효과적인 것인 것으로 판단되었다.

주요어: trinexapac-ethyl, flurprimidol, paclobutrazol, 포복경, 전체 비구조적 탄수화물 총량 (TNC)