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Effect of Light Conditions on the Seasonal Growth and Photosynthetic Ability in Several Wintergrasses

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광환경의 차이가 한지형 잔디의 연중 생육 및 광합성 능력에 미치는 영향

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ABSTRACT

The short green period of zoysiagrass has been a problem in using for turf. This study was performed to check growth response of several wintergrasses under sunny and shady area in Korea. Wintergrasses of 5 species, 27 cultivars introduced from U.S.D.A., were used in this study. After establishment, two fluctuations of top growth were observed which varied according to the species; first, due to drought in May, second, due to high temperature and humidity from July to August. Red fescues and perennial ryegrasses showed severe growth retardation in sunny area during summer period. Kentucky bluegrasses and tall fescues maintained good qualities nearly all the year round and showed slight disease infections. Kentucky bluegrass 'Kenblue' and red fescue 'Agram' grown under shady area showed higher photosynthetic ability than under sunny area, except the temperature range from 30 ℃ to 40 ℃ under 40,000 lux light in red fescue 'Agram'. And the photosynthesis was decreased at the temperature range from 35 ℃ to 40 ℃.

Key words: Wintergrass, Top growth, Visual rating, Photosynthesis, *Poa pratensis, Festuca arundinacea, Festuca rubra, Lolium perenne, Agrostis stolonifera.*

INTRODUCTION

In Korea, five species of genus *Zoysia* and many native varieties grow naturally(Yu *et al.*, 1974). Among them, *Zoysia japonica* adapts itself well and covers most part of sunny side of meadow in Korea. *Zoysia* forms a uniform, dense, low growing, high quality turf, but the establishment and recuperative rate is very poor because of a notoriously slow growth rate, especially the lateral shoot(Hume and Freyre, 1950).

Zoysiagrass discolors with the advent of 10 to 13 ℃ temperature and remains in a state of dormancy throughout the winter period(Youngner, 1961). Wintergrass have a temperature optimum 15.5 to 24 ℃. Most widely utilized species for turfgrass purposes are bluegrass, bentgrass, ryegrass, fescue, bromegrass, orchardgrass *etc.*

In many countries, wintergrasses have been used as year round green turf for parks, gardens and athletic fields, but zoysiagrass has been mainly used for turfgrass in Korea. According to the prolongation of sports season and increase of outdoor activity, the utilization of turfgrass is increasing more and more in season and out of season. Furthermore, the green foundation was absent at the flowering season of the flowering trees, *Forsythia azalea etc.* in early spring. Therefore the short green period of zoysiagrass was a serious problem awating solution. One of the solution is utilization of wintergrasses as year round green turf. Up to now wintergrass, mainly bentgrass, has been only used for establishment of green of golf course in Korea.

The purpose of this study was to check growth response of several wintergrasses under sunny and shady area in Korea. For this purpose it was performed to make clear the seasonal changes of growth and the extent of disease infection, and to investigate photosynthetic ability of several wintergrasses.

MATERIALS AND METHODS

Introduced seeds of wintergrasses(4 genera, 5 species, 27 cultivars) from U.S.D. A in 1983 were used in this study(Table 1). Four blocks of experimental plots were made in College of Agriculture and Life Science, Seoul National University in Suwon, Korea. Among them two blocks were made in sunny area, and the other two blocks, in shady area on the back of three floor building. Each block had 27 plots of 2 m^2. Halves the seeds of 27 cultivars were sown in shady area on August 30th, and the other halves were sown in sunny area on September 13th. Sowing amounts were 12.5 g /m^2 in Kentucky bluegrasses, 40 g /m^2 in tall fescues, 25 g /m^2 in red fescues, 40 g /m^2 in perennial ryegrasses and 5 g /m^2 in creeping bentgrasses.

After establishment in 1984, all plots were mowed every two days at 2.5 cm height from April 19th. Regrowth of top was investigated at every two days after mowing from April 30th to November 10th by measuring cut leaf length. Visual rating was done for evaluating turfgrass quality from February 15th to December 15th, and also for evaluating degree of disease infection from June 15th to September 15th.

Oxygen Electrode and Meter(YSI Co., Ohio, U.S.A) was used for the measurement of photosynthesis and respiration. Kentucky bluegrass 'Kenblue' and red fescue 'Agram' were selected and the leaves of each cultivar were sampled 0.1 g. Sampling was replicated two times in each block. Sodium-phosphate buffer solution(0.1 M, pH 6.5) containing 0.05 ml of 0.625 M $NaHCO_3$ solution was used as reaction solution(Ishii *et al.*, 1977). The incandescent light was thrown on plant materials. Light intensities were varied from dark to

Table 1. Enumeration of wintergrasses used in this experiment

Common name	Scientific name	Cultivar
Kentucky bluegrass	*Poa pratensis*	Birca
		Fylking
		Kenblue
		Majestic
		Newport
		Parade
		Sydsport
		Touchdown
		Vantage
		Victa
Tall fescue	*Festuca arundinacea*	Falcon
		Fawn
		Kenmont
		Monaco
		Rebel
Red fescue	*Festuca rubra*	Agram
		Banner
		Jamestown
		Pennlawn
		Waldiana
Perennial ryegrass	*Lolium perenne*	Citation
		Delray
		Loretta
		Manhattan
		Premier
Creeping bentgrass	*Agrostis stolonifera*	Contrast
		Prominent

40,000 lux at varied temperatures of 20, 25, 30, 35 and 40 ℃. After photosynthetic O_2 evolution and respiration were measured, those were calculated in terms of CO_2 release ($mgCO_2/g/hr$).

RESULT AND DISCUSSION

Germination was observed about 1 week after sowing except 'Fylking'(Kentucky bluegrass), 'Kenmont' and 'Fawn'(tall fescue) and 'Pennlawn'(red fescue) cultivars. After all the plots germinated were established, plots were mowed every two days from April 19th in 1984. From April 30th to November 10th, top growth at two days after mowing was measured.

Results are shown in Fig. 1. In Kentucky bluegrass 'Kenblue', the retardation of top growth at high temperature was slight in sunny area and the recuperation ability was

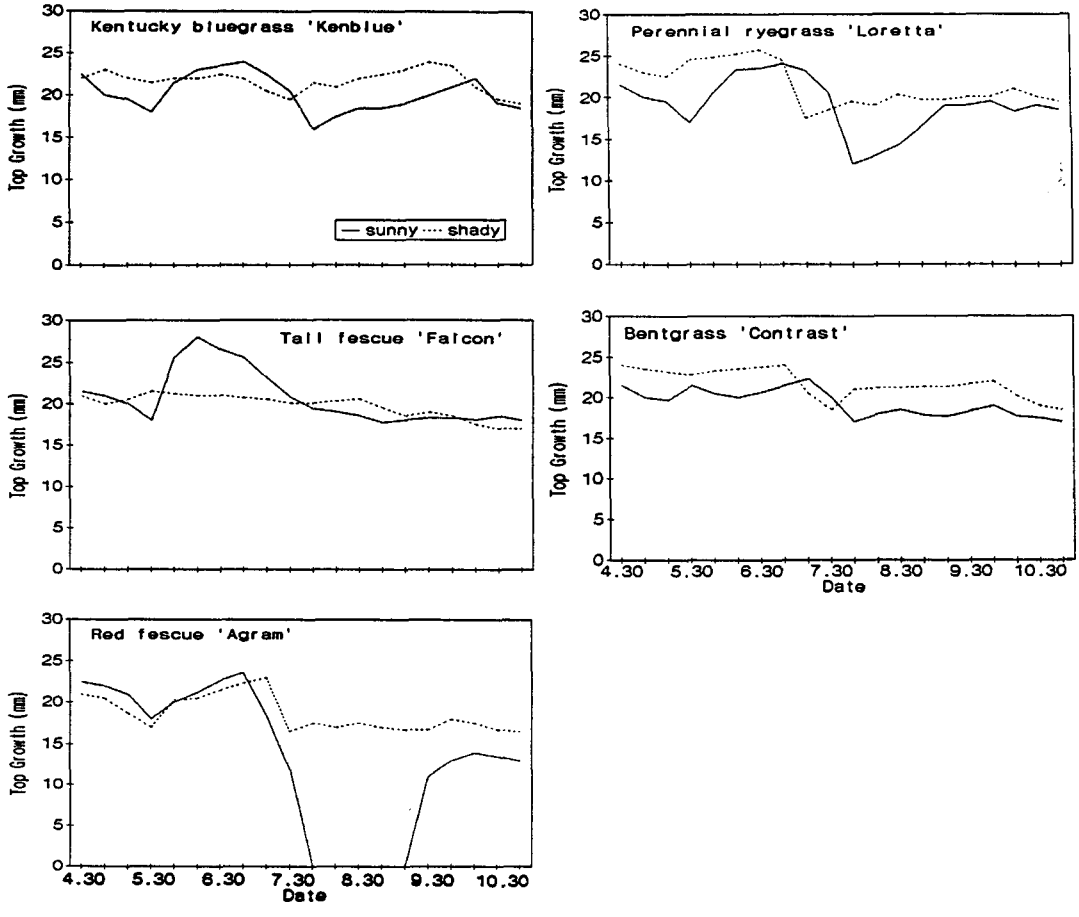

Fig. 1. Seasonal changes of top growth at different light conditions in wintergrasses mowed every two days at 2.5 cm height from April 19th.

good in shady area. Tall fescue 'Falcon' showed increase of top growth during early summer in sunny area, but showed no fluctuation of top growth from summer to late autumn in both areas. Red fescue 'Agram' showed peculiar fluctuation in growth curvature. In shady area the seasonal growth was like that of bentgrass, but in sunny area it quitted growing in the middle of July and resumed in the middle of September. During this period leaves of red fescue showed necrosis symptom. Perennial ryegrass 'Loretta' showed seasonal fluctuation of top growth also. The fluctuation was more severe in sunny area than in shady area. Creeping bentgrass 'Contrast' showed slight fluctuation of seasonal growth.

The first decrease in top growth at the late in May was because of drought at that time. The second decrease shown at the middle in July must had been influenced by the high temperature and humidity during summer period. In wintergrasses, optimum tem-

perature range for shoot growth is 15.5 to 23.5 ℃, including Kentucky bluegrass(Baker and Jung, 1968), creeping bentgrass(Duff, 1967), meadow fescue(Sprague, 1943) and perennial ryegrass(Mitchell, 1953). When wintergrasses were exposed to an extent period of heat moisture stress during midsummer that might caused complete cessation of growth, termed summer dormancy(Laude, 1953).

According to the decrease of temperature, top growth recuperated in both areas. Although top growth was good in tall fescue, recuperation was poor. Harrison and Hodgson(1939) and Madison(1962a) declared the preferred cutting height of several wintergrasses. Kentucky bluegrass, perennial ryegrass and red fescue had optimum range of cutting height in 1~2 inches. But tall fescue in 1.5~3 inches. The mowing height was 2.5 cm in this experiment, so the poor recuperation rate of tall fescue was because of scalping, stubbly and brown appearance when the removal of an excessive quantity of green leaves at any one mowing had done(Beard, 1973). Red fescue showed summer dormancy(Laude, 1953) according to the high temperature. It showed necrosis of top and recuperated at the middle of September. Perennial ryegrass also showed decrease of top growth during summer period in sunny area but not severe like that of red fescue(Fig. 1).

Many qualitative and quantitative methods had been used in the past to evaluate lawn, including creeping yield(Madhi and Stoutemyer, 1955), root growth and distribution, plant height, population density(Madison, 1962b), leaf chlorophyll content(Madison and Anderson, 1963), visual ratings of color and general appearence(Powell *et al.*, 1967) and turf score(Waddington *et al.*, 1964). Mantell and Stanhill(1966) investigated the correlations among the methods used in evaluating lawn quality; visual rating, leaf chlorophyll content, light reflection and plant density. They were highly significant.

In this experiment, evaluation of tu:fgrass qualities were carried out by the method of visual rating. Visual rating values are shown in Table 2. Kentucky bluegrasses maintained good qualities all the year round. They had the best quality in April and May, but visual rating values decreased during summer. Turfgrass qualities were better in sunny area during cold period than in shady area, but they reversed during summer period. Tall fescues were weak in cold period and their qualities were very poor. But they adapted well to the high temperature, so their qualities during summer period were good respectively. Although visual rating values were higher than any other species used in this experiment, their leaves were too tough for being used lawn. Red fescues adapted well to low temperature and they had good qualities during cold period but they showed severe growth retardation during high temperature period. They showed top necrosis during summer(Fig. 1). Perennial ryegrasses showed poor qualities during winter and summer period in sunny area. They maintained good qualities in spring, and medium quality in fall. Expecially 'Loretta' and 'Manhattan' cultivars were very poor during summer period like red fescues. Creeping bentgrasses had medium qualities all the year round.

Disease infection values during summer period are shown in Table 3. The values showed deep relationship with the qualities during the summer. Poor quality implicated in high

Table 2. Seasonal changes of visual rating values[z] of wintergrasses cultivated at different light conditions

Cultivar	Light condition	Month											
		2	3	4	5	6	7	8	9	10	11	12	Mean
P. pratensis													
Birca	Sunny	4	4	5	5	5	4	3	4	4	4	3	4.09
	Shady	2	4	4	5	4	4	4	4	4	5	4	4.00
Kenblue	Sunny	5	5	5	5	3	3	3	3	4	3	2	3.73
	Shady	4	4	4	5	3	3	3	3	4	4	3	3.64
Majestic	Sunny	5	5	5	5	4	3	3	3	4	3	3	3.91
	Shady	4	4	5	5	4	4	4	4	5	5	4	4.36
Newport	Sunny	4	5	5	5	4	4	3	3	4	3	3	3.91
	Shady	3	4	5	5	4	4	4	4	4	5	4	4.09
Parade	Sunny	4	5	5	5	4	4	3	4	5	4	4	4.27
	Shady	2	4	5	5	4	4	4	4	5	5	4	4.18
Sydsport	Sunny	4	5	5	5	4	4	3	4	4	3	3	4.00
	Shady	3	4	4	5	5	4	4	5	5	5	4	4.36
Touchdown	Sunny	4	5	5	5	3	3	3	4	5	4	4	4.18
	Shady	2	4	5	5	4	4	4	5	5	5	4	4.18
Vantage	Sunny	4	5	5	5	4	4	3	4	4	3	3	4.00
	Shady	4	4	5	4	3	3	3	3	4	4	4	3.73
Victa	Sunny	3	4	5	5	5	4	3	4	5	4	3	4.09
	Shady	3	4	5	5	5	5	4	5	5	5	4	4.54
F. arundinacea													
Falcon	Sunny	1	3	4	5	5	5	4	4	4	3	2	3.64
	Shady	3	2	4	5	5	5	4	5	5	4	4	4.18
Monaco	Sunny	1	3	4	5	5	5	4	4	4	3	2	3.64
	Shady	2	2	4	5	5	5	4	5	5	5	4	4.18
Rebel	Sunny	1	3	4	5	5	5	4	4	4	3	2	3.64
	Shady	3	2	5	5	5	5	4	4	5	5	4	4.27
F. rubra													
Agram	Sunny	4	4	5	5	4	2	1	1	2	2	2	2.91
	Shady	3	4	5	5	4	3	3	4	4	3	2	3.64
Banner	Sunny	5	4	4	5	4	2	1	1	2	2	2	2.91
	Shady	3	4	5	5	4	3	2	4	4	3	2	3.55
Jamestown	Sunny	5	4	5	5	4	2	1	1	2	2	2	2.91
	Shady	3	4	5	5	4	3	3	4	4	5	3	3.91
Waldiana	Sunny	5	4	5	5	4	2	1	1	2	2	2	2.91
	Shady	4	4	5	5	4	4	4	4	5	5	4	4.27
L. perenne													
Citation	Sunny	1	4	5	5	4	3	2	3	4	3	3	3.37
	Shady	3	4	5	5	5	4	3	4	5	5	3	4.18
Delray	Sunny	1	4	5	5	3	3	2	3	4	4	3	3.37
	Shady	3	3	4	5	4	4	3	4	4	4	3	3.73
Loretta	Sunny	1	3	5	4	4	3	1	1	2	2	2	2.55
	Shady	3	3	4	5	4	3	3	4	4	4	3	3.64
Manhattan	Sunny	1	3	5	4	3	3	1	1	2	2	2	2.46
	Shady	3	3	4	5	4	3	3	4	4	4	3	3.64
Premier	Sunny	1	3	5	5	4	3	2	3	4	4	3	3.37
	Shady	3	4	4	5	5	4	3	4	5	5	3	4.09
A. Stolonifera													
Contrast	Sunny	2	4	5	5	4	3	2	3	3	4	3	3.46
	Shady	3	3	4	5	4	4	3	4	5	5	4	4.00
Prominent	Sunny	2	4	5	5	4	2	2	3	3	3	3	3.27
	Shady	3	3	4	5	3	3	3	3	4	5	3	3.55

[z] : 1 − very poor, 2 − poor, 3 − medium, 4 − good, 5 − very good.

value of disease infection. Tall fescues showed low disease infection value, on the other hand red fescues and perennial ryegrasses showed severe disease infection in sunny area. One of the most important components of turfgrass is uniformity. Diseases as well as weeds, insects and nematodes disrupt the uniformity in a turf grass community. The major casual organisms of turfgrass diseases are *Rhizoctonia* spp., *Sclerotinia* spp., *Fusarium* spp., *Helminthosporium* spp., *Pythium* spp. and *Typhula* spp. (Beard, 1973). The main organism caused disease infection in this experiment was *Helminthosporium* spp. (data not shown).

Photosynthesis of 'Kenblue'(Kentucky bluegrass) and 'Agram'(red fescue) were measured. Björkman and Holmgren(1963), Björkman(1968) and Holmgren(1968) studied on photosynthetic properties of sun and shade ecotypes of plants. They said that sun and shade ecotypes of plants differed in photosynthetic response, leaf anatomy, chloroplast pigments and leaf nitrogen content. In this experiment, photosynthesis of Kentucky bluegrass 'Kenblue' in varied light intensities and temperatures is shown in Fig. 2. Plants cultivated in shady area showed high photosynthesis rate than in sunny area. Photosynthesis rate increased to 35 ℃ and decreased on 40 ℃ at 40,000 lux. At 20,000 lux, increase of temperature from 35 ℃ to 40 ℃ did not affect on the photosynthesis rate. And from dark to 5,000 lux, respiration was increased according to the increasing of temperature. In red fescue 'Agram', differences of photosynthesis rate in the cultivated areas were varied according to the fluctuation of temperature and light intensity.

In this experiment, it was concluded that Kentucky bluegrass and tall fescue adapted well in both sunny and shady areas but the leaves of tall fescue was too tough, red fescue and perennial ryegrass adapted in shady area but not in sunny area, and creeping bentgrass had medium quality in both area. Among the introduced turfgrasses from U.S. D.A., Kentucky bluegrasses and tall fescues proved to have had good qualities, but tall

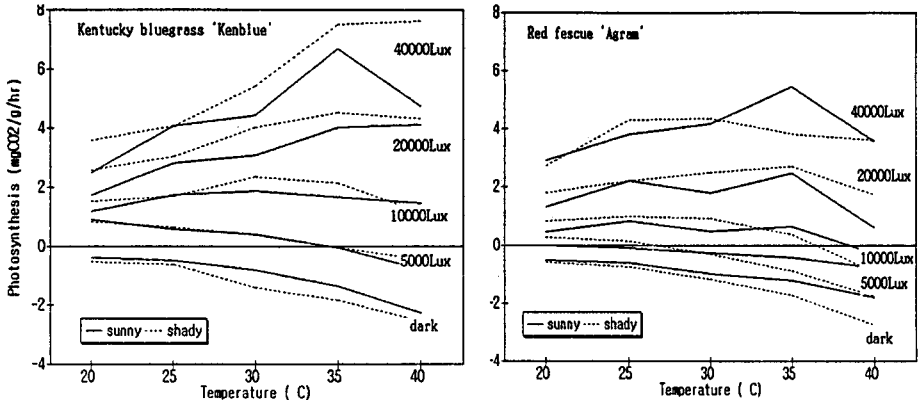

Fig. 2. Photosynthesis of Kentucky bluegrass 'Kenblue' and red fescue 'Agram' at different light and temperature conditions.

Table 3. Changes of disease infection values[z] of wintergrasses cultivated at different light conditions

Cultivar	Light condition	Month				Mean
		2	3	4	5	
P. pratensis						
Birca	Sunny	1	2	2	2	1.75
	Shady	2	2	2	2	2.00
Kenblue	Sunny	3	3	4	3	3.25
	Shady	3	3	3	3	3.00
Majestic	Sunny	2	3	3	3	2.75
	Shady	2	2	2	2	2.00
Newport	Sunny	2	2	3	3	2.50
	Shady	2	2	2	2	2.00
Parade	Sunny	2	2	3	2	2.25
	Shady	2	2	2	2	2.00
Sydsport	Sunny	2	3	4	3	3.00
	Shady	1	2	2	2	1.75
Touchdown	Sunny	2	3	4	3	3.00
	Shady	2	2	2	2	2.00
Vantage	Sunny	2	2	3	2	2.25
	Shady	3	3	3	3	3.00
Victa	Sunny	1	2	2	2	1.75
	Shady	1	1	2	2	1.50
F. arundinacea						
Falcon	Sunny	1	1	2	2	1.50
	Shady	1	1	2	1	1.25
Monaco	Sunny	1	1	2	2	1.50
	Shady	1	1	2	1	1.25
Rebel	Sunny	1	2	2	2	1.75
	Shady	1	1	2	2	1.50
F. rubra						
Agram	Sunny	2	4	5	4	3.75
	Shady	2	4	3	2	2.75
Banner	Sunny	2	4	5	5	4.00
	Shady	2	3	4	2	2.75
Jamestown	Sunny	2	4	5	5	4.00
	Shady	2	3	2	2	2.25
Waldiana	Sunny	2	4	5	5	4.00
	Shady	2	2	3	3	2.50
L. perenne						
Citation	Sunny	2	4	4	4	3.50
	Shady	1	2	3	2	2.00
Delray	Sunny	3	3	4	4	3.50
	Shady	2	2	3	2	2.25
Loretta	Sunny	2	4	5	5	4.00
	Shady	2	3	3	2	2.50
Manhattan	Sunny	3	4	5	5	4.25
	Shady	2	3	3	2	2.50
Premier	Sunny	2	4	4	4	3.50
	Shady	1	2	3	2	2.00
A. stolonifera						
Contrast	Sunny	2	3	4	2	3.00
	Shady	2	2	3	2	2.25
Prominent	Sunny	2	4	4	3	3.25
	Shady	3	2	3	2	2.75

[z] : 1 − no infection, 2 − slight, 3 − medium, 4 − severe, 5 − full.

fescues had stiff and tough leaves and did not fit for turf utilization. Especially, Kentucky bluegrass 'Birka', 'Parade' and 'Victa' proved to have had the best quality in this experiment.

In Korea, many of genera in Gramineae family domesticated such as *Poa*(24 spp., 1 var.), *Agrostis*(3 spp., 2 var), *Festuca*(9 spp., 6 var), *Bromus*(5 spp.), *Dactylis*(1 spp.) and *Lolium*(1 spp.) (An *et al.*, 1981). Though they were well classified, the selection and isolation were difficult. So, the introduced species from U.S.D.A. were used in this study. Maybe the selection and isolation of domestic cool season turfgrasses will be established soon. Then the selection of year round green turf from the domestic cool season turfgrasses will be possible.

적 요

난지형 잔디인 한국잔디의 푸른 기간이 짧아 이용상에 문제가 있어, 양지와 음지에서 한지형 잔디의 생육특성을 조사하여 이용 가능성을 검토하고자 미국 농무성으로부터 분양을 받은 5종 27품종의 잔디를 공시하여 본 실험을 수행하였다. 잔디밭이 조성된 후의 지상부 생육에 있어서 공시된 모든 품종은 연간 2회의 기복을 보였는데, 5월 중의 기복은 건조에 의한 것이고 7~8월의 기복은 고온과 다습에 의한 것으로 종에 따라 현저한 차이를 보였다. 특히 red fescue와 perennial ryegrass는 심한 생육장해 현상을 보였고, 반면에 Kentucky bluegrass와 tall fescue는 연중 잔디품질이 좋았으며 고온기 병의 발생 정도도 낮았다. Kentucky bluegrass 'Kenblue'와 red fescue 'Agram'은 음지에서 생육한 것이 양지에서 생육한 것에 비해 광합성량이 많았다. 그러나 30~40℃ 범위에 40,000 lux하에서는 red fescue에서 반대의 경향을 보였고, 전체적으로 광도에 따라 차이는 있으나 35~40℃의 범위에서 광합성량이 줄어드는 경향을 보였다.

REFERENCES

1. An, H. S., C. Y. Lee and S. H. Park. 1981. An Agronomical Enumeration of Korean Plant Resources. Ilchogag Pub. Co. Korea. pp. 257-272.
2. Baker, B. S. and G. A. Jung. 1968. Effect of environmental conditions on the growth of four perennial grasses. I. Response to controlled temperature. Agron. J. 60:155-158.
3. Beard, J. B. 1973. Turfgrass; Science and Culture. Prentice Hall, Inc. Eaglewood Cliffs, N. J. pp. 384-407, 545-626.
4. Björkman, O. 1968. Further studies on differentiation of photosynthetic properties in sun and shade ecotypes of *Solidago virgaurea*. Physiol. Plant. 21:84-99.
5. Björkman, O. and P. Holmgren. 1963. Adaptability of the photosynthetic apparatus to light intensity in ecotypes from exposed and shaded habitats. Physiol. Plant. 16: 889-914.
6. Duff, D. T. 1967. Some effects of supraoptimal temperatures upon creeping bentgrass (*Agrostis palustris* Hud.). Ph. D. Thesis, Michigan State Univ. pp. 1-61.
7. Harrison, C. M. and C. W. Hodgson. 1939. response of certain perennial grasses to cut-

ting treatments. J. Amer. Soc. Agron. 31:418-430.
8. Holmgren, P. 1968. Leaf factors affecting light-saturated photosynthesis in ecotypes of *Solidago virgaurea* from exposed and shaded habitats. Physiol. Plant. 21:676-698.
9. Hume, E. P. and R. H. Freyre. 1950. Propagation trials with manilagrass, *Zoysia matrella*, in Puerto Rico. Proc. Amer. Soc. Hort. Sci. 55:517-518.
10. Ishii, R., T. Yamagish and Y. Murata. 1977. On a method for measuring photosynthesis and respiration of leaf slice with an oxygen electrode. Jap. J. Crop Sci. 46:53-57.
11. Laude, H. M. 1953. The nature of summer dormancy in perennial grasses. Bot. Gaz. 114:284-292.
12. Madhi, A. and V. T. Stoutemyer. 1955. A method of measurement of population in dense turf. Agron. J. 45:514-515.
13. Madison, J. H. 1962a. Mowing of turfgrass. Ⅱ. Response of three species of grass. Agron. J. 54:250-252.
14. Madison, J. H. 1962b. Turfgrass ecology. Effect of mowing, irrigation and nitrogen treatments of *Agrostis palustris* Huds., Seaside and *Agrostis tenuis* Sibth., highland on population, yield, rating and color. Agron. J. 54:407-412.
15. Madison, J. H. and A. H. Anderson. 1963. A chlorophyll index to measure turfgrass response. Agron. J. 55:461-464.
16. Mantell, A. and G. Stanhill. 1966. Comparison of methods for evaluating of lawngrass to irrigation and nitrogen treatment. Agron. J. 58:465-468.
17. Mitchell, K. J. 1953. Influence of light and temperature on the growth of ryegrass (*Lolium* spp.). I. Pattern of vegetative development. Physiol. Plant. 6:21-46.
18. 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.
19. Sprague, H. B. 1943. The effect of temperature and day length on seedling emergence and early growth of several pasture species. Soil Sci. Soc. Amer. Proc. 8:287-294.
20. Waddington, D. V., J. Troll and B. Hawes. 1964. Effect of various fertilizers on turfgrass yield, color and composition. Agron. J. 56:221-223.
21. Youngner, V. B. 1961. Growth and flowering of *Zoysia* species in response to temperatures, photoperiods and light intensities. Crop Sci. 1:91-93.
22. Yu, T. Y., D. Y. Yeam, Y. J. Kim and S. J. Kim. 1974. Morphological studies of Korean lawn grasses(*Zoysia* spp.). J. Kor. Soc. Hort. Sci. 15(1):79-91.