韓草誌(J. Korean Grassl. Sci.) 11(1) : 12~16, 1991

Difference of Leaching Liability of Minerals in Forages

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牧草에 含有된 數種 無機物의 成分分劃

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摘 要

溶液중 칼륨水準을 달리한 조건에서 水耕栽培된 오차드그라스에 들어있는 無機物中 칼륨, 마그네슘, 칼슘을 각각 물, 알코올, 酸에 可溶性인 것으로 成分分劃했는 데, 그 結果는 다음과 같다.

(1) 牧草에 含有된 칼륨含量 全體에 대한 물, 알코올, 0.5% 塩酸에 의해 溶出된 成分의 比率은 水耕液中 칼륨水準에 영향을 받지 않았으며 각각 90~93%, 4~6%, 2~3% 의 범위였다. (2) 마그네슘量의 약 80%가 水溶性이었으며, 14~22%는 0.5% 塩酸에 의해 溶出되었다. (3) 칼슘含量 全體에 대한 물, 알코올, 0.5% 및 1몰의 塩酸에 의해 溶出된 成分의 比率은 水耕液中 칼륨水準에 영향을 받았는 데, 각각 26~46%, 44~54% 및 8~22%의 범위였다.

以上의 結果로부터, 3가지 無機物中 물에 의해 溶出되는 成分의 比率은, 칼륨>마그네슘>칼슘의 順序였으나, 酸에 의해 溶出되는 成分의 比率은 그 반대인 칼륨<마그네슘<칼슘이었다.

I. Introduction

Potassium leaching from living forages was investigated previously, and it was shown that there were differences of potassium leaching among plant parts and among forage species (Kim et al., 1986). Mineral leaching from dried forage placed on the soil surface of meadow was also examined, and it was observed that there was a great difference of leaching liability among some mineral nutrients (Kim et al., 1989). The result might reflect the differences of plant parts and constituents where the minerals present as well as the solubility of ionized minerals. It is known that most of potassium is water soluble. While some of magnesium in plants are included in phytin (water soluble), chlorophyll (alcohol soluble) and pectin (acid soluble) (Hashimoto, 1953) and calcium in plants can be also divided into some compounds (Hashimoto and Okamoto, 1954). The minerals combined with organic matter cannot be leached out without microbial degradation (Dickinson, 1983).

In the present report, three minerals, potassium, magnesium and calcium in forages were divided into water, alcohol and acid soluble fractions to know the reason of different leaching rate and the possibility of leaching after microbial degradation (Kim et al., 1989).

II. Materials and Methods

Orchardgrass (*Dactylis glomerata* Linn.) was cultivated in the spring season with water culture under different potassium (K_2O) levels (10, 20, 50, 100, and 500 ppm) and sampled on May 13, 1985. The cultivating and sampling methods were shown in a previous report (Kim et al., 1987). A half gram of the dried forage was successively extracted with water, 95% methanol, 0.5% HCl and 1 M (3.6%) HCl, in that order. Each extraction was made by soaking the sample in one of the solutions for 3 hrs and filtering through a paper. The filtered solutions were made up to appropriate volume for analysis (Kim et al., 1989).

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Table 1. Effect of potassium fertilizer level on the potassium contents of the soluble fractions of orchardgrass grown on water culture in spring time

(mg K/g DW)

K_2O-level (ppm)	Water-soluble	MeOH[1]-soluble (95%)	HCl[1]-soluble (0.5%)	HCl-soluble(lN)	Total K[2]
10	16.7±0.6[3]	1.2±0.2	0.5±0.1	0.1±0.0	18.5
	(90)[4]	(6)	(3)	(1)	(100)
20	22.7±4.7	0.9±0.4	0.6±0.1	0.1±0.0	24.3
	(93)	(4)	(3)	(0)	(100)
50	38.7±3.8	2.0±0.2	1.0±0.1	0.1±0.0	41.8
	(93)	(5)	(2)	(0)	(100)
100	64.7±6.0	3.1±0.8	1.6±0.2	0.1±0.0	69.5
	(93)	(5)	(2)	(0)	(100)
500	71.3±6.5	3.7±1.0	2.6±0.4	0.1±0.0	77.7
	(92)	(5)	(3)	(0)	(100)

1) MeOH;methyl alcohol, HCl;hydrochloric acid.
2) Obtained by adding the K in the four fractions.
3) Mean ± S.D. of 3 replicates.
4) Percent to total K.

III. Results and Discussion

Table 1 shows the effect of the application level of K_2O on the potassium (K) contents of the soluble fraction of orchardgrass. All of the K fractions were increased by increasing the K_2O level. Water soluble K was in wide range of 17 to 71 mg/g DW. Methanol soluble and 0.5% HCl soluble K fractions were ranged from 1 to 4 mg and from 1 to 3 mg/g DW, respectively. But the percentage of K in each fraction to total K was not affected by the fertilization levels, and it was 90-93, 4-6 and 2-3% in water, methanol and 0.5%

Table 2. Effect of potassium fertilizer level on the magnesium contents of the soluble fractions of orchardgrass grown on water culture in spring time

(mg Mg/g DW)

K_2O level (ppm)	Water-soluble	MeOH[1]-soluble (95%)	HCl[1]-soluble (0.5%)	HCl-soluble (lN)	Total[2]
10	2.84±0.32[3]	0.16±0.02	0.57±0.03	0.06±0.03	3.63±0.35
	(78)[4]	(4)	(16)	(2)	(100)
20	3.01±0.26	0.13±0.02	0.54±0.04	0.05±0.02	3.74±0.31
	(81)	(3)	(14)	(2)	(100)
50	2.89±0.20	0.16±0.01	0.55±0.05	0.06±0.03	3.67±0.22
	(79)	(4)	(15)	(2)	(100)
100	2.23±0.24	0.13±0.03	0.50±0.02	0.04±0.01	2.89±0.22
	(77)	(5)	(17)	(1)	(100)
500	1.53±0.20	0.09±0.01	0.47±0.03	0.04±0.01	2.13±0.23
	(72)	(4)	(22)	(2)	(100)

1) MeOH;Methyl alcohol, HCl;hydrochloric acid.
2) Obtained by adding the Mg in the four fractions.
3) Mean ± S.D. of 3 replicates.
4) Percent to total Mg.

HCl soluble fractions, respectively. Most of the extractive K of orchardgrass was water soluble.

Table 2 shows the effect of applied K_2O on the magnesium(Mg) contents of the soluble fractions of orchardgrass. The evident reduction in the Mg content of each fraction was observed when the application level of K_2O was over 100 ppm. When cultured at 50 ppm, the Mg distributed in water, methanol and 0.5% HCl-soluble fractions were 2.89, 0.16 and 0.55 mg/g DW, but they were reduced to 1.53, 0.09 and 0.47 mg, respectively, under the culture solution of 500 ppm K_2O. But the percent of Mg in each fraction to total Mg was not affected by the K_2O level of the water culture, as previously shown in the case of the K content. And about 20% of the extractive Mg was not water soluble and two thirds of them were extracted by 0.5% HCl solution.

Table 3 shows the effect of K_2O level in the culture solution on the calcium (Ca) contents of the soluble fractions of orchardgrass. There was a tendency of decreasing the Ca content of each fraction with the increase of the K fertilizer level. Methanol soluble fraction contained a trace amount of Ca at each K fertilizer level. Different from K and Mg, Ca in orchardgrass was more soluble in acid solution than in water suggesting that a large portion of Ca in orchardgrass is unexchangeable. The percentage of water, 0.5% HCl- and 1 M HCl-soluble Ca to total Ca were 26-46%, 44-54%, and 8-22%, respectively. The sum of Ca solubility in water and in 0.5% HCl was similar to that of a report by Ward and Harvers (1982).

Figure 1 summarized the percentage of each mineral in each fraction extracted from orchardgrass to the total amount of corresponding extractive mineral to illustrate different solubilities of K, Mg and Ca. The solubility in water was the highest in K and followed by Mg and Ca. While the solubility in HCl solution was opposite to that in water. The extraction with MeOH was made to remove pectinic and phytinic Ca and Mg from the plant (Hashimoto and Okamoto, 1954), but all the three minerals were little extracted with MeOH after the extraction with water.

The above facts suggested that nearly all of K could be leached with water, but more than 60% of Ca in orchardgrass could not be leached out without undergoing some microbial decomposition which would be notably done under the field condition (Dickinson, 1983). The solubilities of Mg to water and HCl were

Table 3. Effect of potassium fertilizer level on the calcium contents of the soluble fractions of orchardgrass grown on water culture in spring time

(mg Ca/g DW)

K_2O-level (ppm)	Water-soluble	MeOH[1]-soluble (95%)	HCl[1]-soluble (0.5%)	HCl-soluble (1N)	Total Ca[2]
10	2.5±0.3[3]	0.1±0.0	3.7±1.0	1.8±1.7	8.1
	(31)[4]	(1)	(46)	(22)	(100)
20	2.4±0.2	0.1±0.0	2.3±0.1	0.4±0.2	5.2
	(46)	(2)	(44)	(8)	(100)
50	2.1±0.1	0.1±0.0	3.0±0.5	1.3±1.4	6.5
	(32)	(2)	(46)	(20)	(100)
100	1.5±0.2	0.1±0.0	2.4±0.2	0.5±0.3	4.5
	(33)	(2)	(54)	(11)	(100)
500	0.6±0.1	0.1±0.0	1.1±0.9	0.5±0.2	2.3
	(26)	(4)	(48)	(22)	(100)

1) MeOH:methyl alcohol, HCl;hydrochloric acid.
2) Obtained by adding the Ca.
3) Mean ± S.D. of 3 replicates.
4) Percent to total Ca.

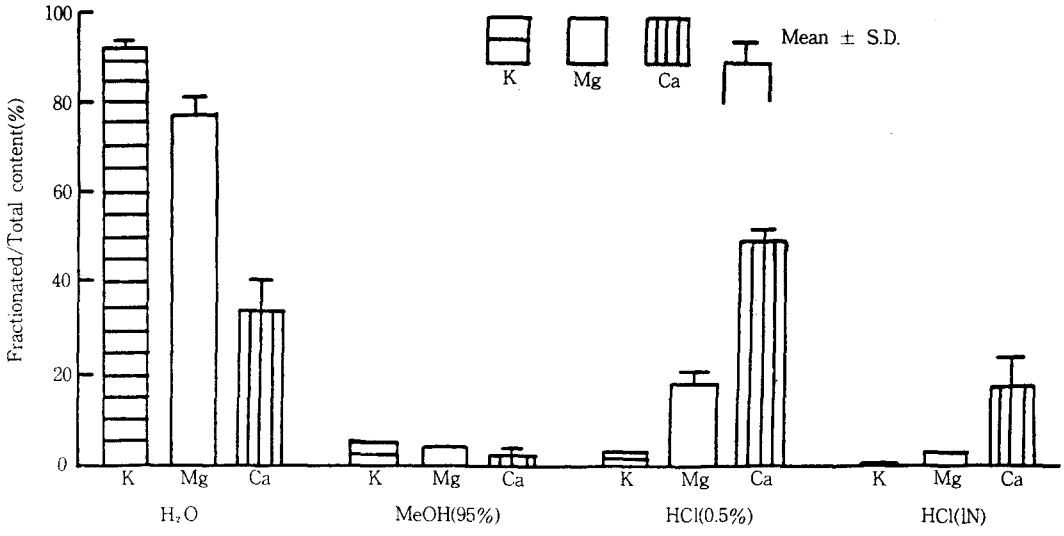

Fig. 1. Comparison of fractionation ratios among minerals fractionated with water, methyl alcohol and hydrochloric acids.

intermediate of those of K and Ca. And the difference of leaching liability of the minerals by some chemical solutions might be the reason of different leaching rate and the possibility of leaching after microbial degradation.

Ⅳ. Summary

Three minerals in orchardgrass (*Dactylis glomerata* Linn.) grown under different potassium (K_2O) levels in water culture, potassium(K), magnesium(Mg) and calcium(Ca) were divided into water, alcohol, and acid soluble fractions to know the reason of different leaching rate.

The results were as follows; (1) The percentage of K in each fraction to total K was not affected by the fertilization levels, and it was 90-93, 4-6, and 2-3% in water, methanol and 0.5% HCl soluble fractions, respectively. (2) About 80% of the extractive Mg was water soluble, and 14-22% of total Mg were extracted by 0.5% HCl solution. (3) The percentage of water, 0.5% HCl- and 1 M HCl-soluble Ca to total Ca were affected by the fertilization levels, and were 26-46%, 44-54%, and 8-22%, respectively.

From the above facts, it is known that the solubility in water was the highest in K and followed by Mg and Ca. While the solubility in HCl solution was opposite to that in water.

Ⅴ. References

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*Written in Japanese with English summary.