Korean J. Ecology 5(4): 204~210, 1982

Ecological Studies on the Montane Grassland of Mt. Soback in Korea

Ⅱ. Production and Nutrients Cyclings.

Kim, Joon Ho and Hyeong Tae Mun*
(*Dept. of Botany, College of Natural Sciences, Seoul National University,*
*Dept. of Biology, Kong-Ju Educational College**)

小白山 山地草原의 生態學的 硏究

Ⅱ. 物質生產과 鹽類循環

金 俊 鎬·文 炯 泰*
(서울大學校 自然科學大學 植物學科, 公州師大 生物教育學科*)

ABSTRACT

Comparative study of the biomass production and the cyclings of nitrogen, phosphorus and potassium was carried out on the east and the northwest facing slope in the montane grassland of Mt. Soback. The maximum productions during the growing season in the east and the northwest slope were 1,150g/m². yr, and 755g/m². yr. in the August, respectively. The positive correlation was appearent between biomass production and A-layer depth of the soil and the correlation coefficient (r=.964) was very significant at 1% level.

In the above ground materials, the nutrients contents were high at the early of the growing season but decreaesd gradually. In roots, however, there are no significant trend throughout the growing season. Total amounts of minerals uptaken by plants during the growing season in the east and the northwest site were 18.20 and 10.66g/m². yr for N, 0.06 and 0.03g/m². yr for P, 0.23 and 0.11g/m². yr for K, respectively. The minerals returned to the soil by litter decomposition and roots decay in the east and the northwest site were 16.19 and 9.62g/m². yr for N, 0.046 and 0.021g/m². yr for P, 0.211 and 0.099g/m². yr for K, respectively. The turnover rate (absorbed/returned) of the nutrients in the east and the northwest site were 1.13 and 1.14 for N, 1.30 and 1.43 for P, 1.09 and 1.11 for K, and the absorption rates of minerals were 0.39 and 0.29% for N, 3.16 and 1.88% for P, 0.91 and 0.57% for K, respectively.

INTRODUCTION

In Korea most of the grasslands are distributed on the dry riverbed and the montane region (Park, 1971) and they are classified as semi-natural grassland by several authors (Chang and Yun 1969, Park 1966). Montane grasslands develop under a set of limiting environmental conditions and usually achieve dynamic equilibrium with its environment. The floristic composition, primary production and nutrients cyclings of the grasslands were studied by many workers (Chang and Yun 1969, Chang *et al.* 1968, Dahlman and Kucera 1965, Kim and Chang 1969, Kim and Mun 1981, Park 1962, 1966, 1970, 1971, Park *et al.* 1971, Perkins *et al.* 1978, Porter 1967, Redmann 1975, Wiegert and Evans 1964, Woodmansee and Duncan 1980). We studied the grassland at the summit of Mt. Soback with special references to the study of environmental factors and vegetation analysis. In that study, we found out that the floristic composition and the environmental factors are quite different between the east and the northwest facing slope. The objectives of this study were 1) to estimate and compare the net primary productions beween two slopes, 2) to find out the relationships between environmental factors and primary production and 3) to study the dynamics of three major nutrient elements in the montane grassland in Korea. The descriptions of the study area, the environmental factors and the floristic composition were published in the previous paper (Kim and Mun, 1981).

METHODS

Measurement of standing crop and litter decomposition

For the estimation of above ground biomass, sampling was made randomly 20 quadrats of 25×25cm on both slopes monthly from May to September in 1976. The dead parts were sorted out from the alive materials and then both samples were weighed after dried for 48 hrs at 80°C in a forced drought oven. A core sampling method, steel corer 4cm in diameter and 10 cm long, was used to make quantitative measurement of root standing biomass. The root contained in the soil coro were collected and dried at 80°C after washing the soil particles with tap water. We could not estimate the amounts of roots newly formed during the growing season and the quantity of the roots decayed for that period. It was assumed that the annual root increment and decrement were one-fourth of the root standing biomass according to Kucera et al. (1967). To study the rate of litter decomposition, the litter which was formed last year were sampled monthly 20 quadrats with quantitative. All plants meterials were ground after weighing to analyze the mineral elements. Soil samples were dried at shade place and then sieved with a 2mm sieve.

Chemical analysis

The total nitrogen in plants and soil was determined by a modified micro-Kjeldahl method. Phosphorus was determined by the chlorostannous-reduced molybdophosphoric blue color method (Jackson, 1958). For determination of potassium, plant materials and soil samples were extracted with 0.2N HCl and 2N ammoniumacetate, respectively, and measured by flame photometer.

Nutrients cyclings

The amounts of minerals uptaken by plants were estimated by the amounts of minerals contained in the plant tops at the time of peak standing crop plus contained in the newly formed roots. The amounts of minerals transferred from one component to another for a year are represented by arrows(Fig. 7 and 8). The amount of minerals returned to the soil via litter decomposition were estimated by the following formula;

$$\sum_{t=1}^{n}\{[(L_t-L_{t+1})C_t]+[(C_t-C_{t+1})L_{t+1}]\}$$

L_t: Quantity of litter at time t

L_{t+1}: Quantity of litter at time $t+1$

C_t: Mineral concentration in the unit weight of litter at time t

C_{t+1}: Mineral concentration in the unit weight of litter at time $t+1$.

RESULTS AND DISCUSSION

Production and decomposition

In the east site, plant growth began on the early of May but the northwest site was somewhat later. It is well known that the slope exposure and degree of slope have profound influence on air and soil tempreature and on floristic composition(Ayyad and Dix, 1964). It is, therefore, quite probable that delayed warming of soil temperature at the northwest slope result in a corresponding delay in plant sprouting and subsequent growth. Some plants species, however, such as *Heloniopsis orientalis* and *Viola orientalis* began to grow at the early of April and anthesis occurred during the mid-May. The pattern of increase in above ground biomass in the east and the northwest slopes (Fig. 1) show that the maximum production occurs at mid-August. The maximum value of the east slope was $760g/m^2$. yr and that of the northwest was $460g/m^2$.

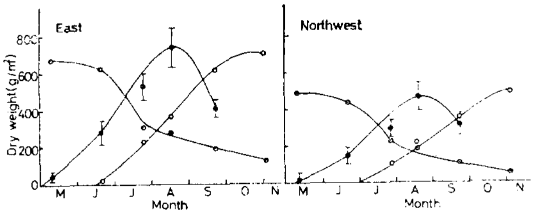

Fig. 1. Seasonal changes of the primary production, dead parts and litter decomposition in the east and the northwest slope. ●—●: net primary production, ○—○: dead parts, ⊙—⊙: litter decomposition.

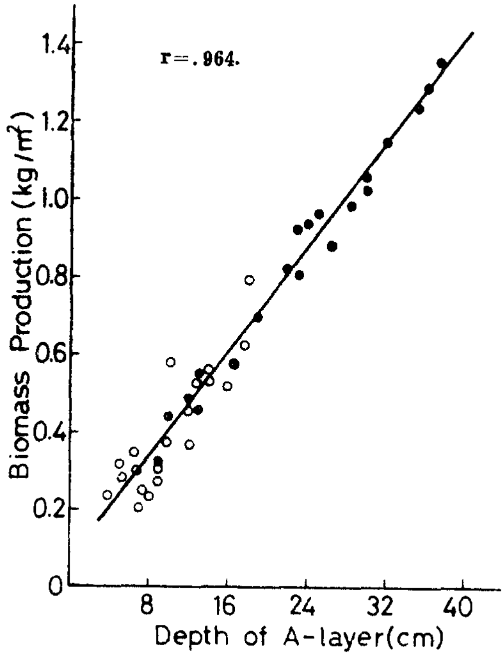

Fig. 2. Correlation between biomass production and A-layer depth of the soil in study area. ●: east, ○: northwest.

yr. These values, particulary in the east slope, were greater than those of the other parts (Chang and Yun 1969, Chang et al. 1968, Kim and Chang 1969, Old 1969, Park 1966, Porter 1967, Wiegert and Evans 1964), similar with the result of Park (1970) but lesser than that of Mutoh et al. (1968). In the previous paper (Kim and Mun, 1981), we mentioned that the pattern of snow accumulation in winter and A-layer depth of the soil along with descending slope were quite different between east and the northwest slope. It seemed that the prevailing wind direction in winter and the difference of floristic composition between two slopes brought about these differences. Among these, the difference of A-layer depth of the soil was considered a major environmental factor causing the biomass difference directly between two slopes. Fig. 2 shows the relationship between A-layer depth of the soil and standing biomass at the study sites. As shown in the figure, the positive correlation was apparent and the correlation coefficient (r=.964) was very significant at 1% level.

Decomposition processes of the litter have been studied by many workers in the grassland and forest ecosystem with a special references to estimate the flow of energy and transfer of mineral nutrients through the decomposers (Birk and Simpson 1980, Hackney and de la Cruz 1980, Perkins et al. 1978, Tanner 1981, Wiegert and Evans 1964). To estimate the amounts of minerals returned to the soil via litter decomposition, we sampled the remaining litter quantitatively from May till November. As shown in Fig. 1, the pattern of litter decomposition were similar in two slopes. Litter decomposition can be limited by available moisture when summer temperatures are optimum for microbial activity (Perkines et al., 1978). In this study area, the precipitation concentrated in the summer season and in that period the temperatures high. So we could expect that the microbial activity would be great in the summer season. From June to August about half of the litter was decomposed as expected. Dead parts of the plant, being recently formed, were separable from litter which was formed last year. The production of dead materials began in June and increased continuously. In October, all above ground parts became dead.

The most plant species in this grassland are perennial and their root standing biomass was greater than above ground biomass. Root system may lose or gain weight without any shedding or formation of new tissue. Increase and decrese of root biomass in a community of perennial plants is brought about as

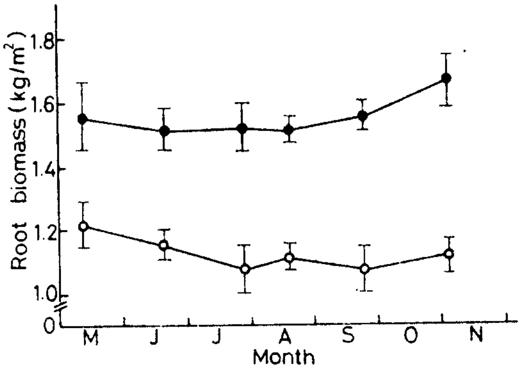

Fig. 3. Seasonal changes of root biomass in the east (●—●) and the northwest(○—○) of the study area.

a result of many factors such as formation of new tissues, shedding and decaying of old tissue, translocation of stored materials to the above ground parts. It is, therefore, impossible to estimate root production by measuring seasonal variation of root standing biomass(Midorikawa *et al.*, 1975). Fig. 3 shows the seasonal variations of root standing biomasses in two slopes. There is no significant seasonal pattern but the biomass of the east slope was greater than that of the northwest slope throughout year. Kucera *et al.*(1976) reported that the annual root increment in the tallgrass prairie was one-fourth of the total underground biomass. If we use this figure, the root biomass increments in the east and the northwest slope were 390g/m². yr and 295g/m². yr, respectively. Consequently, the total production (above ground biomass+below ground biomass) during the growing season in the east and the northwest slope were 1, 150 g/m². yr and 755g/m², yr, respectively.

Nutrients dynamics

The biological cycle of nutrients is a fundamental process supporting the production of organic matter in terrestrial ecosystems. There are many reports on the nutrient dynamics in forests and grasslands(Christie 1981, Clark 1977, Mun *et al*, 1977, Pemadasa 1981, Rochow 1975, Woodmansee and Duncan 1980). Fig. 4 shows the seasonal changes of the amounts of three mineral nutrients per unit weight of the top and the root in the study sites. At the early of the

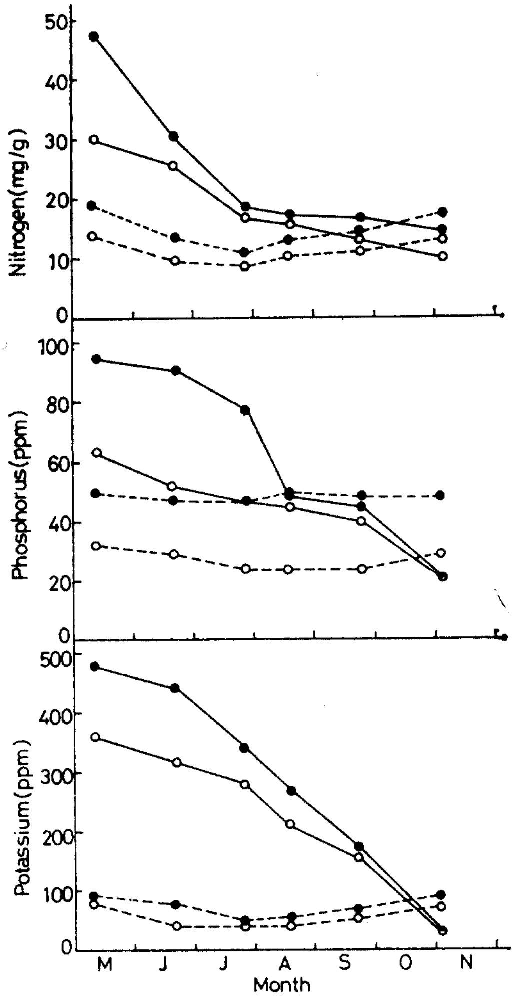

Fig. 4. Seasonal changes of nitrogen, phosphorus and potassium in the plant materials of the study area. ●: east, ○: northwest, solid line: top, dotted line: root

growing season, the nutrients content of the above ground parts were high(30~48mg/g for N, 0.06~0.09mg/g for P, 0.48~0.36mg/g for K) and then decreased gradually as the plant grow (13~17mg/g for N, 0.02~0.05mg/g for P, 0.16~0.17mg/g for K). These decreasing trend would be due to the dilution of the inorganic nutrients with increasing dry matter(Davy and Taylor, 1975). In roots, however, there is no significant seasonal trend throughout the growing season except for slight decrease in summer

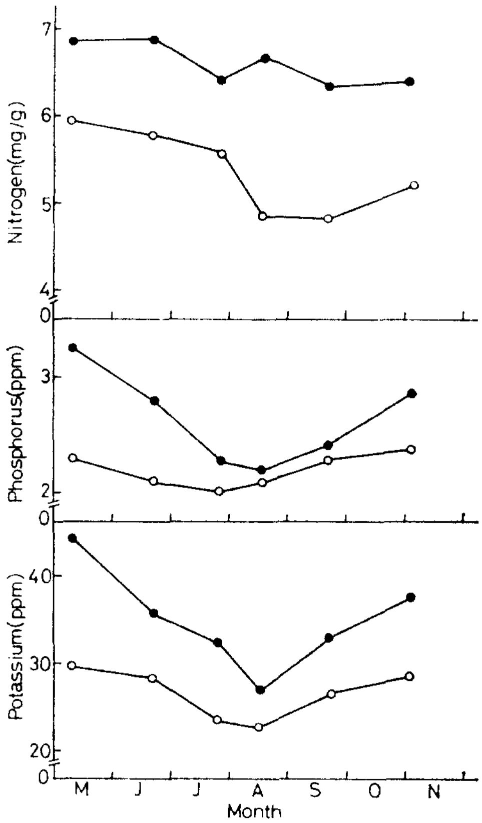

Fig. 5. Seasonal changes of nitrogen, phosphorus and potassium in the soil of the study area. ●—●: east, ○—○: northwest.

season. The nutrients content in soil(Fig. 5) gradually decreased as the plant grow but increased again during the later period of the growing season. The phosphorus content of litter decreased as the time elapsed but the nitrogen and potassium remained nearly constant at low level compared with the alive parts (Fig. 6).

Table 1. shows the contents of three mineral nutrients in various components of the two sites. On the whole, the contents of the components in the east site were greater than those in the northwest site. These difference would have resulted from the difference of the plant species composition between two sites(Kim and Mun, 1981).

Nutrients cyclings

Fig. 7 and 8 shows the nutrients cyclings of the study

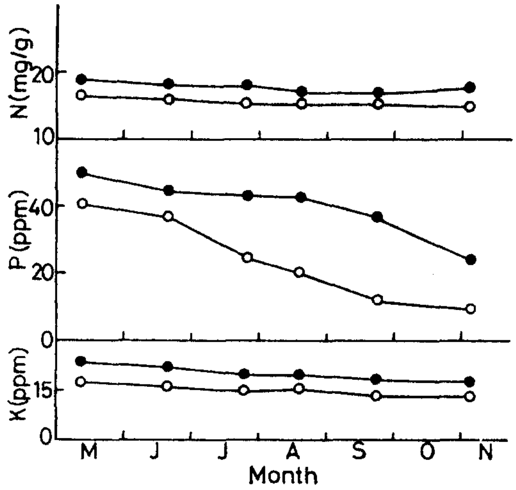

Fig. 6. Seasonal changes of mineral elements in the litter of the study area. ●: east. site, ○: northwest site

Table 1. Contents of three mineral elements in various components of the east and the northwest sites

Components	Nitrogen	phosphorus	potassium
	mg/g dry weight		
East			
Top	17.50	0.048	0.027
Root	13.21	0.049	0.056
Litter	17.10	0.047	0.024
Soil	6.75	0.003	0.038
Northwest			
Top	16.51	0.045	0.021
Root	11.01	0.024	0.042
Litter	16.10	0.025	0.020
Soil	5.29	0.002	0.027

areas. The total amount of mineral elements uptaken by plants during the growing season in the east and the northwest site were 18.20 and 10.66g/m^2. yr for N, 0.06 and 0.03g/m^2. yr for P, 0.23 and 0.11g/m^2. yr for K, respectively. The absorption rates of the three minerals in the east and the northwest site were 0.38 and 0.28% for N, 3.16 and 1.88% for P, 0.91 and 0.57% for K, respectively. The absorption rates

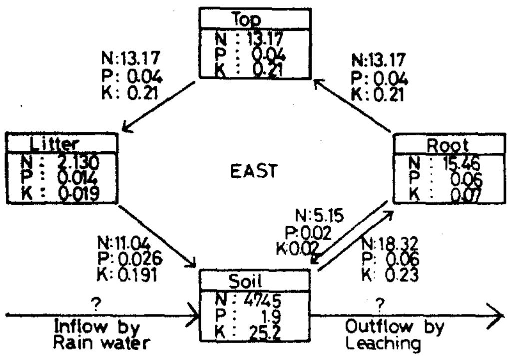

Fig. 7. Distributions of N, P and K among the component in the east site. Numerals in compartment and on the arrows mean the mineral content of each components and its flow between them(g/m²).

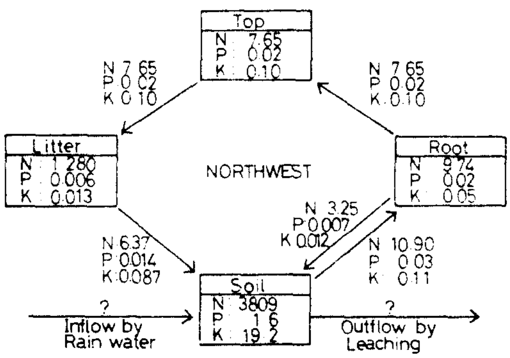

Fig. 8. Distributions of N, P and K among the component in the northwest site. Numerals in compartment and on the arrows mean the mineral content of each components and its flow between them(g/m²).

of the three minerals in the east site were greater than those of the northwest site. This is because the biomass production in the former is greater than those in the latter. As compared to the forest(Mun *et al.*, 1977), the absorption rates in this area were lower. The amounts of N, P and K which transferred to the above ground parts in the east and the northwest site were 13.17 and 7.65g/m². yr for N, 0.04 and 0.02g/m². yr for P, 0.21 and 0.10g/m². yr for K, respectively. The amounts of minerals returned to the soil via litter decomposition and roots decay in the east and the northwest site were 16.07 and 9.38 g/m². yr for N, 0.05 and 0.02g/m². yr for P, 0.22 and 0.10g/m². yr for K, respectively. The turnover rates(absorbed/returned) of minerals in the former and in the latter were 1.13 and 1.14 for N, 1.30 and 1.43 for P, 1.09 and 1.11 for K, respectively. Thus, we can expect that the most of the minerals absorbed by plants in this grassland are returned to the soil during next year. Considerable amounts of minerals would be supplied and leached by precipitation but they are not considered in this study.

摘　要

環境要素와 植生組成이 相異한 山地草原의 東斜面과 北西斜面에서 物質生産과 鹽類循環을 調査하였다. 最大生産量은 8월에 동사면에서 1,150g/m². yr, 북서사면에서 755g/m². yr이었다. 物質生産과 土壤의 A층 깊이 사이에 正의 상관관계가 있었으며(r=0.964) 1% 수준에서 유의하였다.

지상부 식물체의 鹽類含量은 식물의 성장에 따라 점차 감소하였으나 뿌리에서는 연중 거의 변화가 없었다. 生育期間중 식물체에 의해 吸收된 질소, 인산, 가리의 양은 東斜面에서 18.20, 0.06, 0.23g/m². yr, 北西斜面에서 10.66, 0.03, 0.11g/m². yr이었다. 落葉과 죽은 뿌리의 分解에 의해 土壤에 回收되는 질소, 인산, 가리의 양은 東斜面에서 16.19, 0.046, 0.211g/m². yr, 北西斜面에서는 9.62, 0.021, 0.099g/m². yr이었으며 이들의 turnover rate는 동사면에서 각각 1.13, 1.30, 1.09, 북서사면에서 각각 1.14, 1.43, 1.11로 나타났다.

REFERENCES

Ayyad, M. A. G. and R. L. Dix, 1964. An analysis of a vegatation-microenvironmental complex on prairie slopes in Saskatchewan. Ecol. Monogr., **34** : 421~442.

Birk, E. M. and R. W. Simpson, 1980. Steady state and continuous input model of litter accumulation and decomposition in Australian Eucalypt forests. Ecology, **61** : 481~485.

Christie, E. K., 1981. Biomass and nutrient dynamics in a C_4 semiarid Australian grassland community. J. of Applied Ecology, **18** : 907~918.

Chang, N. K. and I. S. Yun, 1969. A study on the grassland types and plant succession in Korea. Korean J. Animal Science, **11** : 254~257.

Chang, N. K., I. S. Yun and B. T. Kim, 1969. Composition and productivity of Chulwon grasslands. Korean J. of Botany, **11** : 140~146.

Clark, F. E., 1977. Internal cycling of ^{15}Nitrogen in shortgrass prairie. Ecology, **58** : 1322~1333.

Dahlmann, R. C. and C. L. Kucera, 1965. Root productivity and turnover in native prairie. Ecology, **46** : 84~89.

Davy, A. J. and K. Taylor, 1975. Seasonal changes in the inorganic nutrient concentration in *Deschampsia caespitosa* (L.) Brauv. in relation to its tolorance of contrasting soils in the Chiltern Hills. J. Ecol., **63** : 27~39.

Hackney, C. T. and A. A. de la Cruz, 1980. In situ decomposition of roots and rhizomes of two tidal marsh plants. Ecology, **61** : 226~231.

Jackson, M. L., 1958. Soil chemical analysis. Prentice-Hall.

Kim, C. M., and N. K. Chang, 1969. Studies on the standing crop and edaphic factor of grassland in Chulwon near the D.M.Z. J. of College of Education, S.N.U., **11** : 95~101.

Kim, J. H. and H. T. Mun, 1981. Ecological studies on the montane grassland of Mt. Soback in Korea. I. Environmental factors and vegetation analysis. Korean J. of Ecology, **4** : 1~7.

Kucera, C. L., R. C. Dahlman and R. M. Koelling, 1967. Total net productivity and turnover on an energy basis for tallgrass prairie. Ecology, **48** : 536~541.

Midorikawa, M., Y. Shimada, H. Iwaki and N. Ohga, 1975. Root production in semi-natural grassland community dominated by *Miscanthus sinensis* in the Kawatabi area. pp.114~122. In M. Numata(ed.). Ecological studies in Japanese grasslands with special reference to the IBP area. Productivity of terrestrial communities. Univ. of Tokyo Press.

Mun, H. T., C. M. Kim and J. H. Kim, 1977. Distributions and cyclings of nitrogen, phosphorus and potassium in Korea alder and oak stands. Korean J. of Botany, **20** : 109~118.

Mutoh, N., K. H. Yoshida, Y. Yokoi, M. Kimura and K. Hogetsu, 1968. Studies on the production processes and net production of *Miscanthus sacchariflorus* community. Jap. J. of Botany, **20** : 67~92.

Old, S. M., 1969. Microclimate, fire and plant production in an Illinois prairie. Ecol. Monogr., **34** : 355~384.

Park, B. K., 1962. An ecological study on several grazing grasslands in the branch station of the Taigwanryong livestock experiment center. Korean J. of Botany, **3** : 1~4.

Park, B. K., 1966. The grassland type in Korea. Korean J. of Botany, **9** : 7~14.

Park. B. K., 1970. A study on the productivity of tall grass type. J. Kor. Cul. Res. Ins., **4** : 7~48.

Park, B. K., 1971. Seasonal changes of standing crop and stratification in native grassland. Korea. J. Kor. Cul. Res. Ins., **6** : 53~65.

Park, B. K., N. K. Chang and O. C. Young, 1971. A study of soil nutrition and productivity on the native grassland in several sites of Kumwha region. J. Kor. Cul. Res. Ins. **5** : 117~125.

Pemadasa, M. A., 1981. The mineral nutrition of the vegetation of a montane grassland in Sri Lanka. J. Ecol., **69** : 125~134.

Perkins. D. F., V. Jones, R. O. Miller and P. Neep, 1978. Primary production, mineral nutrients and litter decomposition in the grassland ecosystem. pp.304~341. In O.W. Heal and D.F. Perkins. (ed.). Production ecology of British moors and montane grasslands. Springer-Verlag, New York.

Porter, C. L. Jr., 1967. Composition and productivity of a subtropical prairie. Ecology, **48** : 937~942.

Redmann, R. E., 1975. Production ecology of grassland plant communities in Western North Dakota. Ecol. Monogr., **45** : 83~106.

Rochow, J. J., 1975. Mineral nutrient pool and cycling in a Missouri forest. J. Ecol., **63** : 985~994.

Tanner, E. V. J., 1981. The decomposition of leaf litter in Jamaican montane rain forests. J. Ecol., **69** : 263~275.

Wiegert, R. G. and F. C. Evans, 1964. Primary production and the disappearance of dead vegetation on an old field in Southeastern Michigan. Ecology, **45** : 49~63.

Woodmansee, R. G. and D. A. Duncan, 1980. Nitrogen and phosphorus dynamics and budgets in annual grassland. Ecology, **61** : 893~904.

(*Received November* 20, 1982)