窒素施用과 刈草間隔이 韓国잔디(*Zoysia japonica* Steud.)의 主要營養成分 및 可溶性炭水貨物含量에 미치는 影響

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Effects of Nitrogen Fertilization and Clipping Interval on Mineral and Water-soluble Carbohydrate Contents in Korean Lawngrass (*Zoysia japonica* Steud.)

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摘 要

窒素肥料 3水準(0, 350, 700kg N $^-$ha^{-1} year^{-1}) 및 刈草間隔 3水準(10, 20, 30日間隔)下에서 이 要因들이 植物體 各部位(葉, 葉鞘를 포함한 差, 匍匐莖 및 根)內 N, P, K, Ca, Mg 및 可溶性炭水化物含量에 如何히 影響을 미치는가에 대해서 1983年 6月부터 10月까지 大田 培材大學實驗圃場에서 造成한지 3年지난 韓國잔디를 대상으로 實驗하였던 바 얻어진 結果는 다음과 같다.

1. 窒素를 增施한 결과 식물체 各部位內 N 含量은 增加하였다. 特히 N 成分은 葉部位에 多量으로 集積되어 있어 貯臟養分으로서의 役割을 하지 못하는 것으로 思料되었다.

2. 窒素肥料에 대한 P 成分의 反應은 植物體部位에 따라 變化가 심하게 나타났는데 葉部位에서는 P 含量이 減少한 反面, 莖 및 匍匐莖에서는 刈草間隔이 30日에서 10日로 短縮되었을 때 한하여 增加하는 樣相을 보였다.

3. K 含量은 窒素를 增量施用할때 葉과 莖部位에 특히 많이 蓄積되었으며 根部位에서는 窒素施用이 오히려 K 含量을 減少시키는 要因으로 作用하였다. 그러나 N 과 K 含量間에는 地上部位와 匍匐莖에서 正의 相關關係가 認定되었다.

4. Ca 含量은 葉과 莖部位에서 刈草間隔을 짧게 하였을때 窒素施用에 따른 負의 反應을 보였다.

5. Mg 含量은 窒素나 刈草間隔에 거의 影響을 받지 않았다.

6. 可溶性炭水化物含量은 窒素施用量이 增加함에 따라 比例的으로 減少하였다. 그러나 刈草間隔의 影響은 莖部位를 除外한 各部位에서 나타나지 않았다.

7. 營養成分에 대한 刈草間隔의 効果는 窒素만큼 크지 않았으나 窒素施用과 함께 나타난 有意的 變化는 部位別로 각각 다르게 表現되었다. 즉 N 含量은 刈草間隔을 短縮하였을 때 葉 및 莖部位에서만 增加되었고 Ca 含量은 30日間隔으로 延長할 때만 增加되는 傾向이었다. 한편 K 및 Mg 含量은 刈草間隔에 의해 影響을 받지 않거나 變動이 심한 狀況으로 나타났다.

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I. Introduction

Korean lawngrass is increasingly being accepted as an important turfgrass species, particularly with the introduction to soil conservation and sport field. Korean lawngrass has better high temperature and drought stress performance compared to other warm season grasses grown in Korea. This may be attributed partially to its physiological characteristics and prolific stolon and root systems.

In a preceding paper (Shim and Yun, 1987), the effects of three nitrogen regimes and three clipping treatments on the yield of Korean lawngrass was reported. In this paper, effects of the same nitrogen rates and clipping intervals on the mineral contents of Korean lawngrass will be reported.

The percent mineral content of warm season turfgrass has been used to indicaste the physiological status of the plant. However, there have been few, if any, studies on environmental changes in mineral content of warm season turfgrasses grown under field conditions. Recently, Shim(1985) has reported on a field study of the seasonal factors affecting nitrogen content of Korean lawngrass. Wedin (1974) stated that the percentage of N in cool season grasses can range from less than 1.5 for N-deficient, mature grasses to several times more. Dotzenko (1961) found that 717kgN ha^{-1} $year^{-1}$ increased the N concentration of smooth bromegrass from 2.2 to 3.4% and that of tall fescue from 1.8 to 2.9%. On the other hand, Shim(1985) found that 300kg ha^{-1} $year^{-1}$ increased N content of Korean lawngrass from 0.9 to 1.6%.

Reid et al. (1970) found that N concentration increased K and Ca concentration but reduced P concentration in tall fescue. High levels of N application increased Mg concentration somewhat.

The water-soluble carbohydrate of plant tissue is an indication of grass regrowth potential. Rhykerd et al. (1966) reported that N fertilizer at rates up to 1345kg ha^{-1} $year^{-1}$ resulted in a highly significant decrease in percentage soluble carbohydrate in orchardgrass, but did not significantly affect the content in bromegrass or timothy.

Joo(1983) pointed out that during July to early August total nonstructural carbohydrate content was reduced in above- and under-ground parts of Korean lawngrass followed by the increment in under-ground part prior to dormancy in mid-autumn.

Shim(1982) also stated that lengthening the interval between harvests decreased the N content of perennial ryegrass, this taking place irrespective of level of nitrogen.

The purpose of this study was to determine the effects of nitrogen and clipping treatments on the mineral content and water-soluble carbohydrate percentage of Korean lawngrass.

II. Materials and methods

The experiment was conducted on three-year old turf field. The status of the soil at the site was a light clay loam. The status of its phosphate and potash was slightly low, and water retention good.

Clippings were collected from late June, 1984, from the study employing three mowing intervals (10, 20, and 30 days, this being equivalent to 6, 6, and 4 mowings, respectively, during experimental period), and three nitorgen levels

(0, 350, and 700kg ha^{-1} $year^{-1}$) using urea (46%N).

In order to adjust the soil status, plots were also fertilized after mowing to supply phosphorus in the form of fused magnesium phosphate (250kg ha^{-1} $year^{-1}$) and potassium in the form of potassium chloride (200kg ha^{-1} $year^{-1}$).

A complete description of the study and dry matter yield data are reported in the accompanying paper (Shim and Yun, 1987).

The clippings were divided into leaf blade, stem including leaf sheath, stolon, and root. These fractions were dried for one hour at 100°C and then at 80°C in dry ovens to constant weight before grinding to pass through 40-mesh screen.

The samples were analyzed for total N using Analyzer system-2 (Fison Co.) Phosphorus, kalium, calcium and magnesium were determined by the method of the A.O.A.C. (1970), and water soluble carbohydrate was analyzed by the method of Smith (1969).

III. Results and discussion

Nitrogen percentage

Fertilizer and clipping studies on Korean lawngrass showed the concentration of nitrogen was significantly influenced by the nitrogen fertilizer applied, increasing with increased levels of nitrogen (Table 1). The influence of clipping treatment on the N concentration was generally not large. In leaves and stems, however, lengthening the interval between cuts from 10 to 30 days caused a marked decrease in N concentration, especially when nitrogen was fertilized up to 700 kg ha^{-1}.

The average N concentration varied from 0.21 to 2.17% depending upon the levels of nitrogen fertilizer and plant fractions. These values are substantially lower than those observed by Shim(1975) who reported that N concentration in perennial ryegrass ranged between 1.86 and 3.84%. Even though perennial ryegrass was not fertilized with nitrogen, the average N concentration of tops was about 3%, thus being still higher than that obtained from Korean lawngrass. Turgeon et al. (1979), comparing eight perennial ryegrass cultivars and fifty three Kentucky bluegrass for the purpose of feeding value, reported that the range of N concentration* in both grasses were 4.2 to 4.8%, and 3.5 to 5.2%, respectively.

Phillips et al. (1954) and Sullivan et al. (1956) reported that N concentration in Kentucky bluegrass varied from 1.1 to 2.5%, which seem to be in line with the findings in this trial with Korean lawngrass.

Comparing plant fractions, nitrogen was contained three times as much in leaves as in roots, and approximately one and a half times as much as in stolons, this implying that N is neither accumulated as reserved nutrient nor used in root respiration.

* Data were transfermed from Cp Values.

Phosphorus percentage

Phosphorus concentration varied between plant fractions, ranging from average 0.08% for roots to average 0.25% for leaves.

In general, the response of mineral nutrients in perennial grasses to nitrogen fertilizer is not consistent. If a plenty of mineral nutrients exists in soil, their quantity in grass must be increased by adding a fertilizer N. Under the soil by the level of availability of mineral nutrients, on the other hand, the application of nitrogen fertilizer tends to accelerate the disappearance of nutrient such as phosphorus existing in plant

Table 1. Effect of nitrogen application and clipping interval on mineral and water-soluble carbohydrate contents in Korean lawngrass.

Plant fraction	Clipping interval	N			P			K			Ca			Mg			WSC+		
		Nitrogen level (kg ha^{-1} year^{-1})																	
		0	350	700	0	350	700	0	350	700	0	350	700	0	350	700	0	350	700
	day									%									
Leaf	10	1.14	1.63	2.17	0.25	0.24	0.21	3.69	3.88	4.04	0.17	0.16	0.15	0.08	0.07	0.08	12.2	10.3	8.6
	20	1.16	1.71	2.17	0.26	0.23	0.21	3.69	3.77	3.92	0.20	0.16	0.14	0.09	0.08	0.06	12.8	11.1	9.9
	30	1.12	1.50	1.96	0.26	0.25	0.25	3.66	4.01	3.99	0.18	0.18	0.18	0.08	0.08	0.07	14.5	10.2	9.0
	N		**			*			**			*			NS			**	
	C		*			NS			NS			*			NS			NS	
	NxC		NS			NS			*			*			NS			NS	
Stem§	10	0.70	1.13	1.66	0.18	0.21	0.23	3.64	3.67	3.940	0.18	0.17	0.13	0.09	0.08	0.08	20.0	15.4	11.0
	20	0.64	1.15	1.57	0.20	0.21	0.22	3.60	3.92	4.12	0.17	0.16	0.14	0.07	0.08	0.07	19.9	16.5	12.9
	30	0.75	1.02	1.30	0.21	0.22	0.21	3.46	3.90	4.16	0.17	0.15	0.15	0.08	0.08	0.07	23.3	17.5	15.3
	N		**			NS			**			*			NS			**	
	C		*			NS			NS			NS			NS			*	
	NxC		*			NS			NS			NS			NS			*	
Stolon	10	0.25	0.39	0.62	0.13	0.15	0.17	3.32	3.31	3.35	0.08	0.12	0.10	0.04	0.04	0.04	25.4	21.9	18.9
	20	0.31	0.44	0.78	0.14	0.14	0.15	3.30	3.45	3.46	0.10	0.10	0.09	0.04	0.04	0.03	27.1	22.7	18.8
	30	0.33	0.44	0.57	0.14	0.15	0.15	3.31	3.31	3.31	0.11	0.10	0.08	0.04	0.04	0.04	26.0	20.0	19.3
	N		**			NS			NS			NS			NS			**	
	C		NS			NS			NS			NS			NS			NS	
	NxC		NS			NS			NS			NS			NS			NS	
Root	10	0.23	0.32	0.40	0.07	0.10	0.07	3.16	3.15	3.12	0.08	0.10	0.11	0.03	0.03	0.03	9.1	8.3	8.1
	20	0.26	0.34	0.46	0.08	0.08	0.08	3.51	3.18	3.28	0.12	0.11	0.110	0.03	0.03	0.03	9.3	8.6	7.6
	30	0.21	0.34	0.39	0.09	0.09	0.09	3.17	3.16	3.16	0.09	0.10	0.10	0.03	0.03	0.03	10.1	9.2	9.3
	N		**			NS			*			NS			NS			*	
	C		NS			NS			NS			NS			NS			NS	
	NxC		NS			NS			*			NS			NS			NS	

§ : Including leaf sheath *, ** indicate 5 and 1% probabilities. NS: Not significant

+ : Water-soluble rarbohydrate

(Kershaw and Banton, 1965 ; MacLeod, 1965). Yuen and Pollard (1957) observed that the uptake of phosphate was not necessarily dependent upon that of nitrogen, although the absorption of phosphate was considerably affected by the form of nitrogen used. However, these results seem not to be the cases in Korean lawngrass. The data in this trial, averaged over nitrogen and clipping treatments, shows that nitrogen fertilizer decreased P concentration in leaf fraction of Korean lawngrass. Also, data for individual nitrogen levels on separate clipping treatment shows that nitrogen fertilizer did not affect grass P level on 30-day clipping intervals but, on 10-day treatments, it slightly increase P in stems and stolons, particularly when its rate of application was increased.

A possible reason for the trend toward increased P at the shortened period of clipping interval with higher nitrogen rates is that stands of Korean lawngrass on plots with high nitrogen were very thick. Shim and Yun(1987) reported that tiller numbers on plots with high nitrogen fertilizer and frequent cut were very much more than those on plots with low or nil nitrogen fertilizer and lengthened cut. Regrowth of grass after frequent clip comes from new shoots rather than from continued growth of old leaves: New shoots grown under high nitrogen fertilizer application contain as high concentration of P than do old shoots without nitrogen fertilizer (Eck et al., 1981).

Potassium percentage

The K concentration in all fractions of Korean lawngrass ranged between 3.15 and 4.16%, these being much higher percentage than N or P concentrations.

Nitrogen fertilizer increased K concentrations of leaves, stems, and stolons, probably due to the availability of soil K maintained by applying fertilizer K. Increases were linear between nitrogen levels. This broadly agreed with the general pattern described by Markland and Roberts (1969) who have tested the relationship between nitrogen level and K concentration in Washington creeping bentgrass.

Stolons and roots had lower K concentration than leaves and Stems.

Data also show that when Korean lawngrass was clipped at 30-day interval, nitrogen fertilizer had no influence on K concentration in stolons. It was notable, also, that K level in roots was slightly but significantly lower at 350kgN and 700kgN than at OkgN.

The reduction of K concentration with increasing nitrogen supply has also been reported by Mortensen(1964) and Eck et al. (1981). According to their results of experiments, by increasing the application of nitrogen fertilizer up to 336kgha^{-1} on smooth bromegrass and tall fescue, and up to 560kg ha on orchardgrass, K concentration was linearly increased. At higher rates than those amounts, however, increase of applied nitrogen affect K concentration less. In this point, the trend toward increased K in Korean lawngrass receiving more amount of nitrogen than 350kg ha implies that this grass might have a great potential of potassium efficiency following high rate of nitrogen applied.

A linear relation was detected between N and K concentration in tops and stolons of Korean lawngrass (Fig. 1), and thus, K concentration was significantly increased with increased N concentration. Kemp (1960) has shown that nitrogen supplies to the grass containing the amount of K above 2% normally increased K concentration in grass. This findings were in line with those in this experiment.

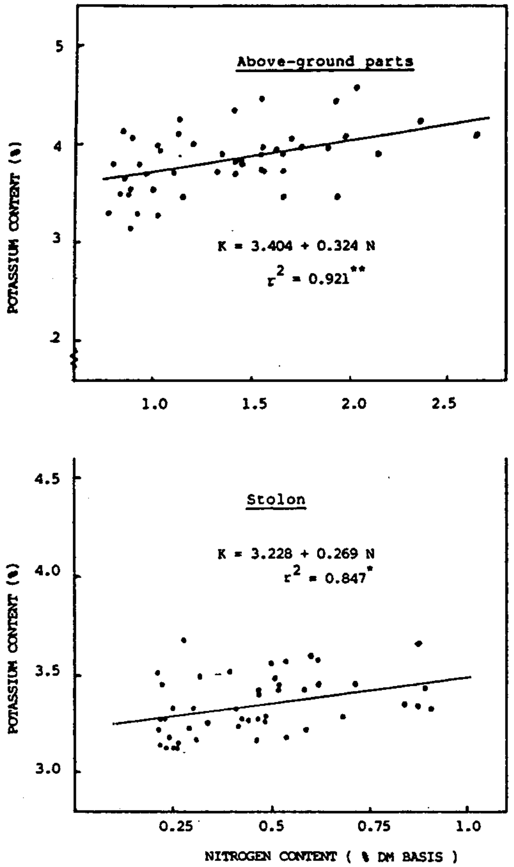

Fig. 1. Potassium content regressed against nitrogen content.
*, ** indicate 5 and 1% probabilities.

Calcium percentage

The average data showed that nitrogen fertilization caused a slight decrease in Ca concentration of Korean lawngrass but that the decrease was significant only at 10- and 20-day clipping treatments for leaves and stems. Meanwhile, Ca concentration tended to be increased only for leaves when clipping treatment was performed with lengthening interval between cuts, chiefly rather from 10 or 20 days to 30 days than from 10 to 20 days.

The Ca concentration of plant fraction was in the range 0.08-0.20%, which are relatively reasonable as compared to the figures proposed by deWit et al. (1963) that the critical level of Ca content for normal growth of grass is about 0.1%.

There appeared to be no consistent different in Ca concentration among levels of nitrogen both in stolons and roots, this nitrogen and clipping interval treatments had little effect on Ca levels in stolons and roots of Korean lawngrass.

Magnesium percentage

The average data showed that nitrogen fertilization and clipping interval treatments did not Mg concentration in plant fractions. Spedding and Diekmahns(1972) have reviewed several factors influencing the Mg content of coolseasongrass and stated that application of nitrogen fertilizer could appreciably affect herbage Mg levels. Eck et al. (1981) showed the experimental evidence that nitrogen fertilization increased Mg concentration in tall fescue but did not affect it in smooth bromegrass.

The average Mg concentration in Korean lawngrass ranged between 0.03 and 0.09%.

Leaves and stems contained considerably higher Mg than stolons or roots. The value for Mg contained in leaves or stems appeared to be above 0.06% which is the critical levels for forage, as indicated by the results of deWit et al. (1963).

Water-soluble carbohydrate(WSC) percentage

Nitrogen ferrtilizer had a substantial influence on WSC percentage in the fractions of Korean lawngrass. WSC percentage underwent a change according to the levels of nitrogen applied, decreasing from a high at 0kgN plot to a low at 700kgN plot. These results support earlier findings (Jones, et al., 1965).

It appeared, also, that WSC level of stolon was somewhat higher than that of other fractions, and WSC percentage occurred in the following order; stolon stem leaf root. Thus, the difference between stolons and leaves was as much as 2-fold, irrespective of clipping treatment. The average percentages were 26.2, 21.5, and 19% in stolons, and 21.1, 16.5, and 13.1% in stems at 0, 350, and 700kgN, respectively. Thus, the diversity in percentage between N levels of 0 and 700kg was 7.2% for stolons and 8% for stems.

The effect of lengthened interval between cuts on WSC percentage was detected in stem only: Lengthening interval from 10 to 30 days increased WSC up to 16.5% for 0kgN, 13.6% for 350kgN, and 39.1% for 700kgN.

Fig. 2 shows the negative linear regression between nitrogen and WSC percentage for plant fractions. WSC in stolons and roots tended to dissipate considerable as nitrogen was contained above 2%. Meanwhile, leaves showed a slow decline of WSC percentage, even though nitrogen content was increased up to 3%.

The carbohydrate reserves in grass represent an accumulation or surplus of material in excess of the immediate needs of the plant for growth and maintenance (Zanoni et al., 1969). Since the establishment of an adequate carbohydrate reserves is essential for producing good verdue (Madison, 1962), nitrogen and clipping practice should be adjusted to prevent the depletion of carbohydrate reserves.

It is reported that, while cutting height of approximately 4 cm was maintained, an exce-

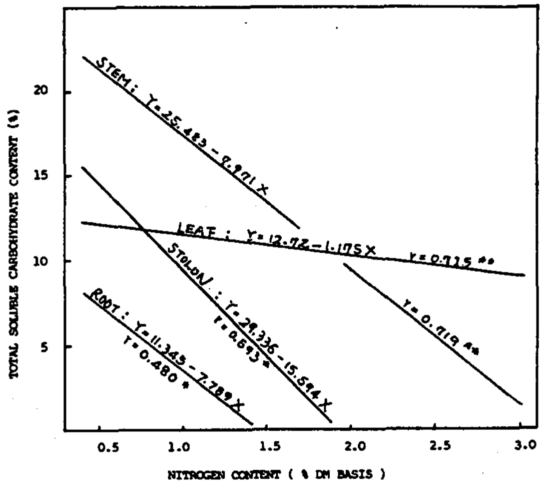

Fig. 2. Relationship between nitrogen content and total soluble carbohydrate content for plant fractions.
*, ** indicate 5 and 1% probabilities.

sive amount of leaf surface was not removed at any one mowing (Shim and Yun, 1987).

In this experiment, Korean lawngrass proved to reserve a great deal of carbohydrate in stolons and stems. If carbohydrate reserves in all fractions except for stems are not influenced by mowing frequency with adequate mowing height, 10 days interval between cuts may stimulate immediate shoot growth and tillering resulting in prompt sod forming.

IV. Summary

Changes in levels of nitrogen, phosphorus, kalium, calcium, magnesium, and water-soluble carbohydrate contents were determined for Korean lawngrass under three levels of nitrogen fertilizer (0, 350, and 700kg ha year) and three levels of clipping interval between cuts (10, 20, and 30 days).

Increasing the level of nitrogen fertilizer

increased the N concentration in all plant fractions (leaves, stems including leaf sheather, stolons, and roots) in the cases of all the clipping treatments. N was contained mostly in leaves, indicating that N is neither accumulated as a reserved nutrient nor used in root respiration. The response of P concentration to nitrogen fertilization fluctuated according to plant fractions: In leaves, N application decreased P concentration but an adverse trend occurred in stem and stolon tissues when clipping interval was shortened from 30 to 10 days. K concentration increased with increasing N rate in leaf and stem tissues but an adverse trend was detected in roots. And thus a positive correlation between N and K contents in both above-ground parts and stolons was established. Under the frequent clipping practice, Ca concentration had a negative response to nitrogen fertilizer for leaf and stem tissues. No influence of nitrogen and clipping treatments was detected for Mg concentration in Korean lawngrass. The percent of water-soluble carbohydrate(WSC) was inversely proportional to the nitrogen fertilization rate. The level of WSC in Korean lawngrass fractions varied little with clipping interval treatments except for stem tissue. The highest level measured averaged 26.2% in stolons at the level of OkgN, while, at the level of 700kgN, 19%WSC was marked.

Shortened clipping interval between cuts positively affected N percentage in leaf and stem

Shortened clipping interval between cuts positively affected N percentage in leaf and stem tissues, especially when two levels of N were fertilized. Little marked variation of K and Mg concentrations as affected by clipping treatment was found. A slight increment of Ca concentration by lengthening clipping interval from 10 to 30 days was obtained at 350 and 700kgN levels.

V. Reference

1. A.O.A.C. 1970. Official methods of analysis of the A.O.A.C. 11th ed.
2. DeWit, C.T., W. Dijkshoorn and J.C. Noggle. 1963. Ionic balance and growth of plants. Versl. landbouwk. Onderz. 69. 15, p. 69.
3. Dotzenko, A.D. 1961. Effect of different nitrogen levels on the yield, total nitrogen content, and nitrogen recovery of six grasses grown under irrigation. Agron. J. 53: 131-133.
4. Eck, H.V., G.C. Wilson, and Tito Martinez. 1981' Tall foscu and smooth bromegrass. II. Effects of nitrogen fertilization and irrigation regimes on quality. Agron. J. 73: 453-456.
5. Jones, D.I.H., G. ApGrifith and R.J.K. Walters. 1965. The effect of nitrogen fertilizers on the water-soluble carbohydrate content of grasses. J. Agric. Sci. 64: 323-328.
6. Joo, Y.K. 1983. Seasonal changes of growth and major nutrients, and effects of mowing on *Zoysia japonica* Steud. and Poa pratensis L. M. Sc. Thesis, Seoul Nat'l. Univ.
7. Kemp, A. 1960. Hypomagnesaemia in milking caw: the response of serum magnesium to alterations in herbage composition resulting from potash and nitrogen dressings on pasture. Neth. J. Agric. Sci. 8: 281-304.
8. Kershaw, E.S. and C.L. Banton. 1965. The mineral content of S22 ryegrass on calcareous loam soil in response to fertilizer

treatments. J. Sci. Fd Agric. 16: 698-701.

9. MacLeod, L.B. 1965. Effect of nitrogen and potassium on the yield, botanical composition on yield and stands of tall fescue. Crop Sci. 7(6): 567-570.

10 Madison, J.H. 1962. Effect of mowing, irrigation, and nitrogen treatments of Agrostis palustris Huds., 'Seaside' and Agrostis tennuis Sibth., 'Highland' on population, yield, rooting, and cover. Agron. J. 54: 407-412.

11. Markland, F.E. and E. C. Roberts. 1969. Influence of nitrogen fertilizers on Washington creeping bentgrass, Agrostis palustris Huds. I. Growth and mineral composition. Agron. J. 61: 698-700.

12. Mortensen, W.P., A.S. Baker, and P. Dermanis. 1964. Effects of cutting frequency of orchardgrass and nitrogen rate on yield, plant nutrient composition and removal. Agron. J. 56: 316-320.

13. Phillips, T.G., J.T. Sullivan, M.E. Loughlin, and V.G. Sprague. 1954 chemical composition of same forage grasses. I. changes with plant maturity. Agron. J. 46: 361-369.

14. Reid, R.L., A.J. Post, and G.A. Jung. 1970. Minoral composition of forages. West Virginia Agric. Exp. Stn. Bull. 589T.

15. Rhykerd, C.L., J.E. Dillon, C.H. Noller, and J.C. Burns. 1966. The influence of nitrogen fertilization and drying method on yield and chemical composition of Dactylis glomerata, Bromus inemis and Phleum pratense. Proc. 10th int. Grassld Congr., Helsinki, 1966. pp. 214-218.

16. Shim, J.S. 1975. Leaf dimensions and productivity of varieties of Lolium perenne and Lolium multiflorum in response to nitrogen supply and frequency of cutting. M. Sc. Thesis, Univ. Wales, U.K.

17. Shim, J.S. 1982. The effect of cutting intervals and nitrogen applicalion on the productivity of perennial ryegrass. II. Nitrogen content and yield digestibility. Yonam Jr. Coll. Anim. Husb. J. 4: 25-33.

18. Shim, J.S. 1985. The effect of fertilizer application on the growth and major nutrients of Korean lawngrass (Zoysia japonica Steud.). Thesis Collection, Pai Chai Univ. 6: 489-518.

19. Shim, J.S. and I.S. Yun. 1987. The effect of nitrogen application and clipping interval on the characteristics of several turf components of Korean lawngrass (Zoysia japonica Steud.). Kor. J. Turfgrass Sci. 1(1): 18-29.

20. Smith, Dale. 1969. Removing and analyzing total nonstructural carbohydrates from plant tissue. Wisconsin Agri. Exp. Stn. Res. Re. 41.

21. Spedding, C.R.W. and E.C. Diekmahns. 1972. Grasses and legumes in British agriculture. (ed.) Commonw. Bur. Past. Fld Crop. Bull. 49. Commonw. Agric. Bur. p. 119.

22. Sullivan, J.T., T.G. Phillips, M.E. Loughlin, and V.G. Sprague. 1956. Chemical composition of some forage grasses. II. Successive cuttings during the growing season. Agron. J. 48: 11-14.

23. Turgeon, A.J., G.G. Stone, and T.R. Rock. 1979. Crude protein level in turfgrass clippings. Agron. J. 71: 229-232.

24. Wedin, W.F. 1974. Fertilization of cool-season grasses. pp. 95-118. In D.A. Mays (ed.), Forage fertilization. Am. Soc. of Agron. Madison, Wis.

25. Yuen, S.H. and A.G. Pollard. 1957. The availability of soil phosphate. IV. The effect of nitrogen on the utilization of

phosphate by Italian ryegrass. J. Sci. Fd Agric. 8: 475-482.
26. Zanori, L.J., L.F. Michelson, W.G. Colby, and M. Drake. 1969. Factors affecting carbohydrate reserves of cool season turfgrasses. Agron. J. 61: 195-198.