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A Study on the Seasonal Color Characteristics of Warm- and Cool-Season Grasses
Ⅱ. Color Characteristics and Life-span of Leaves in Turfgrasses and Cover Plants+

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Ⅱ. 葉色特性 및 葉壽命延長

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ABSTRACT

Nitrogen fertilization and cutting practice were studied on turfgrasses and cover plants to investigate the possibility of maintaining green color during the growing season. Research also involved the effect of the nitrogen on a few morphological characteristics of leaf performance elements which might give an information to coloration and life-span of turf leaves.

Treatments in the first experiment undertaken on pot included one N level; 350kgN/ha applied as compound fertilizer in split applications of one-half in mid-May and the rest both in late June and August, and four spring-summer cuts; late May, late June, late July and late August. The soil filled in pot a moderately well-drained sandy loam.

In the second experiment (field observation) leaf length and width, inflorescence and flowering, and color performance were also investigated.

With nitrogen fertilizer applied on turfs, desirable turf color was maintained during a period of poor coloration in specific seasons such as mid-summer for cool season grasses and late fall for warm season grasses comparing to the non-treatment. However, this was not stimulated

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by cutting treatment to nitrogen status existed. Cutting effect on coloration was more remarkable in both Korean lawngrass and Manilagrass than in cool season turfgrasses such as Italian ryegrass, perennial ryegrass and tall fescue. Especially down-slide of leaf color in cool season turfgrasses could be detected in mid-summer / early fall season ranging up to mid-September.

In early November as well as mid-September, Italian ryegrass, perennial ryegrass and tall fescue retained a high level of green color as followed by nitrogen application and cutting treatment, and little detectable variation of leaf color notation between cool season turfgrasses was obtained. However, Korean lawngrass and Manilagrass failed to retain the green color until early November. Color notations in cool season turfgrasses investigated early November on the final date of the experiment ranged from 5 GY 3 / 1 to 4 / 8 in 'Ramultra' Italian ryegrass, 'Reveile' perennial ryegrass and 'Arid' tall fescue, but those in Zoysiagrasses were 7.5 YR 4 / 8 in Korean lawngrass and 2.5 y 5 / 6 in Manilagrass.

Life-span of leaves was shorter in Italian ryegrass, perennial ryegrass and tall fescue than in both Korean lawngrass and Manilagrass with and without nitrogen application. In general, leaves appeared in early May had a long life-span than those appeared in late April or mid-June. Nitrogen application significantly prolonged the green color retaining period in perennial ryegrass, Italian ryegrass, Korean lawngrass and Manilagrass, and this was contrasted with the fact that there was no prolonged life-span of leaves emerging in early May and mid-June in tall fescue.

SPAD reading values in 48 turfs and cover plants investigated in the field trial were increasing until late June and again decreasing till September. Increasing trends of reading value could be observed in the middle of October in most of grasses. On the other hand, clovers and reed canarygrasses did not restore their color values even in October.

Color differences between inter-varieties, and inter-species occurred during the growing season under the field condition implicated that selection of species and / or cultivars for mixture should be taken into consideration. In Munsell color notation investigated in the final date in the middle of November, 32 cultivars belonged under the category of 5 GY and 10 cultivars under the category of 7.5 GY. This was implying that most of cool season turfs and cover plants grown in the center zone of Korean Peninsula which are able to utilize for landscape use can bear their reasonable green color by early or mid-November when properly managed.

The applicable possibilities of SPAD readings and Munsell color notation to determine the color status of turfgrasses and cover plants used in this study were discussed.

Key words : SPAD reading value, Life-span of leaves, Leaf color, Color notation

INTRODUCTION

Color in turfgrass is one of the useful indicators available concerning the general condition of a turf,and thus the long retention of green color in turfgrass has always been of importance in considerations of turfgrass management. A loss of green color may indicate the development of nutritional deficiency, disease, insect, nematode, excessive water, wilt, or other environmental stress problems.

Among the factors affecting the coloration, or chlorophyll content, of turfgrass are species, rate of fertilization, temperature, and clipping management. It is well known that a color variation is mostly dependent on the amount of turfgrass fertilizer supply. A lot of research subjects in this connection range from comparisons of varieties and fertilizer treatments for steady, unchangeable status of color to studies of specific seasonal variation of chlorophyll concentration in turfgrass leaf fractions.

A minimal nitrogen fertility level is preferred on ornamental areas where a dense, high quality turf exists and primary objective is to maintain acceptable turfgrass color. In contrast, weakened turfs injured by environmental stress or turgrass pests require a higher nitrogen level to stimulate shoot growth and facilitate rapid recovery of damadged areas (Lawrence, 1963). Magnesium is essential for the maintenance of green color and growth in turfgrasses because it is vital constituent of the chlorophyll molecule (Menn and McBee, 1967).

Duff(1967) reported that the maximum chlorophyll content of creeping bentgrass leaves occurred between 23.9 to 29.5℃ and declines as the appropriate level of temperature is increased or decreased. He added that the visual color of bentgrass leaves appeared darker green at 35℃ than at 29.5℃ but chlorophyll content was actually lower. Turfs also appeared darker green at suboptimal soil temperatures that restrict leaf and shoot growth.

Where adequate inputs of nitrogen are maintained under a low intensity of culture, coloration of turfgrass can be continued to keep green until late fall. Thus, on many turfgrass sites, a green turf treated with the appropriate amount of nitrogen fertilizer, together with properties of grasses such as coloration and/or color duration during the seasons unsuitable for turfgrasses to grow was fully recognized as influencing turf quality (Shildrick, 1980). Chang and Kim(1986) who had experimented with Korean lawngrass reported that nitrogen application had an effect on green color of leaf canopies and chlorophyll contents and on elongation of the green period. In addition, they also explained that the increase of N, P and K application prolonged the green period to the last ten days of October. Shim and Yun(1987) also noted that nitrogen application significnatly increased green leaf number resulting in prolongation of green color period in Korean lawngrass and Manilagrass.

Turfgrass color can be an evaluation of the spectral composition of light by visual sense. When radiant energy contacts the turf leaves, certain wavelengths are absorbed and transmitted while other wavelengths are reflected(Beard, 1973). It is well-known, in general, that reflected wavelengths in the range from 380 to 760nm are perceived by the human eyes as the color of the turf.

A chlorophyll index measured as cholorphyll content in miligrams per square decimeter of area had been used(Madison and Andersen, 1963; Mantell and Stanhill, 1966). This index is likely to be effective in measuring certain nutritional responses and found to be no significant response to the effects of mowing, irrigation, or shading, but is known to have incalculatable interaction with these factors. An earlier study(Shim and Seo, 1995) has elucidated that differences between species and/or cultivars in color retaining period of leaves of turfgrasses and cover plants grass while fruiting seeds and their mutual interactions could be detected.

The objectives of the studies reported here were : (a) to evaluate the leaf color characteristics and green color retention of western turfgrasses, *Zoysia japonica* and *Zoysia* *matrella* as affected by nitrogen fertilization and cutting practices; (b) to determine the changes in morphological characters and color of turfgrasses and cover plants grown under field conditons; and (c) seasonal changes of color of the turfgrass and cover plant species and cultivars.

MATERIALS AND METHODS

1. Pot experiment

The experiment was conducted on pots filled with silt loam with 19.6% sand, 60.5% silt, 19.7% clay, pH 5.8 and 3.5% organic matter. Grasses were seeded on 6 March 1995. Turfgrasses used were: (a) *Lolium multiflorum*, 'Ramultra' Italian ryegrass; (b) *Festuca arundinacea* Schreb. 'Arid' Tall fescue; (c) *Lolium perenne* L. 'Reveile' perennial ryegrass; (d) *Zoysia japonica* Steud. Korean lawngrass; and (e) *Zoysia matrella*(L), MERR. Manilagrass. Almost all species and cultivars are commonly used on golf course, areas for landscape and soil conservation.

The trial was arranged in a randomized complete-block design with three replications. 350kg/ha of nitrogen was applied at rates of 1/2 for basic fertilizer and the rest for the time when cut for nitrogen plots on 28 April, 2 June and 12 July, as 11-10-11 compound fertilizer and urea respectively. Turfs were clipped at 4-cm height except control plots and two levels of nitrogen fertilizer (no N and N application) were applied immediately after each cut.

Chlorophyll was measured seven times throughout the growing period at approximately a month interval from 12 April to 21 October, 1995 using a potable SPAD chlorophyll meter(model Minolta 502 ; Minolta Corp.).

To correspond with the standard leaf samplings were collected from the midpoint of the current year's extension growth. A reading was made on opposite side of two-thirds of the 3rd leaf. Thus, one SPAD value recorded for each sample was an average of 14 readings. Detailed procedures were followed by the methods Lee *et. al.*(1992) and Neilsen *et. al.* (1995) had already been used.

Leaf color investigated on both 21 September and 21 October was measured with color number based on the Korean Standard Color charts(KSCC). Color charts were used as reference points in determining the actural turfgrass color. This technique is commonly used in soils work. To investigate the longevity of individual leaf retaining green color, ten leaves per pot were selected immediately after appearing from tiller. Individual leaves were marked to facilitate identification by ringing with color plastic-coated wire on the following dates: the first leaves were taken on 26 April; the second leaves on 2 May; and the third leaves on 9 June. The longevity of a leaf has been proposed as a better description of turf color duration(Davies, 1969). In this study, longevity was defined as life-span of leaf.

Irrigation was frequently supplied to prevent moisture stress.

2. Field experiment

An investigation was conducted at the experimental farm of the Livestock Research Institute, RDA,Suwon, during the growing season between 1 March and 11 November 1995, with 48 warm- and cool-season turfgrass species and cultivars conventionally established for the purpose of performance test.

An experiment was located on silt loam during 1995. Soil pH at the location was 6.0. A fertilizer was uniformly applied at the rate of 120-40-75(N-P-K)kg/ha/year to the whole experiment. All plots were mowed to 4 cm three times during the experiment period when N fertilizer was applied.

Samples for morphological leaf characteristics were harvested from each plot until 20 June and length and width of 10 leaves from each plots were measured by mm unit. In the end of season the presence of inflorescence or flowering was determined by visual observation. The last determination of coloration in turfgrasses and other cover plants was conducted in the end of the growing season. Color determination were also assessed by visual rating from 9 to 1.

Leaf SPAD reading values of 48 grass and legume species and cultures for determination of seasonal change of color in turfs were measured in situ at nearly a month interval using chlorophyll meter. This was started from 6 May throughout 20 October by using the same procedures as the previous pot trial.

Fertilization and other general works in relation to the experiment were followed by the methods which are being undertaken by the Livestock Research Institute, RDA. Analytical procedures and other details were almost same as in the previous experiment(Shim and Seo, 1995).

RESULTS

1. Color studies

Mean values of leaf SPAD reading in five turfgrasses during the growing period are shown in Table 1. Average leaf SPAD reading values of these different turfgrasses varied steadily according to the treatment imposed, and thus where nitrogen or cutting was not treated, coloration tended to decreased more remarkably in cool season turfgrasses than in warm season grasses. For example, leaf SPAD reading values in Korean lawngrass and Manilagrass were 22.4 and 22.5, respectively. Predicted trends in perennial ryegrass and tall fescue showed adverse results when their reading values were 19.9 and 20.1, respectively.

The effect of cutting treatment was also more significant in warm season turfgrasses than in cool season ones. Leaf SPAD reading values obtained by treating cutting practice in Korean lawngrass and Manilagrass were 28.0 and 27.7, respectively, comparing to 24.0 for Italian ryegrass and 22.8 for perennial ryegrass. 'Arid' tall fescue was lowest among

Table 1. Mean values of leaf SPAD reading in five turfgrasses during growing period

Turfgrass	Treatment				Mean
	Control	Cutting	Nitrogen	N+cutting	
'Ramultra' Italian ryegrass	22.4ab*	24.0b	44.0a	38.0a	32.1
'Reveile' perennial ryegrass	19.9b	22.8bc	44.9a	38.7a	31.6
'Arid' tall fescue	20.1ab	21.7c	39.1b	31.5c	28.1
Korean lawngrass	22.4ab	28.0a	36.0bc	34.1b	30.1
Manilagrass	22.5a	27.7a	34.6c	34.0b	29.7
SE	2.31	1.95	3.76	2.04	

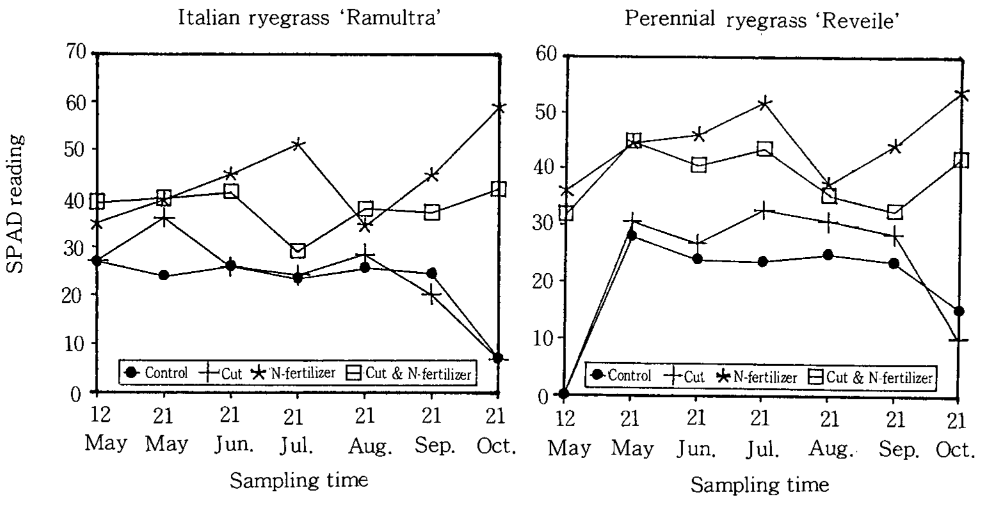
* Means within columns followed by the same letter are not significantly different at the 5% level of probability based on the Duncan Multiple Range Test

cultivars given in the study. These data indicate that two Zoysiagrasses of the study under the condition of site newly established during the growing period were more likely to be retainable than perennial ryegrass or tall fescue in considerations of color retention.

Application of nitrogen fertilizer significantly increased average reading values in all turfgrasses. Italian ryegrass reading value was 96% higher by applying nitrogen than in the control, and perennial ryegrass was 1.26 times higher. Nitrogen response to individual species or cultivar was significantly larger for Italian ryegrass and perennial ryegrass than for two Zoysiagrasses, this fact seeming to be due partly to response difference to environmental condition existing between cool- and warm-season grasses. Otherwise, N plus cutting treatment may not have increased average reading values because the soil did not contain enough nitrogen from the cutting practice to meet plant needs for regrowth. Also, lower effect of N plus cutting treatment on reading value comparing to single nitrogen treatment was more remarkable in Italian ryegrass or perennial ryegrass than in Korean lawngrass or Manilagrass, and little differences between two treatments in two Zoysiagrasses were found.

Effects of nitrogen fertilizer and cutting treatments on leaf SPAD reading value of leaves of 'Ramultra' Italian ryegrass are shown in Fig. 1. Before September, average leaf SPAD reading value of turf leaves shown in the control plot was 25. The relative low reading value from cutting treatment without nitrogen fertilization during the growing season, except May, is believed to occur as a result of the lack of nutrient suppliments needed for recovery from injury following defoliation of a grass plant.

The treatment of nitrogen fertilizer alone applied to 'Ramultra' Italian ryegrass affected leaf SPAD reading value to the end of season. By 21 July, leaf SPAD reading value consistently increased to 51.1, which was much higher than that obtained in the previous season. Sustained leaf SPAD reading value when nitrogen was applied in September is expected to be closer to that obtained on 21 June, but that in October was 59.0, which is



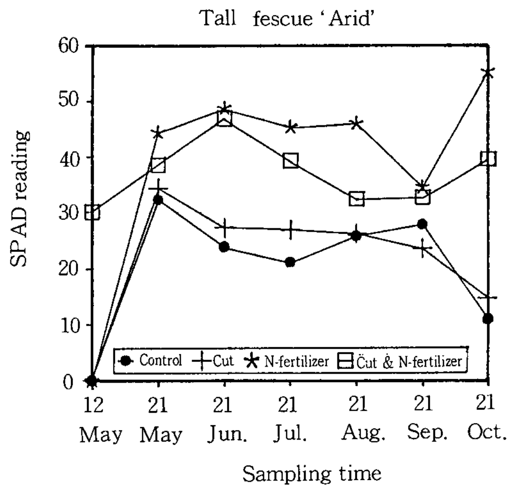


Fig. 1. Effect of sampling time on SPAD reading values of Italian ryegrass, perennial ryegrass and tall fescue according to different treatments.

the highest record.

SPAD reading value in 'Ramultra' Italian ryegrass leaves did not respond to the effect of cutting as stated by Madison and Anderson(1963), and Mantell and Stanhill (1966). The slow increase in leaf SPAD reading of Italian ryegrass leaves produced following N fertilizer plus cutting treatment was apparent when this treatment was done in mid summer. Even when leaf SPAD reading value increased significantly by applying nitrogen fertilizer in October, it was still 29% low, relative to single nitrogen fertilizer applied.

The influence of nitrogen and cutting factors on leaf SPAD reading value in 'Reveile' perennial ryegrass is shown in Fig. 2. On zero N fertilization in absence of cutting practice until 12 May, leaf SPAD reading value in 'Reveile' perennial ryegrass could not be detected due mainly to poor stand of seedling grown after emergence of plant from soil surface. Average SPAD reading value was 28 on 21 May in the control plot, decreased by 23.9 and then levelled off from 21 June onwards. Where cutting treatment was made, leaf SPAD reading value was slightly higher comparing to what is in the control plot, this being particularly notable in mid-summer period.

Data show that leaf SPAD reading values in perennial ryegrass were increased significantly after applying N fertilizer. The trend of increase in reading value was also apparent where N plus cutting treatment was imposed. In September and October, however, reading values were notably less than at the other growing periods. This phenomenon suggests that cutting practice for coloration of perennial ryegrass leaves was undesirable as far as landscape situation is concerned.

The effect of N and cutting treatments on chlorophyll status in 'Arid' tall fescue leaves is also shown in Fig. 1. Early stage of growth in tall fescue was practically not desirable enough to determine the leaf SPAD reading value and thus overall measurement work could start from 21 May except for N fertilizer plus cutting treatment plot. Significant difference in leaf SPAD reading value between treatments was not detected except for nitrogen application but was notable from 21 June onwards. Where nitrogen fertilizer was applied, SPAD reading value in 'Arid' tall fescue leaves was nearly twice that obtained in the control or with cutting treatment, and particularly the maximum reading value was recorded on 21 October when it was 55.2.

Korean Lawngrass, one of warm season turfgrasses, no particular trend in leaf SPAD reading values were detected until 21 September when nitrogen or cutting practice was not imposed on turf (Fig. 2). Leaf SPAD reading values considerably varied according to sampling time where zero nitrogen was applied. They were increased steadily until 21 May, but afterwards the degree of color retentions present in summer period was of little significance month to month and they ranged from 21.0 to 23.4. Where applied by nitrogen, however, maximum leaf SPAD reading values was considerably increased to 40.6 in summer period. This figure was still much lower than that obtained from cool season turfgrasses such as Italian ryegrass, perennial ryegrass or tall fescue. Even in October the leaf SPAD reading value of Korean lawngrass reached the peak of value to 31.0, which was notably lower comparing to each value of cool season grasses at the given time.

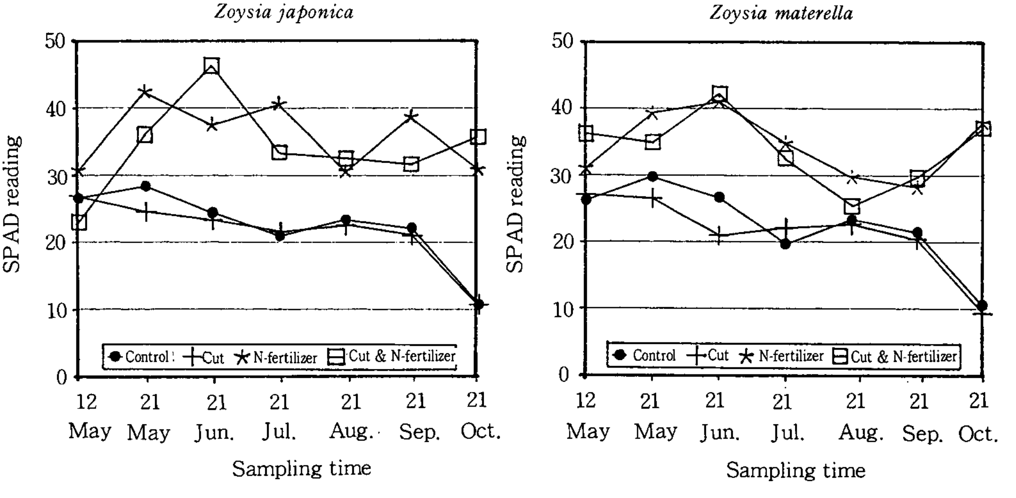


Fig. 2. Effect of sampling time on SPAD reading values of Korean lawngrass and Manilagrass according to different treatments.

It is notable that there was a severe variation in reading value of Korean lawngrass according to sampling time, and N plus cutting treatment had an effect on the increase of coloration until 21 June. Another higher SPAD reading value was obtained on 21 September when it was 38.7 by applying nitrogen alone. On 21 October SPAD reading values were 10.8 in the control, 29.7 with cutting treatment, 31.0 with nitrogen applied and 35.7 with N plus cutting treatment.

Leaf SPAD readings of Manilagrass as affected by nitrogen and cutting treatments are also shown in Fig. 2. By 21 May reading value became highest when it was 29.8 by applying nitrogen fertilizer or cutting practice. There was also a remarkably adverse effect due to summer high temperature. Maximum SPAD reading value in Manilagrass leaves was less than 23.3 by 21 August. Significant reduction of reading values in Manilagrass occurred on 21 October, probably due mainy to the varietal character of a warm season species. By 21 July, nitrogen fertilizer contributed as much to SPAD reading value of this treatment as did nitrogen plus mowing practice. There were little differences between SPAD reading values in Manilagrass receiving nitrogen alone and nitrogen plus cutting. However, average SPAD reading value exceeded that of Korean lawngrass.

General patterns of leaf SPAD reading value in cool- and warm-season turfgrasses as time exceeded are shown in Fig. 3. Collectively, the average values for Italian ryegrass, perennial ryegrass and tall fescue were greater at the cutting treatment level than at the control level except last two cutting dates. The level of nitrogen applied gave always a large effect on average reading value. Particularly significant effect of nitrgoen was detected on both 21 July and 21 October. N plus cutting treatment effect was lower than single nitrogen application but was higher than the other two treatments.

The patterns of average reading value of both Korean lawngrass and Manilagrass were

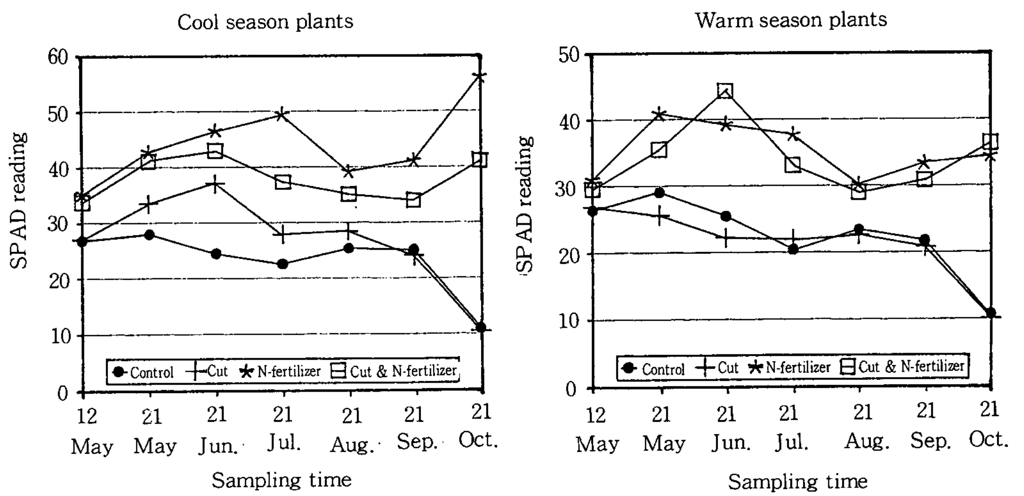


Fig. 3. Effect of sampling time on SPAD reading values of cool- and warm-season plants according to different teatments.

more or less different from those appearing in cool season turfgrasses : higher values in cool season grasses with cutting treatment than in the control were apparent by 21 September, but this trend was not clearly detected in Zoysiagrass. The fact that cutting treatment with nitrogen added showed lower reading values in all cases in cool season grasses indicates that cutting treatment accompanied by N fertilizer may deteriorate the effect on reading value increase in the specific period in cool season grasses.

Data on leaf color as affected by nitrogen fertilization and cutting treatments on two different sampling dates in fall 1995 are presented in Table 2. The pattern of the leaf color in the control on 21 September still remained green but showed slightly different status: color notation was 10GY 4/6 with Italian ryegrass, 5GY 4/6 with perennial ryegrass and Manilagrass, and 5GY5/6 to 5/8 with tall fescue and Korean lawngrass. This indicates that under the condition of non-treatment added, color variation according to species was not considerably significant.

Color measured on 6 November was diversified by ranging from 2.5 Y to 10 YR, when Italian ryegrass and perennial ryegrass were 2.5Y 3/4 and 7/8, respectively, while those in Korean lawngrass and Manilagrass were 7.5YR 4/4 and 10YR 7/8 where no nitrogen fertilizer was applied. Cutting treatment effect was not apparent on 21 September. Conversely, color status in perennial ryegrass and tall fescue were 5 GY 4/6 to 4/8 and those in Korean lawngrass and Manilagrass were 5 GY 4/4 to 4/8, respectively.

Poor color status obtained from nitrogen plus cutting treatment was similar for cool season turfs to that from single nitrogen treatment on 6 November. Application of nitrogen to Italian ryegrass, perennial ryegrass and tall fescue maintained the color status of 5GY 3/1 to 4/8, indicating that nitrogen application would extend the coloration period in a limited number of turfgrasses and cover plants. Nelson(1968) has reported that in the fall, higher levels of green color were maintained from higher levels of inorganic N. Irrespective of nitrogen applied, green color could not be maintained until 6 November with

Table 2. Leaf color notations of five turfgrasses classified according to Korean Standard Color charts on two different sampling dates in the fall, 1995.

Treatment	Sampling time	Turfgrass cultivar				
		'Ramultra' It.ryegrass	'Reveile' Pe.ryegrass	'Arid' Tall fescue	Korean lawngrass	Manilagrass
Control	Sep. 21	10GY8/4*	5GY4/6	5GY5/6	5GY5/8	5GY4/6
	Nov. 6	2.5Y3/4	2.5Y7/8	10YR4/6	7.5YR4/4	10YR7/8
Cutting	Sep. 21	7.5GY3/6	5GY4/8	5GY4/6	5GY4/4	5GY6/8
	Nov. 6	10YR2/2	10YR2/2	10YR3/6	7.5YR4/4	2.5Y6/8
Nitrogen	Sep. 21	5GY3/1	5GY3/4	5GY3/4	5GY4/6	5GY5/8
	Nov. 6	5GY3/1	5GY4/8	5GY4/6	7.5YR4/8	2.5Y5/6
N+cutting	Sep. 21	5GY4/8	5GY3/4	5GY3/4	5GY5/6	7.5GY4/6
	Nov. 6	5GY4/6	5GY4/8	5GY4/6	10YR6/6	2.5Y6/6

* Munsell color notations

Korean lawngrass and Manilagrass. In case of Manilagrass the color varied from 7.5 GY4 /6 on 21 September to 2.5Y 6 /6 on 6 November.

2. Green leaf life-span studies

The effects of nitrogen fertilizer on life-span of leaf blades of five turf species and cultivars is shown in Table 3. Nitrogen application stimulated the prolongation of the life span of leaf blades of all cultivars and species used, especially in Korean lawngrass and Manilagrass, but did not seriousely affected in the leaf blades emerging in late April. In spite of absence of nitrogen status its positive effect of prolongation of life-span in leaf blades emerging on 2 May reached the level of those emerging on 26 April with nitrogen fertilization, particularly in perennial ryegrass.

In both Italian- and perennial ryegrasses, leaf blades emerging on 19 June were forced to shorten their life-spans irrespective of nitrogen status. This phenomenon indicates that high temperature would have interfered leaf growth, and thus accelerated the shortening of the life-span of leaf blades.

Generally leaf blades emerging on 26 April had somewhat longer life-span than those emerging on 19 June in both Italian ryegrass and perennial ryegrass. In tall fescue, life-span of leaf blades emerging on 26 April was much shorter than that of Italian rye-

Table 3. The effect of nitrogen fertilizer on life-span of leaves of five turf species and culivars

Cultivar	Nitrogen level	Life-span of leaves			
		Appeared on 26 April	Appeared on 2 May	Appeared on 9 June	Mean
		Weeks			
'Ramultra'	N_0	7.6	8.3	7.4	9.2
Italian		*	**	NS	
ryegrass	N_1	8.2	9.0	7.9	8.4
'Reveile'	N_0	7.0	8.4	7.0	7.5
perennial		**	**	NS	
ryegrass	N_1	7.7	9.1	7.3	8.0
'Arid' tall	N_0	6.7	8.1	8.3	7.7
fescue		*	**	**	
	N_1	7.1	9.3	9.3	8.6
Korean	N_0	8.9	9.4	9.1	9.1
lawngrass		*	**	*	
	N_1	9.4	10.4	9.6	9.8
Manila-	N_0	8.9	9.7	9.3	9.3
grass		**	**	**	
	N_1	9.6	10.9	10.0	10.2

* fertilization, particuindicates significance at 5% probability

** indicates significance at 1% probability or less

NS indicates non significance

grass or perennial ryegrass irrespective of nitrogen application. Life-span of leaf blades emerging on 2 May was prolonged 9.0 to 9.3 weeks by applying nitrogen. However, it was merely 8.1 to 8.4 weeks with zero nitrogen.

Data show that life-span of leaf blades emerged on 9 June gave no difference between the treatment and non-treatment of nitrogen in both Italian ryegrass and perennial ryegrass. Countable prolongation of life-span of leaf blade in Korean lawngrass were found. Even in leaf blades emerging on 26 April, under the zero nitrogen condition, Korean lawngrass and Manilagrass had long days of retaining green color as compared to the other cool season turfs : Further 1.3-week period lengthened the color retention as compared to Italian ryegrass and 1.9-week period to perennial ryegrass at the zero nitrogen treatment level.

Existing nitrogen supplied to Korean lawngrass and Manilagrass contributed to notable prolongation of life-span of leaf blades emerging on 2 May reached the 10.4-week and 10.9-week period resulting in the level of significance.

3. Leaf coloring trends in turfgrasses and cover plants

Table 4 represents the coloration trend of the leaf blade of turfs and cover plants grown on the experimental field of Livestock Research Institute during the period 6 May to 20 October 1995. Data shown in this Table were the SPAD reading values obtained by measuring with SPAD reading meter to determine the chlorophyll contained in leaf blades of plants. Measurements of SPAD reading values were carried out monthly on the field.

Table 4. SPAD reading values of turfs and cover plants for growing period May to October

Species	Cultivar	Sampling time						
		May 6	May 20	Jun. 20	Jul. 20	Aug. 20	Sep. 20	Oct. 20
Orchardgrass	Potomac	41.9	41.6	41.1	27.8	30.5	28.2	50.8
	Synthesis-2	39.4	40.0	47.5	26.7	29.3	31.7	53.8
	U-8544	–	–	42.2	24.1	41.2	37.5	52.0
	Hallmark	49.2	47.6	48.6	22.5	33.4	36.5	46.6
Mean		43.5	43.1	44.9	25.3	33.6	33.5	50.8
Tall fescue	Fawn	37.4	39.5	39.2	28.2	34.9	30.0	45.9
	Bull forage	–	42.7	43.5	34.5	30.5	28.3	48.4
	Ky 31	34.5	40.4	41.3	35.4	29.4	26.9	49.4
	Au-Triumph	38.7	35.2	47.6	30.9	32.8	34.3	42.6
	Felopa	46.2	50.8	52.3	30.0	38.0	33.9	46.9
Mean		39.2	41.7	44.8	31.8	33.1	30.7	46.6
Perennial ryegrass	Prisma	38.9	40.9	43.8	32.1	36.9	38.8	44.0
	1-6p	41.8	46.7	39.8	32.5	35.6	36.2	50.8
	Friend	41.3	40.3	42.1	33.5	36.7	38.3	46.3
	Hella	39.2	42.9	44.3	38.7	37.0	30.0	44.8
	Lipondo	39.8	43.1	40.6	27.1	33.5	33.0	45.7
Mean		40.2	42.8	42.1	32.8	35.9	35.3	46.3

Table 4. Continued

Species	Cultivar	Sampling time						
		May 6	May 20	Jun. 20	Jul. 20	Aug. 20	Sep. 20	Oct. 20
Kentucky bluegrass	Kenblue	45.1	45.1	51.1	33.7	30.0	35.3	49.4
	Aguila	38.3	47.5	46.6	35.4	30.9	27.1	54.2
	Oxford	40.4	39.7	41.4	31.8	40.2	32.5	52.7
	Troy	–	35.5	41.6	31.7	32.7	26.9	–
	Asset	–	32.4	38.6	32.4	28.4	–	–
Mean		41.3	40.0	43.9	33.0	32.4	30.5	52.1
Italian ryegrass	Tetrone	46.0	39.8	41.4	31.9	32.8	39.4	56.3
	Ramultra	39.8	38.0	40.3	33.9	34.2	36.7	45.3
	Florida 80	39.6	42.6	43.2	32.4	31.5	34.5	43.6
	Bettina	40.5	42.2	41.8	33.2	35.3	31.7	43.2
	Macho	43.9	40.6	39.3	34.0	38.2	38.6	44.5
Mean		42.0	40.6	41.2	33.1	34.4	36.2	46.6
Timothy	Clair	34.6	33.8	43.5	23.6	24.7	27.0	47.3
	Climax	36.3	42.5	41.3	24.1	24.2	24.6	42.9
	Hokusen	30.7	36.9	33.5	32.9	31.5	24.9	–
	Liphlea	32.7	32.0	34.7	27.5	25.2	22.0	41.2
Mean		33.6	36.3	38.3	27.0	26.4	24.6	43.8
Reed canarygrass	Venture	28.1	30.3	42.3	36.7	33.7	45.1	45.5
	Palaton	31.1	40.4	41.0	41.8	28.5	39.2	42.1
	Frontier	30.9	35.5	38.1	47.6	37.9	34.2	41.9
Mean		30.0	35.4	40.5	42.0	33.4	39.5	43.2
Alfalfa	Luna	49.2	51.1	54.0	39.5	50.8	51.7	52.9
	Vernal	41.4	50.3	47.0	49.0	41.5	42.0	48.5
	P-5444	51.2	50.2	55.1	53.6	48.4	45.1	49.4
	Anchor	49.0	51.5	55.7	63.9	44.4	39.9	50.3
Mean		47.7	50.8	53.0	51.5	46.3	44.7	50.3
White clover	California	38.5	34.0	41.8	46.6	52.0	49.1	50.2
	Star	39.7	47.3	54.6	44.6	50.6	40.3	46.3
	Milka	44.7	42.8	50.9	45.3	44.1	43.7	47.8
	Seminole	37.5	47.0	45.2	50.1	54.2	45.7	48.6
	NZ white	38.7	36.8	52.4	41.1	49.6	42.6	49.9
Mean		39.8	41.6	49.0	45.5	50.1	44.3	48.6
Red clover	Kenland	34.2	30.8	37.6	45.8	42.7	46.5	46.8
	Renegade	46.6	46.5	47.9	46.4	51.7	47.6	46.5
	Renova	35.2	43.7	42.7	56.1	47.4	44.1	44.2
	Ram	36.8	39.9	38.0	53.8	47.3	51.5	48.2
Mean		38.2	40.2	41.6	50.5	47.3	47.4	46.4
Hybrid ryegrass	Bison	41.9	42.2	42.2	33.8	35.5	31.8	48.6
Bentgrass	Penncross	33.2	44.7	46.4	34.3	39.7	39.0	45.7
Meadow fescue	Lifelix	41.3	48.2	42.6	33.1	37.2	38.2	49.9
Alkaligrass	Newhy	42.8	38.8	47.6	34.6	38.6	35.3	49.5

Turfgrass and cover plant species and cultivars used for experiment show the average SPAD reading value of moderate coloring turf to range from 33.6 to 43.5 on 6 May. These values agree generally with the values obtained on 20 May. SPAD reading values of six turfgrass species were very high on 20 May, and afterwards decreased till about the middle of September and again increased rapidly about in the late October. The sudden and sharp increment about mid and late October seemed to be related to moderate conditions of a fall weather to suit for plants to grow.

The changes of reading values in orchardgrass cultivars were somewhat variable, and little consistent trends between cultivars were apparent. Until 20 June, the values of SPAD reading in 'Synthesis-2' and 'Hallmark' reached the values of 47.5 and 48.6 in SPAD reading, respectively. However, 'Hallmark' showed sharp decline on 20 October, which was the lowest value among the four cultivars.

Tall fescue cultivars recorded the lower value than orchardgrass cultivars. There was a pronounced increase in cultivar 'Felopa' by 50.8 on 20 May and 52.3 on 20 June but was considerably variable according to the cultivar.

Average SPAD reading values in perenneal ryegrass were not very high in late spring and summer. In late June, difference in value between cultivars was not significantly remarkable except cultivar 'Ripondo', but reading values were relatively higher than orchardgrass or tall fescue cultivars in June. No particular cultivar with high reading value of above 50 was detected except '1-6p' in perennial ryegrass in late October. This implies that there exists no varietal difference in color retention until mid- or late October.

The favorable conditions which prevailed during relatively low temperature period enhanced the SPAD reading value by average 52.1 in Kentucky bluegrass. 'Aguila' Kentucky bluegrass was 54.7 in value on 20 October, which was highest of Kentucky bluegrass cultivars as well as species and cultivars such as 'Synthesis-2' orchardgrass and 'Ky 31' tall fescue. The reading value in 'Tetrone' Italian ryegrass reach 56.3, this being highest of all turfgrass cultivars but other Italian ryegrass cultivars recorded less than 45.

Generally, Kentucky bluegrass and orchardgrass as given by the favorable conditions, which prevailed during late growth stages, resulted in a notable coloration increment irrespective of cultivars. Thus progressive increment of average SPAD reading value until mid-June can be associated with the suitable condition of radiation and precipitation.

As in perennial ryegrass, the average SPAD reading value in the white clover cultivars was also relatively low in the late spring(Table 4). Until 20 June, the average reading value exceeded 49.0 and then lowered 45.5 on 20 July. These values considerably began to fluctuate as growth became more pronounced and the plants matured. Maximum reading values were obtained by 'Star' and 'NZ white' on 20 June where their values were 54.6 and 52.4, respectively. On the other hand, the average reading value in the red clover cultivars consistently increased until late spring growth, and then showed little, if any, change that could be attributed to varietal character.

Alfalfa cultivars showed higher average reading values on 6 May than other legumes (see Table 4). This trend continued to 20 July when the average reading value was 51.5. 'Anchor' alfalfa retained the highest value of 63.9 on 20 June among the leguminous plants. After 20 August, however, a reading value was clearly higher in 'Luma' than in 'Anchor'.

Morphological characteristics of turfgrass and cover plant species and cultivars during the growth period 6 May to 11 November 1995 are presented in Table 5.

These data were obtained from constrained areas in the Experiemtnal Farm at Live-

Table 5. Morphological characteristics of turfs and cover plants

Species	Cultivar	Length of green leaf(cm)			Leaf width	Inflorescence or flowering		Plant performance rating	
		May 6	May 20	Jun. 20	(cm)	Aug. 20	Sep. 20	Oct. 20	Nov. 11
Orchardgrass	Potomac	9.0	13.0	30.0	7.2	INF	–	8.1	9.0
	Synthesis-2	9.5	14.0	45.0	8.1	–	–	8.0	9.1
	U-8544	–	–	20.0	5.2	INF	–	7.3	8.4
	Hallmark	5.0	9.0	25.0	4.1	INF	–	7.5	8.6
Tallfescue	Fawn	9.0	14.0	30.0	8.0	–	INF	8.8	9.4
	Bull forage	3.0	9.0	20.0	10.1	INF	INF	8.1	9.1
	Ky 31	10.0	12.0	40.0	9.2	INF	INF	8.8	9.5
	Au-Triumph	10.0	16.0	50.0	8.6	–	INF	9.0	9.5
	Felopa	11.0	20.0	70.0	8.0	INF	INF	9.0	9.4
Perennial ryegrass	Prisma	13.0	22.0	50.0	3.5	–	–	8.0	8.6
	1-6p	8.0	11.0	27.0	3.0	–	–	8.5	9.0
	Friend	9.0	13.0	40.0	3.4	INF	–	8.4	9.0
	Hella	8.0	11.0	30.0	3.1	INF	–	8.2	8.6
	Lipondo	10.0	13.0	25.0	3.0	–	–	8.0	8.3
Kentucky bluegrass	Kenblue	5.0	10.0	24.0	3.4	–	–	8.0	8.3
	Aguila	4.0	10.0	25.0	3.0	–	–	5.1	7.4
	Oxford	4.0	12.0	24.0	3.3	–	–	8.3	9.0
	Troy	–	4.0	17.0	3.5	INF	–	7.0	7.5
	Asset	–	3.0	10.0	3.2	INF	–	6.7	7.4
Italian ryegrass	Tetrone	14.0	26.0	45.0	3.2	INF	–	8.8	9.0
	Rarmultra	18.0	28.0	35.0	5.2	–	–	8.4	9.0
	Florida 80	20.0	38.0	70.0	5.3	–	–	8.7	8.9
	Bettina	12.0	20.0	40.0	5.2	–	–	8.1	8.8
	Macho	13.0	25.0	45.0	5.6	–	–	8.0	8.8
Timothy	Clair	5.0	12.0	45.0	7.0	–	–	8.0	8.7
	Climax	5.0	9.0	25.0	7.0	–	–	7.0	8.0
	Hokusen	3.0	7.0	20.0	6.7	–	–	7.1	7.9
	Liphlea	5.0	9.0	25.0	6.7	–	–	7.4	8.1
Reed canarygrass	Venture	2.0	10.0	40.0	14.3	–	–	8.0	8.1
	Palaton	2.0	5.0	25.0	15.2	–	–	7.0	7.9
	Frontier	4.0	10.0	40.0	13.1	–	–	8.0	8.5

Table 5. Contiuned

Species	Cultivar	Length of green leaf(cm)			Leaf width	Infloresecence or flowering		Plant perfor-mance rating	
		May 6	May 20	Jun. 20	(cm)	Aug. 20	Sep. 20	Oct. 20	Nov. 11
Alfalfa	Luna	2.5	10.0	25.0	13.1	–	FLO	8.0	8.0
	Vernal	2.0	8.0	24.0	13.2	–	FLO	5.2	5.0
	P-5444	5.0	15.0	40.0	13.0	–	FLO	6.6	6.4
	Anchor	3.0	9.0	27.0	12.5	–	–	5.0	5.1
White clover	California	1.0	5.0	20.0	12.8	–	–	–	–
	Star	2.0	9.0	20.0	13.0	–	–	–	–
	Milka	2.0	8.0	17.0	12.7	–	–	–	–
	Seminole	3.0	12.0	20.0	13.2	–	–	5.5	5.4
	NZ white	1.5	5.0	10.0	13.1	–	–	–	–
Red clover	Kenland	1.0	3.0	10.0	17.2	–	–	6.8	5.5
	Renegade	4.0	9.0	21.0	15.2	FLO	FLO	8.0	8.0
	Renova	5.0	18.0	24.0	17.5	FLO	FLO	8.0	8.0
	Ram	5.0	15.0	25.0	22.3	–	FLO	8.7	8.9
Hybrid ryegrass	Bison	9.0	24.0	55.0	5.2	–	–	8.3	9.0
Bentgrass	Penncross	4.0	11.0	25.0	3.2	–	–	8.5	9.0
Medow fescue	Lifelix	6.0	18.0	35.0	6.2	–	–	8.0	8.8
Alkaligrass	Newhy	5.0	14.0	35.0	4.1	–	–	8.5	8.5

Performance ratings based on 9=best; 1=poorest, and 6 acceptable.

stock Research Institute, RDA. The data do not represent the seasonal trends of leaf growth from 20 June onwards. However, inflorescnece in grasses and flowers in legumes could be investigated without any trouble.

Leaf length of the plants as measured on 20 June varied remarkably between species and cultivars. The plants with leaves of more than 10 cm long on 6 May were : tall fescue cultivars such as 'Ky 31', 'Au-Triumph' and 'Felopa'; 'Prima' perennial ryegrass; Italian ryegrass cultivars such as 'Tetrone', 'Ramultra', 'Florida 80', 'Bettina' and 'Mach'. All cultivars of Italian ryegrass had positive linear functions of seasonal advance.

The leaves of 'Fellopa' tall fescue and 'Florida 80' Italian ryegrass were obtained on 20 June with length ranging up to a maximum of 70 cm. Considering that leaves with more than 50 cm long play an important role as soil cover function, 'Bison' hybrid ryegrass, 'Florida 80' and 'Au-Triumph' tall fescue are closer to this line.

Leaf width data showed little significant difference between cultivars in similar species. Orchardgrass and tall fescue cultivars among grass species except reed canarygrass had notably broader leaves than other species to the end of the growing season.

Small species differences in grass and legume performance occurred on both 20 October and 11 November (Table 5). In the absence of additional fertilizer application, 7.3 to 8.1 ratings of orchardgrass cultivars was obtained on 20 October and then 8.4 to 9.4 ratings on

Table 6. Munsell color notations of 42 turfgrasses and cover plants as measured by Korean Standard Color Charts on 11 November 1995

Munsell color notation	Species	Cultivar
5GY 4/4	Kentucky bluegrass	'Oxford'
	Kentucky bluegrass	'Aguila'
	Kentucky bluegrass	'Kenblue'
	Timothy	'Climax'
	Timothy	'Clair'
	Reed canarygrass	'Palaton'
	Reed canarygrass	'Frontier'
	Reed canarygrass	'Venture'
	Red clover	'Ram'
	Red clover	'Renova'
5GY 4/6	Italian ryegrass	'Florida 80'
	Timothy	'Liphlea'
	Alkaligrass	'Newhy'
	Red clover	'Kenland'
5GY 4/8	White clover	'Seminole'
5GY 3/4	Perennial ryegrass	'Lipondo'
	Perennial ryegrass	'Prisma'
	Italian ryegrass	'Barmultra'
	Italian ryegrass	'Macho'
	Kentucky bluegrass	'Troy'
	Orchardgrass	'Hallmark'
	Orchardgrass	'Syn. No. 2'
	Hybrid ryegrass	'Bison'
	Alfalfa	'P-5444'
5GY 3/6	Perennial ryegrass	'Hella'
	Perennial ryegrass	'1-6p'
	Perennial ryegrass	'Friend
	Italian ryegrass	'Bettina'
	Orchardgrass	'Potomac'
	Alfalfa	'Anchor'
	Alfalfa	'Luna'
	Red clover	'Renegade'
7.5GY 4/4	Tall fescue	'Bull forage'
	Tall fescue	'Au-Triumph'
	Tall fescue	'Felopa'
	Tall fescue	'Fawn'
	Meadow fescue	'Lifelix'
7.5GY 3/4	Kentucky bluegrass	'Asset'
	Orchardgrass	'U-8544'
	Tall fescue	'Ky 31'
7.5GY 3/6	Bentgrass	'Penncross'
	Italian ryegrass	'Tetrone'

11 November. In the other speices, particularly in tall fescue and Italian ryegrass, the number of plants representing high ratings increased greatly by 11 November. Italian ryegrass cultivars showed the range of between 8.0 to 8.8 ratings in the first observation on 20 October and then 8.8 to 9.0 ratings in the second observation on 11 November.

Even in tall fescue, ratings ranged from 8.1 to 9.0 in the first observation and then 9.1 to 9.5 in the second.

Table 6 shows Munsell color notations of 42 commonly used turfgrass and cover plant species and cultivars as measured 11 November 1955. A wide range of colors exists among turfgrass and cover plant species and cultivars, and differences in leaf color among species or cultivars varied on the end of observation date.

Applying fertilizer uniformly until the end of the growing season gave a remarkable effect of color retention in turfgrass and cover plant species and cultivars. Among 42 species and cultivars, were 32 within the range of 5GY category, and particularly 17 species and cultivars had the notation of 5GY 3/4 or 3/6. All cultivars of perennial ryegrass and orchargrass except 'U-8544' were also within their categories.

Ranging from notation 5GY 4/4 to 4/8 were 15 species and cultivars : all three cultivars of reed canarygrass, and Kentucky bluegrass cultivars such as 'Oxford', 'Aguila' and 'Kenblue' showed still a similar pattern for early November environment negatively correlated with actual low temperature.

Also, most of Kentucky bluegrass cultivars belonged under the 5GY category with the exception of 'Asset'. All perennial ryegrass cultivars were found to belong under the category of 5GY 3/4~3/8. On the other hand, five tall fescue cultivars showed 7.5 GY 3/4~4/4.

'Asset' Kentucky bluegrass, 'U-8544' orchardgrass, 'Ky 31' tall fescue and 'Tetrone' Italian ruegrass could be rated as 7.5GY 3/4 and 3/6 types. Meanwhile, tall fescue cultivars as a whole were found to remain within the category of 7.5GY 4/4 type.

DISCUSSION

Assessment of the N status of tufgrasses or cover plants for landscape is traditionally based on the N concentration of leaves of the current season's growth. In general, such leaf concentration information has been used to evaluate the leaf color and to correct the next season's potential nutrients stress. Thus, a more interactive approach to turfgrass nutrients that would allow mornitoring of turfs nutrition status throughout the growing season is desirable.

1. The effects of the different treatments on turf color

The SPAD chlorophyll meter used in this trial is to assess the N status of leaves in a variety of annual crop(Follet *et al.*, 1992; Piekielek and Fox, 1992; Turner and Jund, 1991). It is true that there is insufficient background information available to relate plant N concentration to N requirements at various growth and fruiting stages. However, given the flexibility and speed of SPAD measurements, a possible role is likely to be seen for using a SPAD meter to estimate folia N status in the field. The SPAD reading values here reported is representing the level of chlorophyll containing in leaf blade. Recently improved spectrometer was used to objectively evaluate turfgrass color. These methods of color evaluation are correlated with turf grass color but do not represent the true color of the turf as a whole(Beard, 1973). Although the acculate measurement of turfgrass color is slightly critical since color acceptibility is based on personal preference, the utilization of means to use the appropriate instrument for rapid measurement of chlorophyll status in plant fractions including leaf blade will be easily popularized.

The effects of nitrogen application and cutting treatment on the coloration of turf leaves were to a large extent in accordance with general experience. Thus a high coloration was maintained even at moderate nitrogen level, and leaf performance tended to be comparatively favorable. In the first experiment conducted, nitrogen effect on coloration of turfgrass was most remarkable in perennial ryegrass: increase by applying nitrogen reached 94.5%, whilst 69.6% with Italian ryegrass. The results that relatively low effect of N application on color increment was recorded in Korean lawngrass or Manilagrass seemed to be due partly to varietal characteristics possed by turgrasses. Somewhat analogous observations demonstrated by Piekielck and Fox(1992) in maize suggest that this was probably a sequence of a positive correlation and linear regression between the green color of the turf and the amount of nitrogen applied. Also, the foregoing results show that in the simulated trial SPAD readings representing color performance were considerably higher in two Zoysiagrasses than in two *Lolium* species or tall fescue under the condition of continuous suppliment of nitrogen.

SPAD readings from non-treatments appeared to differ less markedly, but those of Italian ryegrass were still at a disadvantage. However, green color in the two Zoysiagrasses was more responsive to cutting practice. The results that SPAD readings were reduced by cutting practice with cool season turfgrasses as compared to Zoysiagrasses would be attributed to restriction of restoration from injuries after cuts and to slow regrowth following high temperature stress. Therefore, cutting practice in summer period may play a role as a variable to retain the green color in turfgrasses.

The fact that SPAD readings were lower from nitrogen plus cutting treatment than from nitrogen alone, particularly with cool season turfgrasses rather than with Zoysiagrasses. Under other circumstances interactions between nitrogen applied and cutting treatment may lead to other results(Alison, 1966).

As can be seen in the second experiemnt, turfgrasses or cover plants had a considerably low content of chlorophyll in mid-July where nitrogen or regular cutting treatment were not input. This case was also in line with that in the first experiment. Particularly under the field conditon, failure of increasing the reading value in mid-July in grasses is due partly to a) increased reproductive part after the begining of flowering, b) a plenty of dead parts with yellowish leaf blade attached on tillers following regular summer mowing practice, c) excessive shortening combined with the postponement of growth because of high temperature, and d) physiological stress following unfavorable growth period.

The factor which excercised the greatest influence upon blade life-span was nitrogen fertiizer, and the responses to this nitrogen of green leaf life-span, which is indicating a longevity of retaining the green color in a leaf blade, were striking. Namely, the life-spans of cool- and warm-season turfgrasses were increased by 8 and 10 weeks, respectively, by applying nitrogen fertilizer. The longevity of leaf blades attached on tillers of turfgrasses here reported when investigated on 26 April, 2 May and 19 June following nitrogen application was relatively shorter than what Davies(1969) had studied for S-24 perennial ryegrass in U.K.

Although the general pattern of green leaves of turfgrass receiving nitrogen is to decreased its life span, the results obtained in this study was quite contrary to the fact that Davies(1969) found. The interpretation advocated is based on the fact that the extent of the effect of nitrogen on decrease in the life-span of green leaf blade coincides with the period when the leaf appearence rate was most markedly stimulated. In other words, these effects are correlated resposnes bound up with the developmental activity by fertilizer N leading to accelerated senescence of fully expended green leaf blades.

On the other hand, Shim(1966) demonstrated that the life-span of culm leaf blades in Korean lawngrass would be increased by application of nitrogen shortly before head emergence. The overall data here presented may be in line with this results.

In spite of the presence of nitrogen, leaves appeared in early May excercised a suppressive influence over the following leaves, and thus stimulated the secenscence of leaves emerging in mid-June resulting in reduction of nitrogen effect to extend the longevity in both Italian ryegrass and perennial ryegrass.

Korean lawngrass and Manilagrass had their durable abilities to prolong the life-span of leaves as compared to cool season turfgrasses. This phenomenon might be related to the physiological characteristics that responses to temperature, or other nutritional media, vary according to species. It can be explained that proteolysis in leaves of warm season grasses initiates quite slowly even after the development of inflorescence, which is contrary to that in leaves of cool season grasses.

2. The change of color notation

Korean Standard Color charts, together with SPAD reading value, were used to assess the level of color status in leaf blade. In this trial color charts had been used as reference points in the determination of the actual turfgrass color. A wide range of colors exists among turfgrass species and cultivars(Butler, 1963).

Color is a consideration in mixing turfgrass species or blending cultivars. For example, the light, yellow green color of rough bluegrass is not compatible with the color of the commonly used Kentucky bluegrasses, while the color of Pennlawn red fescue blends quite well. The ability to retain a green color in late fall or over the winter period is also an important characteristic to be considered in selecting improved cultivars.

As long as about 3 to 4 months of the winter period and 2 months of summer depression period a year are existed, retaining green color before and after turfgrass growing season may be difficult, in fact, to maintain the green fields satisfying players or the landscape harmonized.

Mixtures of two or three species produce better color, as each reaches its period of maximum growth at different times. In British conditions, fescues are of better appearance during April, May, and June, although they have a poor winter color. *Agrostis* species are more noticeable during July, August, September, and October; perennial ryegrass has good color during the spring and fall; rough-stalked meadowgrass and crested dogstail are usually wintergreen and *Poa annua* is often at its best in winter(Davies, 1969).

However, geographycal or climatical conditions in order to achieve an acceptable level of turfgrass quality should be considered. For example, redtop is not particularly acceptable for use in mixtures with Kentucky bluegrass and red fescue since it has a gray-green color that disrupts the appearance of a Kentucky bluegrass-red fescue polystand(Davis, 1961). Similarly, the light green color of Italian ryegrass are objectionable for use in mixture with Kentucky bluegrass and red fescue.

In this connection, we observed the color change for turfgrasses and cover plants over the growing period and for five turfgrasses on specific dates of the late growing season. All turfgrasses were 5GY type, or grass green color, and 10GY type, or olive gree color in late September under the condition of no external practice input. These color status was changed to 7.5-10YR type, or moderate reddish yellow to orangey yellow color, and 2.5Y type, or moderate yellow color, in early November. It could be observed apparently to be yellowed densely in warm-season turfgrasses such as Zoysiagrass. An adverse effect on changing coloration following nitrogen application was apparent on both 21 September and 6 November : Italian ryegrass, perennial ryegrass and tall fescue could maintain the status of 5 GY types, or yellow green color.

On the other hand, color notations in both Zoysiagrass were 7.5Y, or moderate yellow color, in Manilagrass and 7.5YR, or moderate reddish yellow color, in Korean lawngrass. These results were fully agreed with the findings obtained by Shim and Yun's study (1987) in which green color was extended to early November by applying nitrogen.

The fact that little particular difference between the treatments of nitrogen application alone and nitrogen plus cutting practice could be detected indicates that the coloration of turfgrasses does not respond to the effect of mowing as noted by Beard (1973). As data shown in Table 2, the colors responded by cutting practice were 10YR 2/2 for both Italian ryegrass and perennial ryegrass, 10YR 3/6 for tall fescue, 7.5YR 4/4 for Korean lawngrass and 2.5 Y 6/8 for Manilagrass.

In the late fall when most of warm season grasses loose chlorophyll containing in leaf blade, a large number of turfs and cover plants investigated in the second experiment be-

long within the category of 5 GY and 7.5 GY, indicating yellow green. However, there existed the various diversified nature of color among 48 different species and/or cultivars, and this possibly gives us an example to utilize in terms of colorful landscape consideration of mixing species or blending cultivars in gardens and other places for the purpose of color harmony.

摘 要

生育期間 중 窒素施肥 및 刈草가 寒地型 및 暖地型 地被植物類의 葉色變化特性에 미치는 영향을 調査하였다. 또한 본 연구는 窒素가 葉色發現要素의 形態的 特性에 미치는 反應 관계도 포함하고 있다. 폿트실험에서 사용된 供試草種은 Ramultra 이탈리안 라이그래스, Reveile 페레니알 라이그래스, Arid 톨페스큐 및 들잔디, 금잔디 등 5개 초종이며 窒素 시비(350kg/N/ha)와 刈草 두 要因으로 실시하였다. 窒素는 全量의 1/2을 基肥로 하였고 殘餘量은 追肥로 각 刈草時에 分割施肥하였다. 刈草는 5월하순, 6월하순, 7월하순 및 8월하순에 실시하였다. 폿트내 土壤은 排水가 양호한 砂壤土를 充塡하였다.

圃場實驗에서는 48개 品種 및 草種을 사용하였으며, 이들을 對象으로 1995년 5월 6일부터 10월 20일 까지 葉色調査를 실시하였다. 또한 48개 草種중 草勢가 良好한 試驗區에서 42개 초종을 대상으로 葉長, 葉幅, 花序 및 開花狀態를 測定하고 生育期 最終日에는 目測에 의한 植物狀態를 觀測하였다.

폿트시험 및 포장시험에 供試된 잔디 草種을 대상으로 4월부터 11월까지 SPAD葉綠素測定器를 이용한 葉色變化를 측정하였다. 이 조사에는 携帶用 SPAD葉綠素 測定器를 사용하여 측정하였다. 이 두 種類의 實驗을 통해 얻어진 結果를 綜合하면 다음과 같다.

1. 平均 SPAD價는 窒素 및 刈草處理를 하지 않은 試驗區에서는 供試된 5개 잔디 草種間에 큰 차이가 없었다. 다만 Reveile 페레니알 라이그래스 草種에서만 다른 잔디草種에 비하여 가장 낮은 SPAD價가 나타났다. 그러나 窒素處理區에서는 Ramultra 이탈리안 라이그래스 및 Reveile 페레니알 라이그래스는 SPAD價가 각각 44 및 44.9를 記錄하여 들잔디 및 금잔디의 36과 34.6보다 有意的으로 높았다. 한편 刈草를 한 경우에는 오히려 들잔디나 금잔디가 더 有意的으로 높아 SPAD價에 있어서 刈草는 暖地型 및 寒地型間 葉綠素含量差에 하나의 變數로 作用하고 있었다. 窒素 및 刈草의 同時處理區에서는 窒素 單一 處理區에서보다 오히려 SPAD價를 減少시키는 것으로 나타났으며 그 減少程度는 들잔디 및 금잔디에서보다 이탈리안 라이그래스, 페레니알 라이그래스 및 톨페스큐와 같은 寒地型 잔디類에서 더욱 顯著하였다.
2. 刈草單行處理區에서는 잔디草種에 관계없이 生育後期最終日에서는 對照區보다 오히려 SPAD價를 減少시키는 경향을 보였다.
3. 9월하순에 調査된 5개 잔디초종의 葉色은 窒素施肥나 刈草에 관계없이 거의 일정한 色度를 維持하고 있었다. 질소를 施用했을 때 11월초순에는 草種에 따라 달리 나타났다. 즉 이탈리안 라이그래스, 페레니알 라이그래스 및 톨 페스큐는 5 GY 3/1에서 4/8에 이르는 色度를 나타내고 있었지만 들잔디나 금잔디는 각각 7.5 YR 4/8 및 2.5 Y 5/6의 色度를 보여 寒地型 잔디가 여전히 理想的인 綠色을 유지하고 있었던데 비해 韓國잔디類는 典型的인 黃色을 띄고 있었다. 한편 窒素施肥와 刈草를 동시에 처리한 試驗區에서는 窒素單用處理한 시험구

에서의 결과와 크게 다르지 않았다.

4. 5개 잔디草種의 葉壽命은 5월초순에 出現한 잎이 無處理區에서 8.8週로 가장 길게 延長되었으며 질소를 시용했을 때는 9.7週였다. 품종별로 보면 전체적으로 韓國 잔디類가 寒地型 3개 잔디초종보다 葉壽命이 더 길었다. 특히 5월 2일에 출현한 葉은 질소시용의 경우 들잔디가 10.4週, 금잔디가 10.9週이었으며 無窒素 상태에서는 들잔디가 9.4週, 금잔디가 9.7週를 기록하였다. 이는 寒地型 잔디草種의 平均 8.3週(無窒素區의 경우)나 9.1週(窒素施用區)보다도 有意的으로 葉壽命이 延長된것을 알 수 있다.
5. 圃場條件에서 生長한 48개 잔디類 및 地被植物에 대한 SPAD價를 조사한 결과 대체로 全草種에서 6월 하순까지는 SPAD價가 增加하는 경향을 보이다가 夏季에 접어들면서 급격히 低下된 후 10월 중순에 다시 증가하는 경향을 보였다. 그러나 클로버類나 리드 카나리그래스類에서는 이 경향이 뚜렷하게 나타나지 않았다. 또한 調査된 SPAD가는 草種과 同一 草種내에서 品種間에 차이를 보이고 있어서 混播時에 色度를 勘案하여 초종을 선택해야 할 것으로 思料되었다.
6. 圃場條件에서 調査된 잔디류 및 지피식물의 草長은 6월하순경에 이르러 크게 伸長하였으나 伸長幅은 草種에 따라 다르게 나타났다. 또한 植物狀態 역시 초종과 동일 초종내 품종에 따라서 차이가 있음을 確認하였다.
7. 11월 중순, 42개 草種에 대해 韓國標準色度帖에 의해 葉色을 조사한 결과 5 GY에 속하는 것은 32개 초종이었고, 나머지 10개초종은 7.5 GY에 속하여 寒地型 잔디類 및 地被植物은 11월 초순까지 약간의 황색을 띈 녹색인 5 GY 내지는 7.5 GY에 속한다는 것을 확인할 수 있었다.

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