韓草誌(J. Korean Grassl. Sci.) 13(3) : 184~189, 1993

Effect of Mineral Content of Orchardgrass (*Dactylis glomerata* L.) on Mineral Balance of Goats

Sangdeog A. Kim, Mitsuaki Ohshima* and Shigekata Yoshida*

오차드그라스(*Dactylis glomerata* L.)의 無機含量差에 따른 山羊의 無機質 出納에 關한 硏究

金相德 · 大島光昭* · 吉田重方*

摘　要

收穫時期와 칼륨비료의 施用水準이 각각 다른 오차드그라스(*Dactylis glomerata* L.)를 代謝試驗用 케이지 안의 염소(山羊)에게 급여하여 牧草中 무기질함량이 염소의 무기물질 出納에 어떤 영향을 주는가를 알아보고자 본 실험을 실시하였다.

低칼륨급여구의 오차드그라스 乾草中 칼륨과 마그네슘含量은 건물량 기준으로 각각 3.4%와 0.26%이었고 中칼륨구의 함량은 4.9%와 0.21%이었으며 高칼륨구의 함량은 5.8%와 0.21%이었다. 高칼륨급여구에서의 尿中 칼륨배설량은 低칼륨구보다 有意하게 많았고, 低칼륨구의 糞中 및 尿中 마그네슘배설량은 中칼륨구 및 高칼륨구보다 많았다. 尿中 마그네슘排泄量은 血漿의 마그네슘濃度 正相關의 경향이 있었으며, 高칼륨급여구의 염소(山羊)는 다른 급여구에 비해 飮水量과 排尿量이 많은 경향이었다.

I. INTRODUCTION

The nutrient flow in pasture should be explored as the whole soil-plant-animal complex. In the former reports potassium flow between soil and plant was investigated(Kim *et al*., 1987, 1989) remaining the relations between plant and animal and between soil and animal excreta returned to the soil. But it needs many years to estimate the above relations on the field.

So, in the present experiment, only the mineral flow between plant and animal was investigated by model study using hay as the feeds and goats as the experimental animal. In the study, the interest was concentrated upon the effect of potassium content of forage on the potassium and the magnesium balances in goats.

To study the mineral balance of animals, grazing on pasture is unsuitable because of inaccurate determination of the intake and the selective feeding of animals. Therefore only a few researchers(e.g. Kemp, 1958) have studied on it by grazing animals on pasture.

In the present experiment, orchardgrass hays which were harvested in different seasons and grown with different levels of potassium fertilizer were fed to goats kept in metabolic cages. From the results, some of the reasons of the incidence of hypomagnesaemia was suggested.

II. MATERIALS AND METHODS

This experiment was carried out on Nagoya University Farm situated in Central Japan.

The hay used here was prepared from orchardgrass cultivated at various potassium fertilizer levels on meadow and used in a previous study(Kim *et al*., 1993), and it was divided into three according

Dep. Animal Resources, Joongbu University, Kumsan-gun, Chungchong Nam-do 312-940, KOREA(中部大學 動物資源學科)
* University Farm, Faculty of Agriculture, Nagoya University, Togo-cho, Aichi-ken 470-01, JAPAN(日本 名古屋大學 農學部 農場)

to the potassium contents. The first, second and third growths of orchardgrass (*Dactylis glomerata* L.), grown on the meadow were harvested on April 24, June 2 and July 24 in 1986 at heading stages (1st and 2nd growths) and at vegetative stage (3rd growth).

After harvesting, the forage plants were sun-cured and preserved until the feeding experiment. The forage plants were composed of those cultivated in five different fertilized K levels as described previously(Kim *et al.*, 1987). To keep the enough forages for the feeding trials, they were divided into three; K-low, K-medium, and K-high. The K-low feed was consisted of the harvests of April and June from the K-0 plot and of that of July from the K-0 and K-low plots. The medium feed was the forage harvested in April from K-low and K-medium plots. The K-high feed was the mixture of the harvests of April from K-high plot and that of June from K-medium, medium+FYM, and K-high plots.

Three Shiba strain Japanese goats weighing about 17 kg were individually housed in metabolic cages at April 10, 1987. And the feeding experiment on the cage was carried out from April 13 to May 19, 1987. Orchardgrass hay was fed to them twice daily at 9 AM and 3 PM as to offer 460g DM per day. Two grams of table salt and 10g of $CaHPO_4$ were also fed to each animal everyday. The three diets were offered to all goats in a Latin-square design over three periods. During each period, faeces and urine were collected for 5 days after 7 days of preliminary feeding.

The faeces were dried with a draft-oven at 80℃ and the urine was acidified with H_2SO_4 and kept in a refrigerator before analyses. Blood samples were taken once at 1 PM on one day before the last of each period from the jugular vein with multiple purpose syringe(NM-20G, Nipro Co. Ltd., Osaka) and vacuum neotube(S-L10, Nipro Co. Ltd., Osaka).

Crude ash content of the feeds was determined with conventional method. The contents of K and Mg in the feeds, urine and faeces were analysed with a flame photometer and an atomic absorption spectrophotometer, respectively. Serum Mg concentration was analysed with a method of Willis(1960). Comparisons among means of each treatment were performed by using both the analysis of variance and the Studentized range, Q, test(Snedecor and Cochran, 1982).

Ⅲ. RESULTS AND DISCUSSION

Table 1 shows the contents of crude ash, K and Mg in the feeds. Crude ash contents were 9.0, 11.2 and 12.9% on a dry matter basis in K-low, K-medium and K-high treatments, respectively. The K contents were 3.4, 4.9 and 5.8%, respectively, and Mg contents were 0.26, 0.21 and 0.21%, respectively. The differences of the K contents were greater than those of the crude ash and Mg contents among the three feeds. This result was supported by a fact reported by Bohman *et al.* (1983) that high K content of forage was accompanied with low crude ash content of it in a pasture where grass tetany occurred. However, Mg content in the feed material was higher than the marginal content of 0.20% advised by Kemp *et al.* (1961).

Table 1. Contents of crude ash, potassium and magnesium of materials of the goat experiment (DM basis)

Treatment	Crude ash (%)	K (mg/g)	Mg (mg/g)
K-low	9.0	33.7	2.6
K-medium	11.2	48.7	2.1
K-high	12.9	57.9	2.1

Table 2 shows the dry matter(DM) intake and DM digestibility in the goat trials. The DM intake was not significantly different, but a little low in K-medium feed treatment because of the presence of residual feed. The DM digestibility of the K-low, K-medium and K-high diets were 61, 65 and 65%, respectively, and the former was significantly lower than the latter two. However, it was difficult to keep the uniform leaf:stem ratio in so matured grass as used and in such a small intake level of goats as being 400 g DM/head/day, in spite of the uniformity is very important for the feeding trial. These differences might be derived from the different harvesting dates rather than the different K levels. But the differences were not so great as raising some complexity for determining the effects of K or Mg contents of forage plants on the mineral balances of animals.

Table 2. Dry matter intake and DM digestibility in the goat trial[1].

Treatment	DM intake (g/day)	DM digestibility (%)
K-low	460[a]	61.2[a]
K-medium	426[a]	65.1[b]
K-high	456[a]	64.7[b]

[1] Means on the same column that do not have a common letter differ ($P<0.05$).

Table 3 shows the K balances of goats. Intake of K was significantly more on K-high than on K-low. Faecal K excretion on K-medium was significantly higher than that on K-low, however, the ratios of the excretion to K intake was nearly same between the two diets. Faecal K excretion on K-high showed an intermediate value but the ratio of it to the K intake was the lowest. These inconsistent results in the faecal excretion of K might be derived from the difficulty of keeping uniform proportion of leaf and stem at feeding the hays and from the comparatively low K contents of the faeces. Urinary K excretion was significantly more on K-high than on K-low, but the ratio of the excretion to K intake was not different. There was not any significant difference in K retention among the three treatments, though it was the highest in K-high treatment.

Table 3. Potassium balances of goats[1].

(g/day)

	K-low	K-medium	K-high
Intake	15.5[a]	20.7[ab]	26.4[b]
Faecal excretion	2.02[a]	3.01[b]	2.52[ab]
(ratio to the intake)	(13)	(14)	(10)
Urinary excretion	11.90[a]	15.86[ab]	20.83[b]
(ratio to the intake)	(77)	(77)	(79)
Retention	1.58[a]	1.83[a]	3.05[a]
(ratio to the intake)	(10)	(9)	(11)

[1] Means on the same line that do not have a common letter differ ($P<0.05$).

Table 4 shows the Mg balances of goats. The Mg intake was more on K-low than on K-high. Faecal and urinary Mg excretions on K-low were higher than those on K-medium and K-high reflecting the higher Mg content of the K-low feed, as was shown by Chicco *et al.* (1972). But the difference in the urinary excretion was not significant. There was not any significant difference in K retention among the feed treatments.

Though it was not presented in any tables, there was a tendency of positive relation between urinary Mg excretion and serum Mg concentration (r=

0.4378) and a weak negative relations between faecal and urinary Mg excretions (r=0.6231, $P<0.10$). However, a significant negative relationship was observed between faecal Mg and urinary K excretions (r=−0.6671, $P<0.05$), and the result was opposite to the results of the previous report(Kim *et al.*, 1988). The opposite relationship between the two experiments might be derived from irregular proportion of K and Mg in the present experiment, while in the previous report the feeds were prepared to contain the same amount of Mg with different levels of K.

Table 4. Magnesium balances of goats[1)].

(mg/day)

	K-low	K-medium	K-high
Intake	1,200[b]	890[a]	974[ab]
Faecal excretion	930[b]	687[a]	691[a]
(ratio to the intake)	(78)	(77)	(71)
Urinary excretion	62[a]	24[a]	34[a]
(ratio to the intake)	(5)	(3)	(3)
Retention	208[a]	179[a]	249[a]
(ratio to the intake)	(17)	(20)	(26)

[1)] Means on the same line that do not have a common letter differ ($P<0.05$).

Table 5 shows the effect of the feeding K levels on serum Mg and K concentrations, water intake and volume of urine of goats. There were not any detectable differences in both Mg and K concentrations among the three feed treatments. The Mg concentrations were higher than 1.0 mg/dl, which is considered as the marginal against hypomagnesaemic tetany(Kemp, 1960). From the facts, it was considered that some factors other than K affected on the serum Mg concentrations in the present study. It has been reported that not only high K content but also other factors such as higher water content (Bohman *et al.*, 1983), higher organic acid content, shortage of available energy of feeding material (Martens and Rayssiguier, 1980) were responsible to the Mg absorption in ruminant livestock on the outbreak of the hypomagnesaemic tetany.

Goats on K-high treatment drank more water and excreted more urine than those on the other feeds, but the differences were not significant at 5 % levle. Similar result was also reported by Kawagoe and Kayama(1981). The goats on K-low and K-medium feeds were almost the same in both the water intake and the volume of urine. This fact suggests that the K content of the K-medium diet might not be so high as to increase the water int-

Table 5. Effect of potassium content of forage plants on serum magnesium and potassium concentrations, water intake and volume of urine of goats[1)].

Treatment	Serum Mg (mg/dl)	Serum K (mg/dl)	Water intake (l/day)	Volume of urine (l/day)
K-low	2.3[a]	21[a]	1.72[a]	1.03[a]
K-medium	2.1[a]	22[a]	1.73[a]	1.00[a]
K-high	2.2[a]	23[a]	2.16[a]	1.39[a]

[1)] Means on the same column that do not have a common letter differ ($P<0.05$).

ake. The three feeds used in the present study might be different in organic matter contents as well as mineral contents because they were prepared from forages harvested on different dates, and it is known that organic matter such as nitrogen also affect on water intake and urine excretion(ARC, 1980). So, it is difficult to discuss the relationship between K intake and water balance of animals from the present data.

The conclusion which can be drawn from the present experiment was that there was a negative relationship between urinary K and urinary Mg excretions ($r=-0.5469$) in goats fed orchardgrass hays containing graded levels of K from 3.4 to 5.8% and Mg over 0.2%, though it was not significant at 10% level. And the results suggested that it is necessary to use such feeds containing the same amount of minerals other than K and the same amount of organic components of the same digestibilities for studying the effect of the K content of forages on the Mg balance of animals.

Ⅳ. SUMMARY

Orchardgrass(*Dactylis glomerata* L.) hays, which had been harvested in different seasons and grown with different levels of potassium (K) fertilizer, were fed to goats in metabolic cages in order to know the effect of forage mineral content on mineral balance of goats.

The K contents of the feed were 3.4, 4.9 and 5.8%, and magnesium (Mg) contents were 0.26, 0.21 and 0.21% on a dry matter (DM) basis in K-low, K-medium and K-high treatments, respectively. Urinary K excretion was significantly more on K-high than on K-low treatment. Faecal and urinary Mg excretions on K-low were higher than those on K-medium and K-high feeds. And there was a tendency of positive relation between urinary Mg excretion and serum Mg concentration. Goats on K-high treatment seemed to drink more water and excrete more urine than those on the other feeds.

Ⅴ. REFERENCES

1. Agricultural Research Council (ARC). 1980. Requirements for water. In 'The nutrient requirement of ruminant livestock'. Commonwealth Agricultural Bureaux. London. pp. 295-306.
2. Bohman, V.R., F.P. Horn, B.A. Stewart, A.C. Mathers and D.L. Grunes. 1983. Wheat pasture poisoning(I). J. Anim. Sci. 57:1352-1363.
3. Chicco, C.F., C.B. Ammerman, W.G. Hillis and L.R. Arrington. 1972. Utilization of dietary magnesium by sheep. Am. J. Physiol. 222:1469-1472.
4. Kawagoe, I. and R. Kayama. 1981. Effects of high dietary potassium intake in the form of hay on the metabolism of macro-minerals by dairy cattle. Jpn. J. Zootech. Sci. 52:334-342.
5. Kemp. A. 1958. Influence of fertilizer treatment of grassland on the incidence of hypomagnesaemia and hypomagesaemic tetany(grass tetany) in milking cows. Neth. J. Agric. Sci. 6:281-297.
6. Kemp. A. 1960. Hypomagnesaemia in milking cows: 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.
7. Kemp. A., W.B. Deijs, O.J. Hemkes and A.J.H. Van Es. 1961. Hypomagnesaemia in milking cows: Intake and utilization of magnesium from herbage by lactating cows. Neth. J. agric. Sci. 9:134-149.
8. Kim, S.A., M. Ohshima, H. Tano and R. Kayama. 1988. Effect of green crop fractionation of Italian ryegrass(*Lolium multiflorum* Lam.) on the magnesium and potassium balances in goats. J. Japan. Grassl. Sci. 34:202-209.
9. Kim, S.A., S. Yoshida and R. Kayama. 1989. Mineral leaching from forage placed on soil surface of meadow-Especially for potassium. J. Korean Grassl. Sci. 9:43-47.
10. Kim, S.A., S. Yoshida, M. Ohshima and R.

Kayama. 1993. Response of magnesium content of forages to potassium application in grassland. J. Korean Grassl. Sci. 13(2):105-111.

11. Kim, S.A., S. Yoshida, T. Okubo and R. Kayama. 1987. Potassium behavior between soil and forage in grasslands. J. Japan. Grassl. Sci. 33:345-355.

12. Martens, H. and Y. Rayssiguier. 1980. Magnesium metabolism and hypomagnesaemia. In 'Digestive physiology and metabolism in ruminants'. (Ed. by Y. Ruckebushch and P. Thivend). AIV Publishing Inc. Connecticut. pp. 447-466.

13. Snedecor, C.W. and W.C. Cochran. 1982. Statistical methods(7th edition). Iowa State Univ. Press. Iowa. pp. 215-333.

14. Willis, J.B. 1960. The determination of metals in blood serum by atomic absorption spectroscopy. II. Magnesium. Spectrochimica Acta. 16: 273-278.