韓國잔디와 Zoysia-82의 Sprigging에 對한 灌水의 影響

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Influence of Irrigation Frequency on Sprigging of Korean Lawngrass and Zoysia-82

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摘 要

4 가지의 灌水處理回數가 韓國잔디와 zoysia-82에 미치는 影響을 調査한 結果는 다음과 같다.

1. 韓國잔디가 各 灌水處理마다 zoysia-82보다 葉長은 길고 葉幅은 넓은 편이었다.

2. Runner의 生長은 zoysia-82가 旺盛했으며, 두 品種 共히 每日 1回 灌水, 對比區(自然狀態), 5日, 10日 마다 1回 灌水區 順으로 runner의 길이가 길고 1日 生長量도 많았다.

3. 移植時 單位 sprig當 各 部位別 乾物重은 韓國잔디가 더 무거웠으나 生育을 거듭할수록 zoysia-82가 더 무거웠고, 1日 乾物重 增加量도 zoysia-82가 더 많았다.

4. 地表面 被覆率은 各 灌水處理別 zoysia-82가 韓國잔디보다 빨랐다. 두 品種 共히 每日 灌水區 가장 빨랐고, 對比區, 5日, 10日 마다 1回 灌水區 順으로 빨랐다.

I. Introduction

Turfs were developed by mordern man in order to enhance his environment. The more technologically advanced the civilization, the more widely turfs are used.

The concept of turf as we know it today had its origin when man started to domesticate animals. In the period of recorded history numerous references to grass(turf) are to be found in the Bible[2].

The first research in America appeared to have been conducted in Connecticut in 1885. After World War II, the Agricultural Research Service, U.S. Department of Agriculture, and almost every State Agricultural Station were involved to some degree in turf research[2]. Today, according to the tissue culture, creation of variation and variety improvement of turfgrasses are conducted[4,9].

The first turf research in Korea was initiated in 1965[12]. Today, according to the increasing

of standard of living and aesthetic concern, turfs are utilized in many aspects. The Turfgrass Society of Korea was established in 1987.

Zoysiagrass is a warm season, slow growing, sod-forming grass that belongs to the family *Gramineae*, sub-family *Festucoideae*, and tribe *Zoysieae*[1]. This grass spreads by above and below surface runners, and is characterized by vigorous growth of all plant parts when ambient temperatures reach 28 to 32°C. On the other hand, when temperatures drop much below 15°C, growth slows rapidly and leaves begin to lose color. Turf becomes dormant and remains dormant for about 6 to 7 months until late spring when temperature increases and growth resumes[5,8,10,11]

Madison(1962)[6] reported that the frequent irrigation treatment decreased rooting, dry weight, verdure, chlorophyll and yield, and increased only population of 'Seaside' and 'Highland' bentgrass.

Mantell and Stanhill(1966)[7] showed that without any nitrogen application, an increase in irrigation frequency had no significant effect on plant density in kikuyugrass, but when nitrogen levels were adequate it was responsive to mowing, irrigation, or shading practices.

Despite its great importance as a turf, little is known about the effect of irrigation frequency on the sprig establishment of zoysiagrass. Therefore, this study was conducted to compare zoysia-82 having more vigorous growth than other zoysiagrasses[3] with Korean lawngrass and to determine how these two types of zoysia grasses would respond to irrigation frequency in the summer of a best growing season.

II. Materials and methods

For this study, Korean lawngrass (*Z. japonica* Steud.) obtained from the field of Kyungpook National University and zoysia-82 obtained from Taegu Country Club in 1982 were transplanted in the pot of 26cm in diameter and 24cm in height by 10cm sprig on May 17,1987. The total length of transplanted sprigs were adjusted to about 50cm per pot.

At the start of the experiment, the grasses were mowed back to 4cm. Irrigation was conducted at noon with 400ml of water every one day, five days, ten days, and control (natural state), respectively. Nitrogen fertilizer was applied at a rate of 0.5g per pot per month, and no herbicide was used because some herbicides change leaf color and growth habits. Therefore, weeds were controlled by hand-pulling.

Leaf length and width were measured from June 16 to Aug. 15 with 15 days interval. To minimize the environmental variation, the measurement was made on the 3rd leaf.

The 3rd internode length and stolon growth were measured for six days during the late June and July, respectively. Measurements were made on five runners of each strain per replication.

The total runner length was measured in fresh state at 30, 60, and 90 days after sprigging. To prevent water loss, all plants pulled out were washed and placed in a polyethylene bag before they were taken to the laboratory. After measuring of total runner length, each plant part was separated, oven-dried overnight at 110°C and weighed.

Percent ground cover was checked by visual far-sightedness test.

The experiment as laid-out in a split-plot design with three replications; varieties in main-plot and irrigation treatments in subplot, respectively.

III. Results and discussion

Due to the four different frequencies of irrigation, the length and width of leaves were significantly different among the treatments but no mean varietal difference in leaf length at 45 days and leaf width at 30 days after sprigging was recognized, respectively (Table 1). The leaf of Korean lawngrass was longer and wider than that of zoysia-82 for the all irrigation treatments of all measuring dates except leaf length at 30 days after sprigging. With times, leaf length of two varieties was the longest in the irrigation treatment of once per day.

The length of 3rd internode and stolon measured from the growing point of two zoysiagrasses during two warm periods are shown in Table 2. The two periods were from June 24 to June 30 and from July 25 to July 31. In Korean lawngrass, there was only measurable length for the 3rd internode and stolon growth in once per day of irrigation during the 2nd measuring periods.

In zoysia-82, the 3rd internode length was longer in the following order of irrigation frequency: 1) once per day, 2) control (natural state), 3) once per five days, and 4) once per ten days at the 1st measuring periods. It ranged from 9.4 to 0.0 cm. But control plot was showed the longest internode length at the 2nd measuring periods. It was suggested that control plot be received more abundant moistures than the plot of once per day of irrigation for rainy season in Korea. Average internode length for two periods was longer in the following order of irrigation frequency: 1) once per day, 2) control, 3) once per five days, and 4) once per ten days.

The results of stolon length were the same as the results of the 3rd internode length. Mean daily growth of stolon length for two periods was in the following order of irrigation frequency: 1) once per day, 2) control, 3) once per five days, and 4) once per ten days. It ranged from 2.0 to 0.1cm. Internode length and growth of stolon length were reduced as zoysia-82 becomes competitive with itself.

There were significant differences in the total length of runner (rhizome + stolon) and average growth rate per day at all measuring dates except at 30 days after sprigging between varieties (Table 3). Zoysia-82 was more vigorous than Korean lawngrass in the growth of runner. In two varieties, the length and daily growth rate of runner were in the following order of irrigation frequency: 1) once per day, 2) control 3) once per five days, and 4) once per ten days.

The total length of runner measured at the terminal day was ranged from 537.3 to 2596.2 cm and from 222.5 to 831.1cm per replication in zoysia-82 and Korean lawngrass, respectively. The highest daily growth rate was obtained in once per day of irrigation in zoysia-82 and the lowest daily growth was obtained in once per ten days in Korean lawngrass. It ranged from 28.3 to 1.9cm. It was suggested that zoysia-82 having more rhizome and stolon per unit area may give it more advantage for winter survival and recuperative potential.

Dry weight and growth rate of plant parts measured with 30 days interval from sprigging are shown in Table 4. At sprigging, the dry weights of plant parts of Korean lawngrass were heavier than those of zoysia-82. But, as they grew up, the dry weight of each part of zoysia-82 was getting heavier, and the daily growth rate of dry weight of zoysia-82 was more abundant

Table 1. Growth of leaf length and width of two zoysia strains grown under different frequency of irrigation.

Varieties	Irrigation frequency (I.F.)	Leaf length(cm) June 16 (30DAS*)	July 1 (45DAS)	July 16 (60DAS)	July 31 (75DAS)	Aug. 15 (90DAS)	Leaf width(mm) June 16 (30DAS)	July 1 (45DAS)	July 16 (60DAS)	July 31 (75DAS)	Aug. 15 (90DAS)
Zoysia-82	Control	5.7	6.3	6.4	9.7	10.6	4.0	4.2	4.1	4.2	4.2
	Once/ day	6.6	8.0	8.9	15.9	20.5	4.2	4.2	4.2	4.2	4.2
	Once/5days	6.1	7.5	7.8	8.8	9.7	3.7	4.2	4.2	4.2	4.2
	Once/10days	5.3	6.8	7.0	8.2	8.3	3.5	4.2	4.2	4.2	4.2
	$\bar{x}$	5.9	7.2	7.5	10.7	12.3	3.9	4.2	4.2	4.2	4.2
Korean	Control	4.4	7.4	8.5	11.3	13.1	3.9	5.2	5.2	5.2	5.3
lawngrass	Once/ day	5.7	7.7	9.6	14.7	21.5	4.6	5.4	5.4	5.4	5.4
	Once/5days	5.1	6.8	7.8	10.6	14.9	4.3	5.1	5.1	5.2	5.1
	Once/10days	3.5	6.7	7.7	9.5	13.2	3.9	4.7	4.8	4.8	4.9
	$\bar{x}$	4.7	7.2	8.4	11.5	15.7	4.2	5.1	5.1	5.2	5.2
Mean	Control	5.1	6.9	7.5	10.5	11.9	4.0	4.7	4.7	4.7	4.8
	Once/day	6.2	7.9	9.3	15.3	21.0	4.4	4.8	4.8	4.8	4.8
	Once/5days	5.6	7.2	7.8	9.7	12.3	4.0	4.7	4.7	4.7	4.7
	Once/10days	4.4	6.8	7.4	8.9	10.8	3.7	4.5	4.5	4.5	4.6
L.S.D. (5%)											
Between varieties		0.4	NS	0.1	0.4	1.1	NS	0.0	0.1	0.2	0.3
Between I.F. within varieties		0.3	0.3	0.4	0.4	1.3	0.3	0.3	0.2	0.2	0.2
Between I.F.		0.2	0.2	0.3	0.3	0.9	0.2	0.2	0.2	1.1	0.1
Between varieties within I.F.		0.5	0.7	0.4	0.5	1.5	0.5	0.2	0.2	0.2	0.3

*DAS : Days after sprigging.

Table 2. Average third internode length and growth of stolon length from growing point of two zoysia grasses during two warm periods by the different frequency of irrigation

Varieties	Irrigation frequency (I.F.)	Ave. internode length			Stolon length				
		June 24-30	July 25-31	Ave. for two periods	June 24	June 30	July 25	July 31	Ave. mean growth 1
					cm				-cm·day^{-1}
Zoysia-82	Control	6.5	7.6	7.1	14.1	22.5	16.4	28.1	1.7
	Once/day	9.4	5.7	7.5	18.6	34.2	14.0	22.4	2.0
	Once/5days	5.6	4.2	4.8	12.4	17.1	9.9	12.7	0.6
	Once/10days	0.0	4.0	2.1	0.0	0.0	9.8	11.3	0.1
	x	5.4	5.4	5.4	11.3	18.5	12.5	18.6	1.1
Korean	Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lawngrass	Once/day	0.0	3.2	1.6	0.0	0.0	8.7	12.5	0.3
	Once/5days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Once/10days	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	x	0.0	0.8	0.4	0.0	0.0	2.2	3.1	0.1
Mean	Control	3.3	3.8	3.6	7.1	11.3	8.2	14.1	0.9
	Once/day	4.7	4.5	4.6	9.3	17.1	11.4	17.5	1.2
	Once/5days	2.8	2.1	2.4	6.2	8.6	5.0	6.4	0.3
	Once/10days	0.0	2.0	1.1	6.0	0.0	4.9	5.7	0.1
L.S.D. (5%)									
Between varieties		0.8	1.4	1.1	1.5	2.2	3.0	5.2	0.3
Between I.F. within varieties		0.8	0.8	0.6	1.7	2.7	1.9	2.7	0.2
Between I.F.		0.6	0.6	0.4	1.2	1.9	1.4	1.9	0.1
Between varieties within I.F.		1.0	1.5	1.2	2.0	3.0	3.3	5.4	0.3

1 Average mean growth = $\frac{(\text{June 30} - \text{June 24}) + (\text{July 31} - \text{July 25})}{12}$

2 Measurements (cm) are an average of 5 readings in each replication.

Table 3. Total runner length and average growth rate per day in fresh state of two zoysia strains measured with 30-day intervals from springging.

Varieties	Irrigation frequency (I.F)	Dyas after sprigging				Average growth rate
		0	30	60	90	
			cm · rep.$^{-1}$			cm·rep·day^{-1}
Zoysia-82	Control	50.0	59.7	514.2	1499.0	16.1
	Once/day	50.0	76.3	1388.0	2596.2	28.3
	Once/5days	50.0	55.4	466.9	664.5	6.8
	Once/10days	50.0	54.6	182.1	537.3	5.4
	x	50.0	61.5	637.8	1324.2	14.2
Korean	Control	50.0	54.4	111.0	689.0	7.1
lawngrass	Once/day	50.0	55.5	293.4	831.1	8.7
	Once/5days	50.0	53.9	112.9	289.9	2.7
	Once/10days	50.0	53.1	77.0	222.5	1.9
	x	50.0	54.2	148.6	508.1	5.1
Mean	Control	50.0	57.1	312.6	1094.0	11.6
	Once/day	50.0	65.9	840.7	1713.7	18.5
	Once/5days	50.0	54.7	289.9	477.2	4.8
	Once/10days	50.0	53.9	129.6	379.9	3.7
L.S.D.(5%)						
Between varieties		NS	NS	68.7	116.5	1.3
Between I.F. within varieties		NS	8.7	54.1	150.2	1.7
Between I.F.		NS	6.1	38.2	106.2	1.2
Between varieties within I.F.		NS	13.1	78.6	166.6	1.9

Table 4. Influence of irrigation frequency on dry weight and growth rate of plant parts for two zoysia strains measured with 30 days interval from sprigging.

Varieties	Irrigation frequency (I.F.)	0[1]	30[1]	60[1]	90[1]	0[1]	30[1]	60[1]	90[1]	0[1]	30[1]	60[1]	90[1]
		g · rep^{-1}											
Zoysia-82	Control	0.4[3]	0.4[4]	2.9[4]	12.0[4]	0.5[3]	0.9[4]	4.6[4]	26.6[4]	0.1[3]	0.2[4]	1.6[4]	6.4[4]
	Once/day	0.4	0.6	7.6	17.5	0.5	1.7	14.6	53.3	0.1	0.4	1.7	3.7
	Once/5days	0.4	0.4	1.9	5.1	0.5	1.2	3.9	16.3	0.1	0.3	1.3	2.7
	Once/10days	0.4	0.4	1.4	4.5	0.5	0.8	2.2	12.5	0.1	0.2	0.6	2.2
	x	0.4	0.5	3.5	9.8	0.5	1.2	6.3	27.2	1.0	0.3	1.3	3.8
Korean	Control	0.6[3]	0.7[4]	1.3[4]	7.2[4]	0.8[3]	0.9[4]	3.4[4]	20.5[4]	0.2[3]	0.3[4]	1.0[4]	6.1[4]
lawngrass	Once/day	0.6	0.7	3.1	7.5	0.8	1.1	8.4	37.6	0.2	0.3	1.6	3.5
	Once/5days	0.6	0.6	1.3	3.3	0.8	0.9	3.1	10.9	0.2	0.3	0.9	2.5
	Once/10days	0.6	0.6	0.8	2.7	0.8	0.9	1.7	9.5	0.2	0.2	0.7	2.2
	x	0.6	0.7	1.6	5.2	0.8	1.0	4.2	19.6	0.2	0.3	1.1	3.6
Mean	Control	0.5	0.6	2.1	9.6	0.7	0.9	4.0	23.6	0.2	0.3	1.3	6.3
	Once/day	0.5	0.7	5.4	12.5	0.7	1.4	11.5	45.5	0.2	0.4	1.7	3.6
	Once/5days	0.5	0.5	1.6	4.2	0.7	1.1	3.5	13.6	0.2	0.3	1.1	2.6
	Once/10days	0.5	0.5	1.1	3.6	0.7	0.9	2.0	11.0	0.2	0.2	0.7	2.2
L.S.D(5%)													
Between varieties		NS	0.1	0.2	1.7	NS	0.2	0.5	6.4	NS	NS	0.2	NS
Between I.F. within varieties		NS	NS	0.2	0.7	NS	0.3	0.6	3.5	NS	0.0	0.3	NS
Between I.F.		NS	0.0	0.1	0.5	NS	0.2	0.4	2.4	NS	0.0	0.2	0.4
Between varieties within I.F.		NS	NS	0.3	1.8	NS	0.3	0.8	6.8	NS	0.1	0.3	NS

Table 4. (continued)

Varieties	Irrigation frequency (I.F.)	Relative growth rate[2]						
		0	30	60	90	Leaf and Runner branch stem	Root	Total
		g·rep^{-1}				mg·rep^{-1} day^{-1}		
Zoysia-82	Control	1.2[3]	1.6[4]	9.1[4]	45.1[4]	128.0	289.5	70.0	487.6
	Once/day	1.2	2.8	24.0	74.6	189.7	585.8	39.7	815.3
	Once/5days	1.2	2.0	7.2	24.2	52.3	175.0	28.2	255.6
	Once/10days	1.2	1.5	4.3	19.1	44.6	132.7	23.3	200.7
	x	1.2	2.0	11.2	40.8	103.7	295.8	40.3	439.8
Korean	Control	1.7[3]	1.9[4]	5.8[4]	34.0[4]	74.0	218.7	65.5	358.4
lawngrass	Once/day	1.7	2.2	13.2	49.0	80.3	409.0	36.1	525.5
	Once/5days	1.7	1.8	5.3	16.8	30.0	112.5	25.4	168.1
	Once/10days	1.7	1.8	3.4	14.5	23.4	96.5	21.7	141.7
	x	1.7	1.9	6.9	28.6	51.9	209.2	37.2	298.4
Mean	Control	1.5	1.8	7.5	39.6	101.0	254.1	67.8	423.0
	Once/day	1.5	2.5	18.6	61.8	135.0	497.4	37.9	670.4
	Once/5days	1.5	1.9	6.3	20.5	41.2	143.8	26.8	211.9
	Once/10days	1.5	1.7	3.9	16.8	34.0	114.6	22.5	171.2
L.S.D.(5%)									
Between varieties		NS	NS	0.7	8.7	19.3	71.8	NS	97.3
Between I.F. within varieties		NS	0.4	0.9	4.2	8.5	38.9	NS	3.3
Between I.F.		NS	0.2	0.6	3.0	6.0	27.5	4.4	47.2
Between varieties within I.F.		NS	0.4	1.1	9.1	19.9	75.6	NS	101.0

1 Days after sprigging
2 Growth rate of plant parts for 90 days
3 Measurements are an average of 50 readings per 10 in each varieties
4 Measurement are an average of 5 readings in each replications.

than that of Korean lawngrass. For both varieties, the heaviest dry weights of leaf and branch stem, runner, root, and whole plant were obtained from the irrigation frequency of once per day at each measuring date except root dry weight at 90 days after sprigging in control (natural state).

Generally, root dry weight over total dry weight(T/R-ratio) of Korean lawngrass was greater than that of zoysia-82 at all measuring dates (Fig. 1). For both varieties, T/R-ratio was increased rapidly from 60 days after sprigging in the irrigation of once per day.

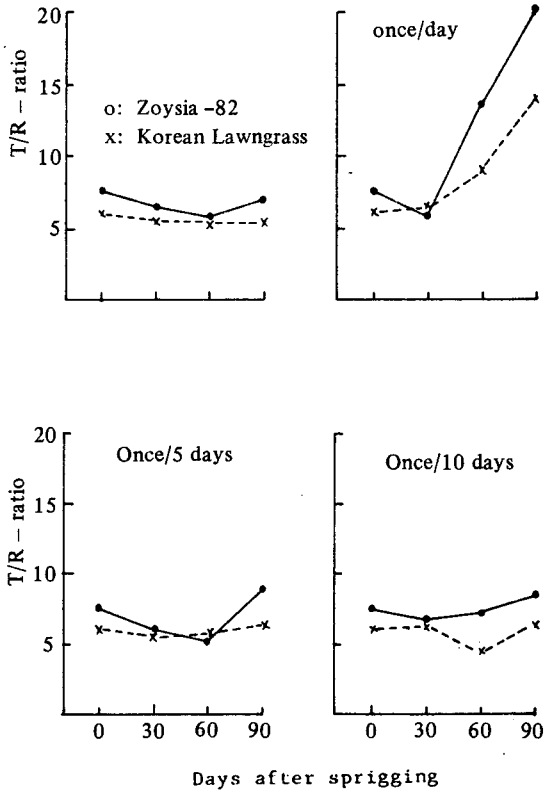

Fig. 1. Changes in ratio of root dry weight over total dry weight(T/R-ratio) of two zoysia strains after sprigging by the four irrigation treatments.

Percent ground cover of zoysia-82 was faster in all irrigation frequencies than that of Korean lawngrass (Fig. 2). Zoysia-82 was revealed 100% ground cover at 60 and 85 days after sprigging in once per day of irrigation and in control, respectively. On the contrary, Korean lawngrass reached 100% ground cover at 79 days after sprigging in once per day of irrigation during the

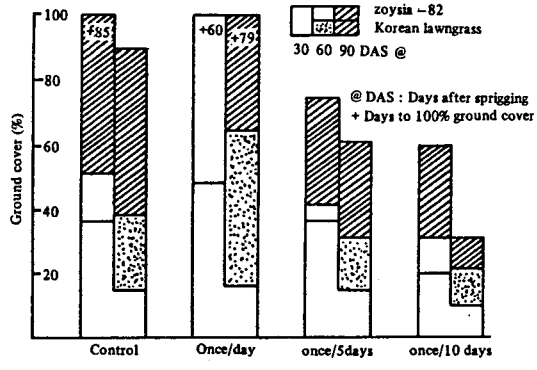

Fig. 2. Percent ground cover of two grasses grown under four different frequency of irrigation.

experiment periods. For both varieties, percent ground cover was faster in the following order: 1) once per day, 2) control, 3) once per five days, and 4) once per ten days.

Correlation coefficients among thirteen characters of two zoysia grasses are shown in Table 5. The correlations between leaf length and percent ground cover, and between T/R-ratio and percent ground cover were positive and significant while those among other characters related with percent ground cover only except leaf width were positive and highly significant.

As the results of this study, it was suggested that zoysia-82 be more superior to Korean lawngrass in the respect of the growth rate of each plant parts and ground cover. Therefore, zoysia-82 was easier and more economical than Korean lawngrass for the establishment with sprig.

Table 5. Correlation coefficients among thirteen characters of two zoysia strains related with morphological characters.

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1)LL[a/]	0.453*	0.418*	0.437*	0.412*	0.735**	0.003	0.656**	0.453*	0.730**	-0.013	0.695**	0.437*
(2)LW		-0.039	-0.444*	-0.346	-0.107	0.099	-0.155	-0.357	-0.115	0.060	-0.228	-0.444*
(3)GC			0.690**	0.764**	0.765**	0.674**	0.807**	0.762**	0.765**	0.683**	0.482*	0.690**
(4)TRL				0.980**	0.885**	0.391	0.924**	0.980**	0.888**	0.412*	0.752**	1.000@
(5)DWT					0.908**	0.503*	0.957**	0.999**	0.911**	0.521**	0.729**	0.979**
(6)DWL						0.318	0.987**	0.906**	0.999**	0.328	0.881**	0.885**
(7)DRT							0.441*	0.501*	0.318	0.999**	-0.142	0.391
(8)TDW								0.955**	0.988**	0.452*	0.817**	0.925
(9)RGRR									0.908**	0.519**	0.729**	0.908**
(10)RGRL										0.328	0.882**	0.888**
(11)RGRT											-0.129	0.412*
(12)TRR												0.752**
(13)RRD												

*, **: Significant at the 5% and 1% level, respectively

a/LL = Leaf length, LW = Leaf width, GC = Percent ground cover,
TRL = Total runner length, DWR = Dry weight of runner, DWL = Dry weight of leaf & leaf stem,
DRT = Dry weight of root, TDW = Total dry weight, RGRR = Relative growth rate of runner dry wt.,
RGRL = Relative growth rate of leaf & leaf stem dry wt., RGRT = Relative growth rate of root dry wt.,
TRR = Total dry wt. / Root dry wt., RRD = Relative growth rate of runner per day in fresh state.

IV. Summary

This study was carried out to compare zoysia-82 having more vigorous growth than other zoysiagrasses with Korean lawngrass and to determine how these two types of zoysia grasses would respond to irrigation frequency.

The results obtained are summarized as follows:

1. The length of Korean lawngrass was longer and wider than that of zoysia-82 at all treatments of irrigation.

2. Zoysia-82 was more vigorous than Korean lawngrass in the growth of runner. For both varieties, the length and daily growth rate of runner were in the following order of irrigation frequency: 1) once per day, 2) control (natural state), 3) once per five days, and 4) once per ten days.

3. Dry weight and growth rate of plant parts of Korean lawn-grass were heavier than those of zoysia-82 at sprigging. But, as they grew up, the dry weight of each part of zoysia-82 was getting heavier, and the daily growth rate of dry weight of zoysia-82 was more abundant than that of Korean lawngrass.

4. Percent ground cover of zoysia-82 was faster in all irrigation frequencies than that of Korean lawngrass. For both varieties, percent ground cover was faster in the following order: 1) once per day, 2) control, 3) once per five days, and 4) once per ten days.

V. Reference

1. Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, N.J.
2. Huffine, W.W. and F.V. Grau. 1969. History of turf usage. pp. 1-8. Hanson, A.A. and F.V. Juska (ed.) Turfgrass Science. Amer. Sco. of Agron., Ine., Mad., Wis.
3. Kim, I.S. 1983. Studies on the ecotypes of native red fescue (*Festuca rubra* L.) in Korea. M.S. Thesis. Coll. of Agri., Kyungpook Natl. Univ.
4. Krans, J. V., V.T. Henning and K.C. Torres. 1982. Callus induction, maintenance and plant regeneration in creeping bentgrass. Crop Sci. 22: 1193-1197.
5. LeCroy, W. 1963. Characterizing zoysia by field and anatomical studies. Ph.D. Thesis. Purdue Univ.
6. Madison, J.H. 1962. Turfgrass ecology: Effects of mowing, irrigation, and nitrogen treatments of *Agrostis palustris* Huds., 'Seaside' and *Agrostis tenius* Sibth., 'Highland' on population yield, rooting and cover. Agron. J. 54: 407-412.
7. Mantell, A. and G. Stanhill. 1966. Comparison of methods for evaluating the response of lawngrass to irrigation and nitrogen treatments. Agron. J. 58(5); 465-468.
8. Powell, A.J., R.E. Blaser and R.E. Schmidt. 1967. Physiological and color aspects of turfgrasses with fall and winter nitrogen. Agron. J. 59: 303-307.
9. Torello, W.A., A.G. Syminton and R. Rufner. 1984. Callus induction, plant regeneration, and evidence of somatic embryogenesis in red fescue. Crop Sci. 24: 1037-1040.
10. Youm, D.Y. 1974. Physiological mechanism of seed dormancy and its practical use for seed propagation of Korean lawngrass (*Zoysia japonica* STEUD.) Ph. D. Thesis. Coll. of Agri., Seoul Natl. Univ.
11. Youngner, V.B. 1961, Growth and flowering of zoysia species in response to temperatures,

photoperiods, and light intensities. Crop Sci. 1: 91-93.

12. Yu, T.Y. and S.J. Han. 1965. Effect of light, chemicals, stratification and age of seeds on germination of *Zoysia japonica* seeds. Coll. of Agri., SNU: Commemorative Jour. for 60th Anniversary of the foundation: 15-28.