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The Energy Flow and Mineral Cycles in a *Zoysia japonica* and a *Miscanthus sinensis* Ecosystem on Mt. Kwanak 5. The Cycles of Potassium

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관악산의 잔디와 억새 생태계에 있어서 에너지의 흐름과 무기물의 순환 5. 칼륨의 순환

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ABSTRACT

To elucidate the mineral cycles of potassium in a dynamic grassland ecosystem in a steady state condition, this investigation was conducted along the northwest side on Mt. Kwanak. The experimental results may be summarized on communities of *Z. japonica* and *M. sinensis* as follows.

As compared with some properties of the surface soils among two semi-natural grasslands, the levels of exchangeable potassium were high in *M. sinensis* and low in *Z. japonica*.

Contents of potassium for the litters of *Z. japonica* and *M. sinensis* were 1.69% and 2.51%, respectively.

The annual production of potassium was 1.32 g /m^2 in the *Z. japonica* grassland and 3. 08 g /m^2 in the *M. sinensis* grassland. For a case of steady production and release, the ratio of annual mineral production to the amount accumulated on top of the mineral soil in a steady state provides estimates of the release constant k.

The models of the release, accumulation and annual cycle of potassium in a grassland ecosystem are determined by the equation (1) to (3), respectively (Table 3).

Since it requires a period of about each 0.693 /r, 3 /r and 5 /r years for the release and accumulation of 50, 95 and 99% of its steady-state level, the estimates for potassium in a dynamic grassland ecosystem of Mt. Kwanak were 1.5, 6.6 and 11.0 years in the *Z. japonica* grassland, and were 2.7, 11.9 and 19.8 years in the *M. sinensis* grassland.

The amounts of annual cycles for potassium in a grassland ecosystem under the steady-state conditions were 1.32 g /m^2 in the *Z. japonica* grassland and 3.08 g /m^2 in the *M. sinensis* grassland.

Key words : *Zoysia japonica, Miscanthus sinensis,* Mt. Kwanak, Potassium cycles.

INTRODUCTION

The soil of a grassland is a complex system which has many processes taking place simultaneously and which might properly be interpreted in terms of nutrient chemistry, microbial transformations of organic matter, mineral weathering and others. Plant communities alter the organic and inorganic reactions in soils through cycling processes and are in turn altered by such changes(Oohara et al., 1971).

The important assessment of the nutrient cycle in an ecosystem must consider the role of the litter, decomposing as it affects the structure of the grassland. Koelling and Kucera(1965) have shown that for any complete assessment of such a cycle, leaching of several elements takes place at least from standing dead vegetation. According to Oohara et al. (1971 a, b, c, d & e) and Chang et al. (1995a, b, c & d) there is the role of the mineralization, accumulation and annual cycles of nitrogen and phosphorus in the grassland ecosystems in a steady state condition. While it may not be directly applicable to agricultural ecosystems, it is valuable since it suggests testable inferences concerning more complex systems(Oohara et al., 1971).

In the present study the chemical composition of potassium in litters under the dynamic ecosystems of grasslands has been determined to assess the levels of nutrients in such litter. Furthermore, the cycles of potassium in the grasslands of *Z. japonica* and *M. sinensis* were estimated and compared. It was the intent of the present study to gain information concerning the role of the cycles of potassium in the functions of the grassland ecosystems.

MATERIALS AND METHODS

The area used for this study and the methods to prepare the litter samples of *Z. japonica* and *M. sinensis* for potassium analysis are the same as in the previous papers of Chang et al. (1995a, b, c & d). Organic potassium was estimated as the difference between the inorganic potassium extracted from comparable ignited (at 550℃) and unignited samples. Exchangeable potassium was extracted with an 1N CH_3COONH_4 solution of pH 7. 00.

Potassium in this extract was determined by the flame photometry and an atomic absorption spectro-photometer(Model 303).

RESULTS AND DISCUSSION

1. Characteristics of the soils

Exchangeable potassium contents of the surface soils for the grasslands of *Z. japonica* and *M. sinensis* were given in Table 1. The differences of their contents among two grasslands were significant at a 5% level and over. The result of this statistical treatment indicates that the levels of exchangeable potassium for the grassland soils of *M. sinensis* are higher than those for the *Z. japonica* grassland.

Although there was no significant correlation between the percentages of organic and exchangeable potassium for the surface soil under two grasslands, the amounts of organic and exchangeable potassium of the surface soils of the *M. sinensis* grassland showed higher tendency than those of the *Z. japonica* grassland. When the level of exchangeable potassium is high, the potassium ion concentration becomes higher. Thus, it may be conjectured that the level of soil pH would increase in the grassland. As shown in Table 1, the exchangeable potassium contents has no significant differences between the *Z. japonica* grassland and the *M. sinensis* grassland. There was no significant difference of the pH levels in Table 1 between two grasslands.

The average amount and annual production of potassium for litters of the *Z. japonica* grassland were 1,694 ppm and 1.32 g /m^2, and those of *M. sinensis* were 2,516 ppm and 3.08 g /m^2, respectively . Other detailed characteristics of the litter organic matters for each horizon of surface soils and each grass species are shown in Table 1.

2. The estimates of release constant of potassium

Table 1 shows a range in the annual production of potassium by the grass-litter. These

Table 1. Potassium for the grass-litter or soil organic matter under two grassland ecosystems on Mt. Kwanak

Grasslands	Horizon	pH	Soil dry weight (g /m^2)	Organic matter (%)	Organic K (%)	Exchangeable K (ppm)	Organic K (g /m^2)
Z. japonica	L	5.02	780.55±61.67	71.77±2.53	1.69±0.168	563±45.8	1.32±0.115
	F	5.43	292.51±2.58	35.93±1.93	1.10±0.046	544±47.7	0.32±0.037
	H	6.00	553.87±60.43	16.52±2.11	0.91±0.059	444±25.6	0.50±0.054
	A_1	5.74	8344.87±599.14	12.96±1.52	0.26±0.006	375±22.9	2.15±0.165
M. sinensis	L	4.89	1224.91±66.13	53.42±1.68	2.51±0.139	570±56.2	3.08±0.225
	F	4.57	2890.33±133.12	45.46±1.78	1.58±0.152	563±48.1	4.56±0.291
	H	5.70	6111.25±316.74	8.04±1.34	0.77±0.116	456±37.7	4.71±0.303
	A_1	5.50	4282.22±306.66	4.45±1.03	0.69±0.066	450±29.2	2.94±0.194

Table 2. Parameters for exponential accumulation and release of potassium in grassland ecosystems with a steady litter addition

Grasslands	Release constants	1 /k & 1 /k'	Half time (years)	95% time (years)	99% time (years)
Z. japonica	k =0.455	2.20	1.52	6.59	10.99
	k' =0.308	3.25	2.25	9.74	16.23
M. sinensis	k =0.253	3.95	2.74	11.86	19.76
	k' =0.202	4.95	3.43	14.85	24.75

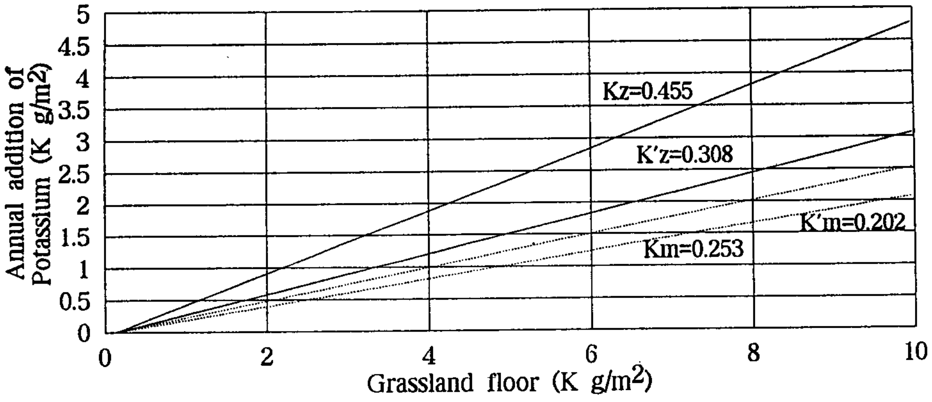

Fig. 1. Estimates of the release constants for potassium in the two grasslands from the ratio of annual addition of potassium to the steady state accumulation of a grassland floor.

products were 1.32 g/m² in the *Z. japonica* grassland and 3.08 g/m² in the *M. sinensis* grassland.

Under the assumption (Oohara et al., 1971 a & e; Chang et al., 1995) that the grassland floors in the stands here selected may approximate a steady state, one method of estimating the release or loss constant k for potassium of the grass-litter can be obtained from the ratio of the vertical and horizontal coordinates of each point on Fig.1. Other methods are also indicated in the previous papers (Oohara et al., 1971 a, b, c, d & e). The estimates of constants for the *Z. japonica* grassland and *M. sinensis* grassland are given by Table 2. As compared with each grassland, that of k had a high value in the *Z. japonica* grassland, while being low in *M. sinensis*. From this result it seems reasonable to suggest that the chemical composition of the grass-litter and its annual addition to the mineral soil in a semi-natural grassland ecosystem are different on account of the grass species of which the grassland is composed.

The release constant k' as a fraction of the original total was determined by the assumption of Oohara et al., (1971 a & e) and Chang et al.,(1995). The estimates of k' are invariably smaller than k. As shown in Fig.1 and Table 2, these showed the same tendency of change for each mineral element and each grassland. This suggests that the higher the release or loss constant of mineral elements from the litter organic matter in the surface soil are, the more rapidly these elements return to the soil . The release constant k's of the litter of *Z. japonica* and *M. sinensis* on Mt. Kwanak were 0.308 and 0.202, respectively. The periods from organic potassium to 50, 95 and 99% of exchangeable potassium were 2.3, 9.7 and 16.2 years in the *Z. japonica* grassland ecosystem, and 3.4, 14.9 and 24.8 years in the *M. sinensis* grassland ecosystem.

3. The cycles of potassium

Since the release constants of potassium for grass-litters have been determined, the release models of potassium under the grassland ecosystems of the steady state conditions can be defined as the basic concept of decomposition(Oohara et al., a & e); in the case of potassium

$$K = K_0 e^{-kt} \quad \cdots\cdots (1)$$

where K_0 is the weights of potassium in the surface soil initially. Table 3 presents exponential equations for the two grasslands at Mt. Kwanak and Fig. 2 shows the exponential curves of these models. The accumulation model of potassium on the grassland floor is also given as follows; for potassium(Ka)

$$Ka = \frac{L_k}{k}(1-e^{-kt}) \quad \cdots\cdots (2)$$

where L_k expresses the amount of an annual addition for this element. This graphical curve is given as the mirror image of the curve for the release(Fig. 3). According to Ovington(1957), *Pinus sylvestris* of an age of 55years at Thetforde Chase absorbs 87 percent of the total uptake for N, P and K from litters accumulated on the grassland floor amounting to 76 percent of Ca, 75 percent of Mg and 69 percent of Na, respectively. In agreement with the results of Ovington (1957), it has been shown in this paper that a greater quantity of Ca and Mg than N, P and K are taken up from the mineral soils.

The equation of annual cycles of potassium in a steady state ecosystem of a grassland are given by using the assumptions of the previous papers Oohara et al.,(1971 a & e) and Chang et al.,(1995); for K

$$K_Y = L_k\left(\frac{1-e^{-k't}}{k'} - \frac{1-e^{-kt}}{k}\right) \quad \cdots\cdots (3)$$

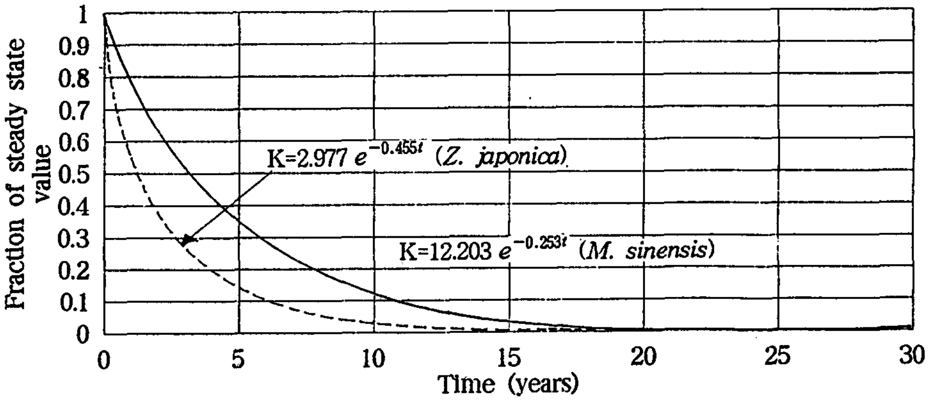

Fig. 2. Exponential curves for the release of potassium of grass-litters under the two grassland ecosystems on Mt. Kwanak.

where K_Y is the amount of an annual cycle. These models of the two grassland ecosystems are shown in Table 3., Fig. 3 and Fig. 4 present the graphical expression of these equations. The amounts of annual cycles of these elements in the grassland ecosystems of a steady state condition can be estimated by the same principle likewise. Those of potassium in the *Z. japonica* and *M. sinensis* grassland were 1.32 and 3.02 g/m², respectively. This differs from the current annual uptake and mean annual uptake (Ovington, 1959), but it can be said that the levels of those may contribute directly to the amounts of the

Table 3. Models of release, accumulation and annual cycle for grass-litter in two grasslands on Mt. Kwanak

Grasslands	Release models	Accumulation models
Z. japonica	$K = 2.977e^{-0.455t}$	$Ka = 2.977(1-e^{-0.455t})$
M. sinensis	$K = 12.203e^{-0.253t}$	$Ka = 12.203(1-e^{-0.253t})$

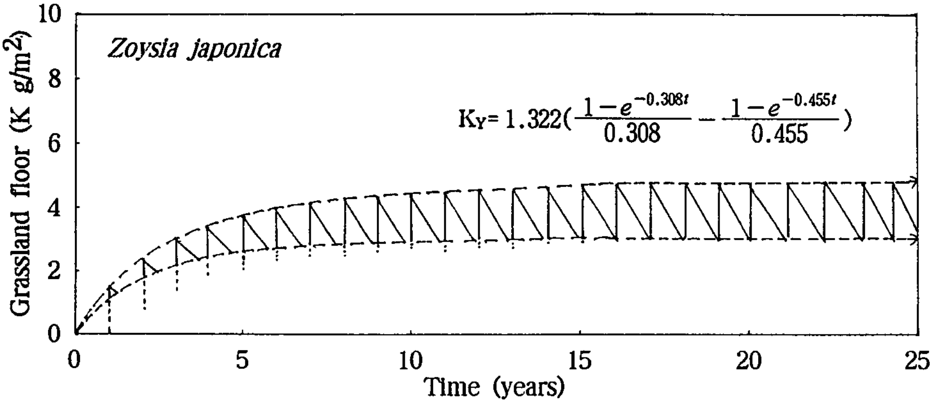

Fig. 3. The annual K cycle and accumulation of grass-litters in *Z. japonica* grasslands on Mt. Kwanak.

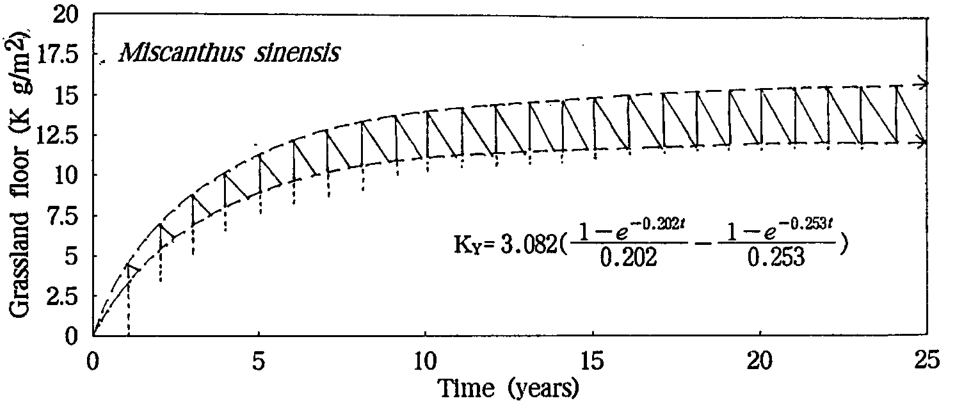

Fig. 4. The annual K cycle and accumulation of grass-litters in *M. sinensis* grasslands on Mt. Kwanak.

Table 4. Models of release, accumulation and annual cycle for grass-litters in two grasslands on Mt. Kwanak

Grasslands	Total accumulation models	Annual cycle models
Z. japonica	$Kt=4.299(1-e^{-0.308t})$	$K_Y = 1.322(\frac{1-e^{-0.308t}}{0.308} - \frac{1-e^{-0.455t}}{0.455})$
M. sinensis	$Kt=15.285(1-e^{-0.202t})$	$K_Y = 3.082(\frac{1-e^{-0.202t}}{0.202} - \frac{1-e^{-0.253t}}{0.253})$

major portion of the current annual uptake or mean annual uptake. Therefore, a shortage of mineral nutrients is hardly ever seen in semi-natural grasslands of a steady state condition but can often be seen in tame pastures. Annually, Management of pastures requires an addition of supply at least the same levels of fertilizers equalling amounts of annual cycles of various mineral nutrients to absorb the mean annual uptake for the steady harvest of forage crops.

적 요

본 연구는 유동적인 초지생태계에서의 칼륨의 순환을 관악산의 북서면에 위치하는 잔디와 억새초지를 통해 규명하고자 한 것으로 그 결과는 다음과 같다.

두 개의 초지군락에서 표면층의 토양을 비교해 보면 치환성 칼륨이 잔디군락보다는 억새군락에 더 높게 함유되어 있음을 알 수 있다. 낙엽에서 칼륨의 함량은 잔디와 억새군락에 있어서 각각 1.69%와 2.52%였다. 칼륨의 연생산량은 잔디군락에서는 1.32g/m²이었고 억새군락에서는 3.08g/m²이었다. 평형상태에서 무기토양의 표면층에 축적된 무기물의 연생산비율은 분해상수 k로 추정되었다. 초지생태계에서 칼륨의 축적 및 연순환에 대한 분해모델은 식(1)과 (3)으로 각각 결정될 수 있다.(표 3)

평형상태에서 50, 95 및 99%로 분해 및 축적되는데 걸리는 시간은 각각 0.693/r, 3/r과 5/r 년이므로, 본 연구를 통하여 관악산의 초지생태계에서 칼륨이 50, 95 및 99%로 분해 및 축적되는데 걸리는 시간은 잔디군락에서는 1.5년, 6.6년과 11.0년으로 나타났으며 억새군락에서는 2.7년, 11.9년 및 19.8년으로 각각 나타났다.

평형상태하의 초지생태계에서 칼륨의 연중순환되는 함량은 잔디군락과 억새군락에서 각각 3.32g/m²과 3.08g/m²으로 나타났다.

REFERENCES

1. Koelling, M.R. and C.L. Kucera. 1965. Ecology. 43 : 679~686.
2. Campbell, L.A., E.A. Paul, and D.A. Rennie. 1967. Soil Sci. 104 : 217~224.
3. Chang, N.K., J.S. Kim and K.M. Kang. 1995a. Korean Journal of Turfgrass Science. 9(2);101-108.
4. Chang, N.K., J.S. Kim and K.M. Kang. 1995b. Korean Journal of Turfgrass. Science. 9(2);109-118
5. Oohara, H., N. Yosida and N.K. Chang. 1971a. J. Japan. Grassl. Sci. 17(1) : 7~18

6. Oohara, H., N. Yosida, K. Ataku and N.K. Chang. 1971b. J. Japan. Grassl. Sci. 17(1) : 19~27.
7. Oohara, H., N. Yosida and N.K. Chang. 1971c. J. Japan. Grassl. Sci. 17(2) : 86~96.
8. Oohara, H., N. Yosida and N.K. Chang. 1971d. J. Japan. Grassl. Sci. 17(2) : 97~105.
9. Oohara, H., N. Yosida and N.K. Chang. 1971e. Obihiro Zootech. Res. Bull. 7 :165~175.
10. Ovington, J.D. 1957. Ann. Bot. N.S. 21 : 287~314.
11. Ovington, J.D. 1957. Ann. Bot. N.S. 23 : 75~88.0.