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Mineral Leaching from Forage Placed on Soil Surface of Meadow
− Especially for Potassium −

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草地土壤의 表面에 놓인 牧草로 부터의 칼리 및 그 외의 無機養分溶出

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摘　要

草地生態系에 있어서의 칼리(K)의 動態에 관한 研究의 한 부분으로서, 草地土壤의 表面에 놓인 牧草落葉의 分解에 따른 칼리의 溶出狀況을 그외의 無機養分의 溶出과 比較하여, 칼리溶出의 特性을 알아 낼 目的으로 실험을 수행했다.

초지토양의 표면에 놓인 牧草葉은 1年의 시험기간중에 當初乾物量의 약 30%로 分解되었으며, 그 分解速度는 月降水量보다는 平均氣溫과 더 높은 相關關係를 보였다.

낙엽분해에 따르는 植物體로 부터의 養分溶出은 칼리>인(P)>마그네슘(Mg), 질소(N)>칼슘(Ca)의 順이었다. 칼리와 인은 1個月 경과후에 當初含有量의 40%와 45%로 현저하게 減少되었으며, 칼리는 그 以後에도 牧草의 分解에 따라 계속해서 溶出되어 9個月째에는 1%로 減少되었다. 마그네슘과 질소는 목초의 분해와 거의 一致해서 溶出되었으나, 칼슘은 낙엽의 분해가 진행되어도 當初含有量에서 큰 減少가 일어나지 않았다.

以上의 結果로 부터 질소를 포함한 無機物의 溶出은 牧草의 分解와 대체로 같은 傾向을 나타내는 것을 알았으며, 칼리의 溶出은 특히 牧草落葉의 分解初期에 많다는 것을 알았다. 따라서 牧草落葉으로 부터의 칼리의 溶出이 草地生態系에 있어서의 칼리의 再循環에 큰 役割을 하는 것으로 생각되어 졌다.

I. INTRODUCTION

Leaching of potassium is known not only on soil (Bonner & Galston, 1952) but also on plant body (Foth, 1978). But the nature of leaching is very different between soil and plant. Potassium leaching from soil means partial loss of potassium from soil, while that from plant body means addition of potassium to soil.

On the meadow a part of forages are left as harvest loss, litter or standing dead, and potassium in them are leached and returned to soil (Fujiwara & Iida, 1958; Okawa & Kusano, 1975). Potassium is markedly liable to be released from plant tissues since it merely exists as ion form in plants. And the liability for potassium leaching from living forages was ranked as follows; dead leaves > over-mature leaves > mature leaves > immature leaves > stem and ear or flower (Kim et al., 1986).

Therefore, it is considered that potassium leaching from dead leaves to the soil will be meaningful for a recycle system of potassium in the grassland agro-ecosystem. In this study, for the purpose of comparing the potassium leaching with those of other minerals, the leaching of minerals including nitrogen from dead plant body was investigated by putting orchardgrass hay on meadow.

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II. MATERIALS AND METHODS

This experiment was made in the field of Nagoya University Farm. Orchardgrass was harvested on October 8, 1985 from an orchardgrass meadow fertilized K at the medium level (Kim et al., 1988). The forage was air-dried, cut into 5 cm lengths and then put into plastic net bags (17 cm x 25 cm; 16 mesh) at a rate of 10 g (8.2 g DM) per bag.

The bags were placed on the soil surface of the orchardgrass meadow, and fixed with metal hooks to prevent from being moved with rainfall or wind. Two experiments were designed, one was for continuous leaching up to one year and the other was for monthly leaching during one year. For the purpose, a part of the bags were left on the meadow for one year from November 22, 1985 and the contents of them were sampled monthly. The other bags were set on the meadow monthly from November, 1985 to October, 1986 and withdrawn after leaving one month. During the experimental period, the forage on the meadow was harvested four times (Table 1).

The plant samples in the bag were separated from contaminated soil with a sieve of 100 mesh, dried at 80-85°C, and milled for chemical analyses. Then, a half gram each of the milled sample was extracted for 18 h by 25 ml of 1 M hydrochloric acid, and adequate volume of extract was diluted with distilled water up to 100 ml and filtered (Norin Suisan-Sho, 1979). The diluted solutions were directly subjected to K determination by flame photometry (FLA, Eko Seikisangyo Co. Ltd., Tokyo), and Ca and Mg determinations were made with an atomic absorption/flame emission spectrophotometer (AA-646, Shimadzu Co. Ltd., Kyoto). Nitrogen and P were determined by Kjeldahl or C/N corder method and by a photometric (molybdo-vanadate reagent) method (Horwitz, 1975)

Table 1. The dry matter breakdown of air-dried orchardgrass placed on an orchardgrass meadow for a year or for a month[1]

Placed one year			Placed one month		
Period	Remained (g DW/bag)	Percentage (%)	Period	Remained (g DW/bag)	Percentage (%)
Nov. 22, 1985	8.2	100	Nov. 22, 1985	8.2	100
Nov-Dec2, 3)	7.2±0.3	88± 4	Nov-Dec 2, 3)	7.2±0.3	88±4
Nov-Jan, 1986	7.2±0.4	88± 5	Dec-Jan, 1986	7.5±0.2	91±2
Nov-Feb	6.7±0.3	82± 4	Jan-Feb	7.5±0.1	91±1
Nov-Mar	6.3±0.2	77± 2	Feb-Mar	7.2±0.2	88±2
Nov-Apr3)	5.9±0.9	72±11	Mar-Apr3)	6.0±0.2	73±2
Nov-May	4.5±0.5	55± 6	Apr-May	5.1±0.3	62±4
Nov-Jun3)	3.9±0.5	48± 6	May-Jun3)	5.1±0.3	62±4
Nov-Jul	3.9±0.4	48± 5	Jun-Jul	3.1±0.2	38±2
Nov-Aug3)	2.3±0.1	28± 1	Jul-Aug3)	5.2±0.1	63±1
Nov-Sep	2.6±0.4	32± 5	Aug-Sep	4.1±0.1	50±1
Nov-Oct	2.7±0.1	33± 1	Sep-Oct	5.9±0.3	72±4
Nov-Nov	2.5±0.2	30± 2	Oct-Nov	6.4±0.3	78±4

1) Mean ± S.D. of 3 replicates.
2) The bags were sampled on 22nd day of every month.
3) Orchardgrass grown on the meadow was harvested within the period.

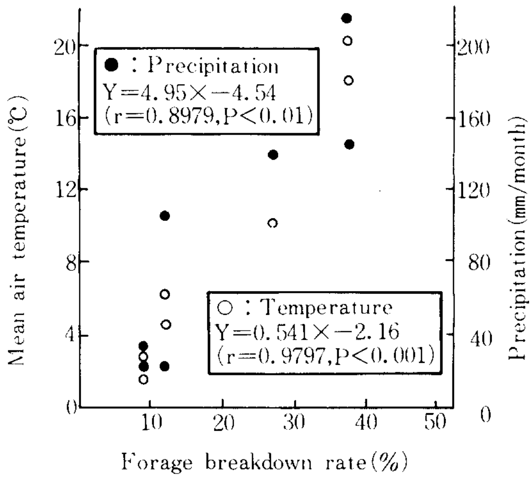

Fig. 1. Relationships between the forage breakdown rate and the mean air temperature and the precipitation.

$$\text{Forage breakdown rate} = \frac{\text{Initial Wt} - \text{Wt. on sampling date}}{\text{Initial Wt.}} \times 100\ (\%).$$

with a double-beam spectrophotometer (UV-140, Shimadzu Co., Ltd., Kyoto), respectively.

III. RESULTS AND DISCUSSION

Table 1 shows the dry matter breakdown of air-dried forages placed on an orchardgrass meadow throughout a year or for one month. The dry weight of forage in the bag decreased from 8.2g to 2.5g (30% of the initial weight) on a DM basis by being left for a year, and 23% of the dry weight was lost within the first 4 months, and this value was significantly lower than that reported by Dickinson (1983) as being 65%. The DM breakdown from bags placed on the meadow for one month varied with season, and the rate of breakdown was the greatest in July, 1986 and the least in January or February, 1986.

Figure 1 shows the relations of the forage breakdown rate from bags placed for one month with the mean air temperature and the precipitation. The study was made for 7 months from November, 1985 to June, 1986. There were very close relationships between them, and the increase of temperature had more strong effect on the breakdown rate than that of precipitation. In fact, in the period (June-July) of Table 1, when both temperature and precipitation increased, the rate of forage breakdown was the greatest. These facts show that the DM breakdown depends on environmental factors such as temperature and precipitation.

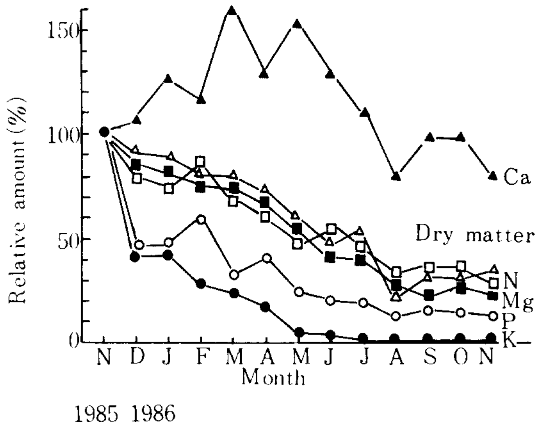

Fig. 2. Time course of the relative amounts of nutrients in dried forage on the meadow for one year to the initial contents.

Figure 2 shows the time course of the relative amount of each nutrient to initial one in the dried forages left on the meadow for one year. In the Figure, the amount of each nutrient was obtained by multiplying its content with dry weight of forage remained. The relative amounts of K and P decreased rapidly in the first month to 40 and 45 % of the initial amounts, respectively, and then decreased gradually and they were only 1 and 12 % in August, 1986, respectively. Further decompositions could not be observed. The time course of the relative amounts of forage dry weight, N and Mg were quite similar throughout the experimental period. Besides, sudden decrease of the relative amounts of the nutrients was found in December, May and August. The time course of Ca was quite different from those of other nutrients; that is, the relative amount of Ca was more than 100 % suggesting that there was some contamination with soil Ca. But lower values than 100 % were obtained after August.

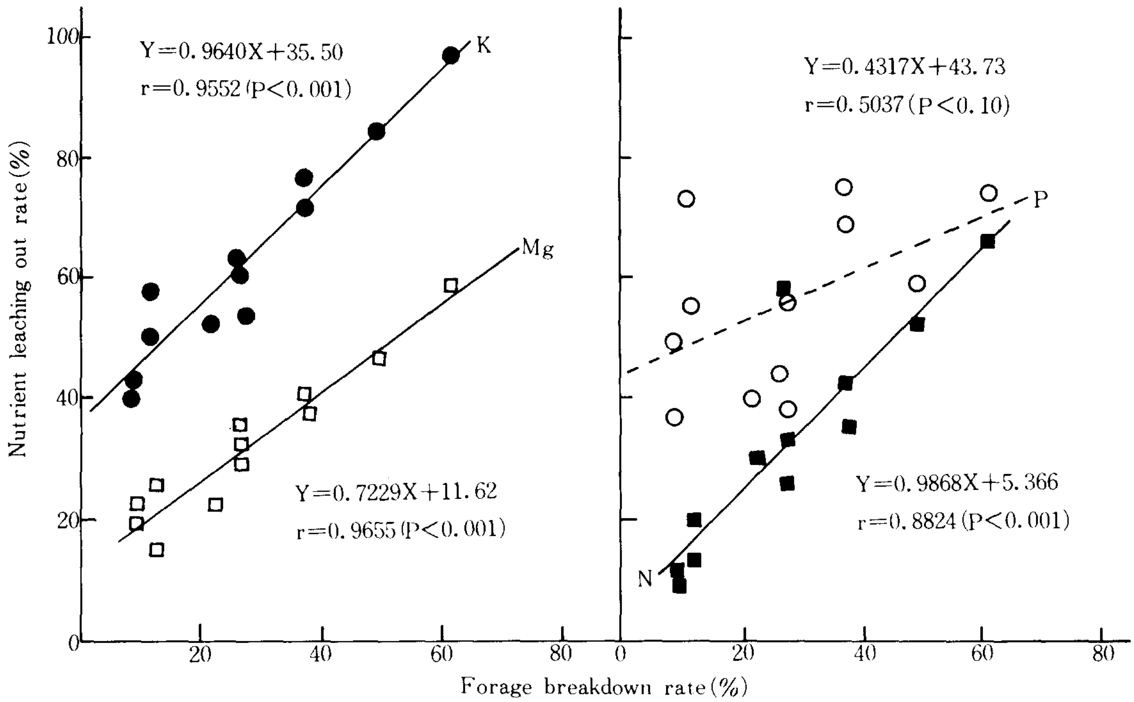

Fig. 3. Relationships between the forage breakdown and the nutrient leaching out rates for one month.

It implies that leaching of Ca from plant body also occurred in grassland. Moreover, the simultaneous decomposition of N with DM means that most of the DM breakdown is derived from microbial decomposition of plant tissue and plant components, because most of N in plant is protein and protein can not leach out without the decomposition.

Figure 3 shows the relations between the forage breakdown and the nutrient leaching out rates within a month. The forage breakdown rate was significantly correlated with the leaching rates of K, Mg and N at 0.1 % level,, but was not significantly correlated with that of P. The coefficient of slope(b) and intercept(a) of the equations (Y = a + bX), shown in Fig. 3, suggested that K leaching depended on the forage breakdown (b = 0.96) and that the K leaching preceded the breakdown (a = 35). The leaching of Mg and N preceding the forage breakdown was small (a is 11 and 5.3, respectively) and most of it occurred by the forage breakdown (b is 0.72 and 0.98, respectively). The result of Mg leaching hints the different solubility between several Mg fractions of the plant (Hashimoto, 1953), and also suggested that most of N in the dried plant body was included in the water-insoluble fractions and it became soluble with the microbial decomposition of plant body. Most of the leaching of P preceded the forage breakdown (a = 43) and a little accompanied with breakdown of forage (b = 0.43). There may have been fixations of P by microorganisms and resulted in the low leaching accompanied with the forage breakdown as reported by Dickinson (1983).

From the results, it became clear that the leaching of mineral nutrients including N from dried forage occurred with the advance of forage breakdown. And among the nutrients studied, K was leached out most frequently in the greatest amount. This fact coincides with the results of Kim et al.(1986), who suggested that K in a grassland agro-ecosystem acts efficiently and repeatedly in comparison with plant nutrients such as N and P. So it can be concluded that K leaching from dead forages to soil takes an important role in a recycle system of K in the grassland agro-ecosystem.

IV. SUMMARY

The leaching of minerals including nitrogen(N) from dead plant body was investigated by putting orchardgrass hay on meadow, with an intention to know the role of potassium(K) leaching in a recycle system of K in the grassland agro-ecosystem.

The dry weight of forages decreased to 30 % of the initial weight on a dry matter basis by being left on the meadow for a year, and the increase of temperature had more strong effect on the forage breakdown rate than that of precipitation.

The liability of nutrient leaching from the dead forage was ranked as follows; K > phosphorus(P) > magnesium(Mg), N > calcium(Ca). The relative amounts of K and P decreased rapidly in the first month to 40 and 45 % of the initial amounts, respectively, and K decreased in the ninth month to 1 % of the initial amount. The time course of the relative amounts of forage dry weight, N and Mg were quite similar throughout the experimental period, but the relative amount of Ca did not decrease to a certain extent.

From the results above, it became clear that the leaching of mineral nutrients including N from dried forage occurred with the advance of forage breakdown. Among the nutrients studied, K was leached out in the greatest amount and it is suggested that the K leaching preceded the forage breakdown. So it can be concluded that K leaching from dead forages to soil takes an important role in a recycle system of K in the grassland agro-ecosystem.

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