暗赤色土におけるカリとナトリウム施用がローズグラスの収量及び養分吸収に及ぼす影響

Yield and Nutrient Absorption of Rhodesgrass on an Okinawan Dark Red Soil Treated with Potassium and Sodium

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Introduction

In a previouse paper, one of the authers reported that potassium application showed favorable effect on the yield of Sudanegrass, at least on the fresh matter yields in addition to potassium absorption of the grass, on Dark Red soils under the greenhouse conditions[5]. Rhodesgrass, however, did not increase in the yield by potassium application when it was grown on a Dard Red soil under the field conditions[6]. It was assumed, in that field experiment, that the Rhodesgrass plant was supplied with air-born sodium in the rain being particular to island environment of Okinawa, since sodium is generally regarded to play a compensation role for potassium in the growth of plant[1].

The objectives of the present report were to investigate effects of application of potassium and sodium on the yield as well as absorption of mineral nutrients of Rhodesgrass.

Material and Methods

A Dark Red soil (0 to 18 cm) was collected from the University of the Ryukyus Experiment Farm No. 17 and used for the pot experiment. Some of the chemical properties of the soil were shown in Table 1.

Ammonium sulfate and superphosphate applied in the experiment were at a rate of 0.4g of N and P_2O_5/pot/cut, respectively. Potassium chloride and sodium chloride were applied at varing levels, namely 0.0, 0.2, 0.4, and 0.8g K_2O/pot/cut, and 0.0, 0.2, and 0.4g Na_2O/pot/cut, respectively. The soil was transfered to Wagner pots (1/500, 000 ha), which contained 2.2kg of soil, after mixing with the halves of the above amounts of fertilizers. The fertilizer treatment was duplicated three times. The pots were arranged in a way of randomization.

Rhodesgrass (Chloris gayana Kunth, Culti. var. KATAMBORA) seeds were sown in the pots on June 21, 1985, and the grass was

Table 1. Chemical properties of the soil used for the pot experiment

第1表 ポット栽培に使用した土壌の化学性

pH		CEC	Exchangeable bases, me/100g				Base satu.	Organic	Total	Available P_2O_5
H_2O	KCl	me/100g	Ca	Mg	K	Na	%	C, %	N, %	mg/100g
6.0	5.4	14.1	11.4	1.5	0.9	0.1	99	0.63	0.10	8.5

grown in the greenhouse. The other halves of the given amounts of fertilizers were top dressed 20 days after germination. The grass was harvested as the lst cut on the 60th day from planting. The grass was continued to grow after receiving the same quantities of fertilizers to the 1 at cut, and harvested as the 2 nd cut on the 40th day from the 1 st cut. These two cuts were done when the grass was about to ear up. The yields of the Rhodesgrass plant were determined on the 1 st and 2 nd cuts, and the grass samples were analyzed for nitrogen, potassium, sodium, calcium, and magnesium.

Results and Discussion

1. Yield of the grass

The fresh matter yield of the Rhodesgrass plant was shown in Table 2, and the dry matter yield in Fig. 1. Significance of the F values obtained from the analysis of variance on these yields of the Rhodesgrass plant were summarized in Table 3.

The grwoth of the grass was not vigorous enough for the 1 st cut as indicated in Table 2. In the 1st cut of the grass, the application of potassium and sodium did not give any significant effect on the both of fresh and dry matter yields, and the interaction of the potassium and sodium applications was found not significant (Tables 2 and 3, and Fig. 1).

In the 2 nd cut of the grass, the fresh matter yield was significantly effected by the

Table 2. Fresh matter yield of the Rhodesgrass Plant as affected by application of ptassium and sodium*

第2表 ローズグラスの青刈収量に及ぼすカリ及びナトリウム施用の影響*

Na_2O applied ナトリウム施用量 (g/pot)	K_2O applied カリ施用量 (g/pot) 0	0.2	0.4	0.8
		1 st cut 第1回刈取 (g/pot)		
0.0	76.1± 5.1	84.4± 8.2	84.3±12.2	89.6±19.9
0.2	75.1± 3.4	92.5±14.4	92.6± 6.1	82.5± 8.3
0.4	90.8± 6.2	84.4± 7.3	89.6± 6.0	89.9± 5.1
		2 nd cut 第2回刈取 (g/pot)		
0.0	136.2±10.9	157.3± 5.5	163.8± 8.3	181.4±12.5
0.2	174.7± 2.7	162.6±16.4	171.6±17.6	165.2±10.4
0.4	172.8± 7.3	171.1± 8.0	175.5± 9.7	175.6±27.7
		Total 第1回第2回刈取合計 (g/pot)		
0.0	212.3±13.7	241.7±13.1	248.1±18.5	271.0±16.2
0.2	249.7± 5.6	255.1±17.5	267.2±15.6	247.7± 7.7
0.4	263.7± 2.1	252.1± 8.0	265.1±14.2	265.5±22.6

*The values are the means and standard deviations. 数値は平均±標準偏差。

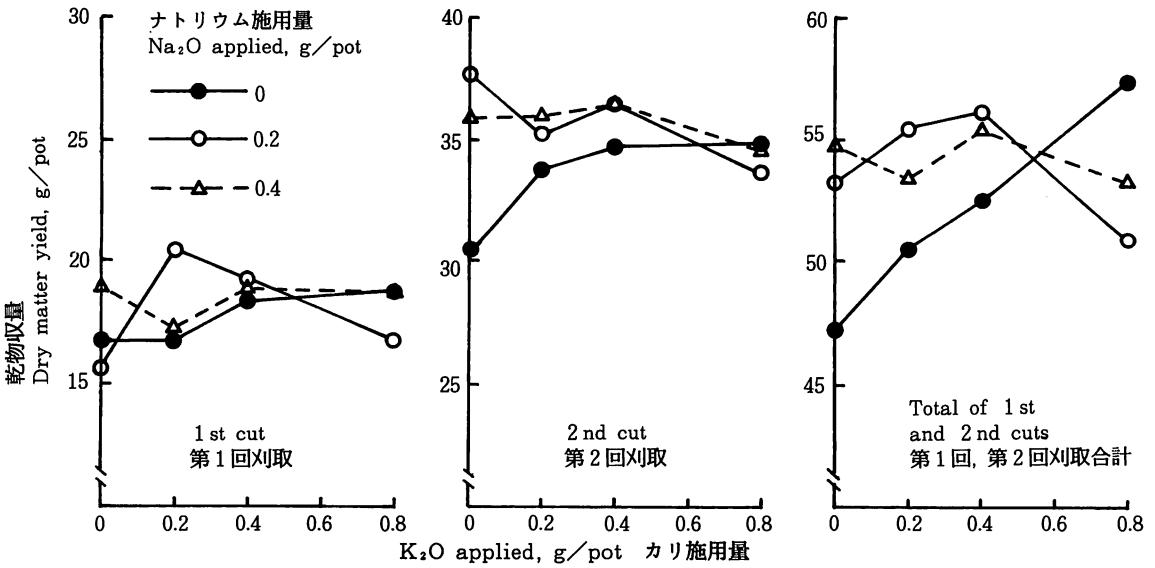

Fig. 1. Effect of potassium and sodium applications on the dry matter yield of the Rhodesgrass plant

第1図 ローズグラスの乾物収量に及ぼすカリ及びナトリウム施用の影響

Table 3. Significance of F values in analysis of variance for the yields of fresh and dry matter of the Rhodesgrass plant

第3表 ローズグラス青刈及び乾物収量に対する分散分析F値の有意性

Source of variance 要 因	1 st cut 第1回刈取	2 nd cut 第2回刈取	Total 合計
		Fresh matter yield 青刈収量	
Effect of K_2O application カリ施用の効果	N. s.[a]	N. s.	5%
Effect of Na_2O application ナトリウム施用の効果	N. s.	5%	5%
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	10%	5%
		Dry matter yield 乾物収量	
Effect of K_2O application カリ施用の効果	N. s.	N. s.	N. s.
Effect of Na_2O application ナトリウム施用の効果	N. s.	N. s.	N. s.
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	10%	1%

a) N. s. Stands for "not significant". N. s. は有意性なしを示す。

sodium application, but tended to decrease by the potassium application. However, only the interaction of applied potassium and sodium was significant in the dry matter yield (Tables 2 and 3, and Fig. 1).

The total fresh matter yield of the 1st and 2nd cuts was significantly effected by the potassium and sodium applications, and in addition the interaction of the application of potassium and sodium was significant (Tables 2 and 3). In the total dry matter yield, it was very clear from Fig. 1, that the grass responded very much to potassium when no sodium was applied. The analysis of variance, however, showed only the interaction of applied potassium and sodium was significant as a whole (Table 3).

The results obtained here manifests that the response of the Rhodesgrass plant to applied potassium will be diminished when the grass is somewhat supplied with sodium. Since there are much possibilities of supply of sodium from the rain in Okinawa under the island environment[2,4], it may not be un-

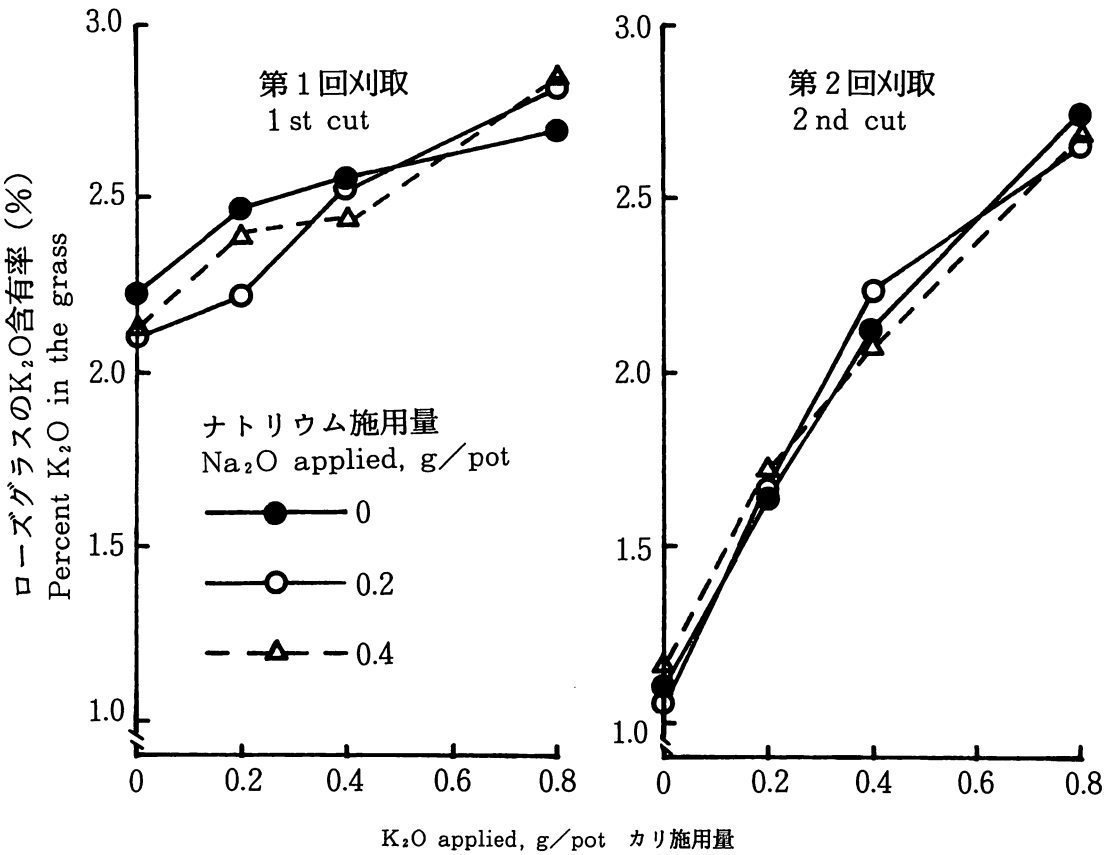

Fig. 2. Effect of potassium and sodium applications on potassium concentration of the Rhodesgrass plant

第2図 ローズグラスのカリ含有率に及ぼすカリ及びナトリウム施用の影響

usual if crops do not respond to applied potassium in the field. Significance of sodium in the cultivation of the forage crops must be studied further in relation to potassium fertilization.

2. Nutrient absorption of the grass

(1) Nitrogen

As a whole, the mean values and standard deviations of percent of nitrogen in the Rhodesgrass plant were 0.82 ± 0.06 and 0.92 ± 0.08, on the basis of dry matter, for the 1 st cut and 2 nd cut, respectively. Percent of nitrogen in the grass was rather low and varied little by the application of potassium and sodium. This was presumably resulted from the low level of nitrogen in the soil (Table 1), and nitrogen applied was rather inadequte.

(2) Potassium

Potassium concentration of the Rhodesgrass plant was significantly affected by the application of potassium but not by the sodium application (Fig. 2 and Table 4). Accordingly, potassium uptake of the grass was effected by the potassium application (Fig. 3 and Table 5). These results indicate good accordance with those on Dark Red soil in a previous report[5]. In addition to the effect of the potassium appliction, the interaction of the application of potassium and sodium was significant in the potassium uptake which was reasonably depended on the yield of the grass.

(3) Sodium

Sodium concentration of the grass was significantly affected by both of the sodium

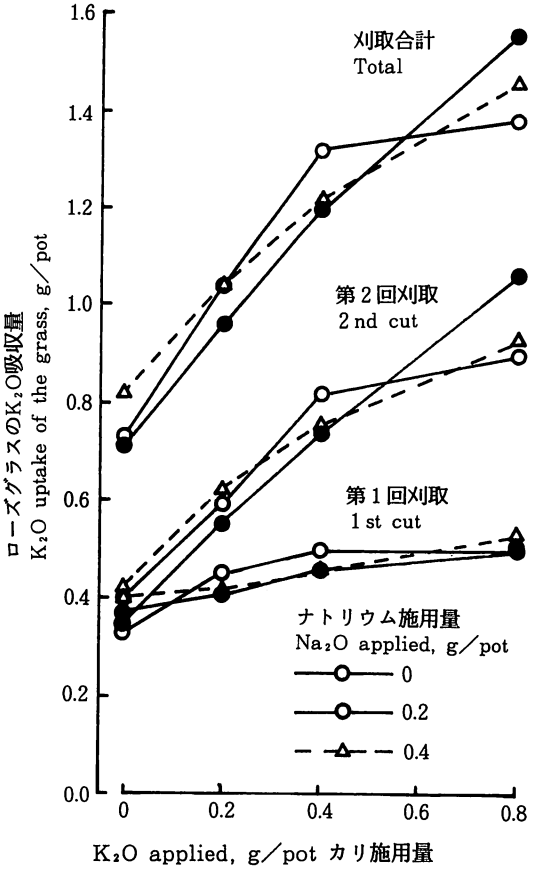

Fig. 3. Effect of potassium and sodium aplications on potassium uptake of the Rhodesgrass Plant

第3図 ローズグラスのカリ吸収に及ぼすカリ及びナトリウム施用の影響

and potassium applications (Fig. 4 and Table 4); namely the sodium concentration increased by the application of sodium but tended to decrease with the application of potassium. This interaction between the sodium and potassium applications in percent of sodium of the grass was significant (Table 4).

Sodium uptake of the Rhodesgrass plant was also significantly affected by both of the sodium and potassium applications in the

same way with the sodium concentration (Fig. 5 and Table 5).

These results suggest that sodium, which is considered abandant in Okinawa as air-born salt originating from the sea water, is possibly playing a role in potassium economy in the field, because the potassium absorption of the grass would be depressed to some extent when sodium is supplied.

(4) Calcium

Percent of calcium in the Rhodesgrass plant did not vary to a noticeable extent by the application of potassium and sodium. Statistical means and standerd deviations for CaO concentration in the grass was shown in Table 6. The quantity of CaO absorbed by the grass per pot also varied only to a less extent by the potassium and sodium treatment (Table 6).

Concerning with elemental absorption of the plant, antagonistic relations between potassium and calcium were tested elsewhere[3]. However, it was not the case in this experiment grwoing the Rhodesgrass plant on a Dark Red soil of Okinawa.

(5) Magnesium

Magnesium concentration in the Rhodesgrass plant was not affected by the treatment with potassium and sodium, and the quantity of MgO absorbed by the grass also showed variation only to a less extent by the treatment (Table 6).

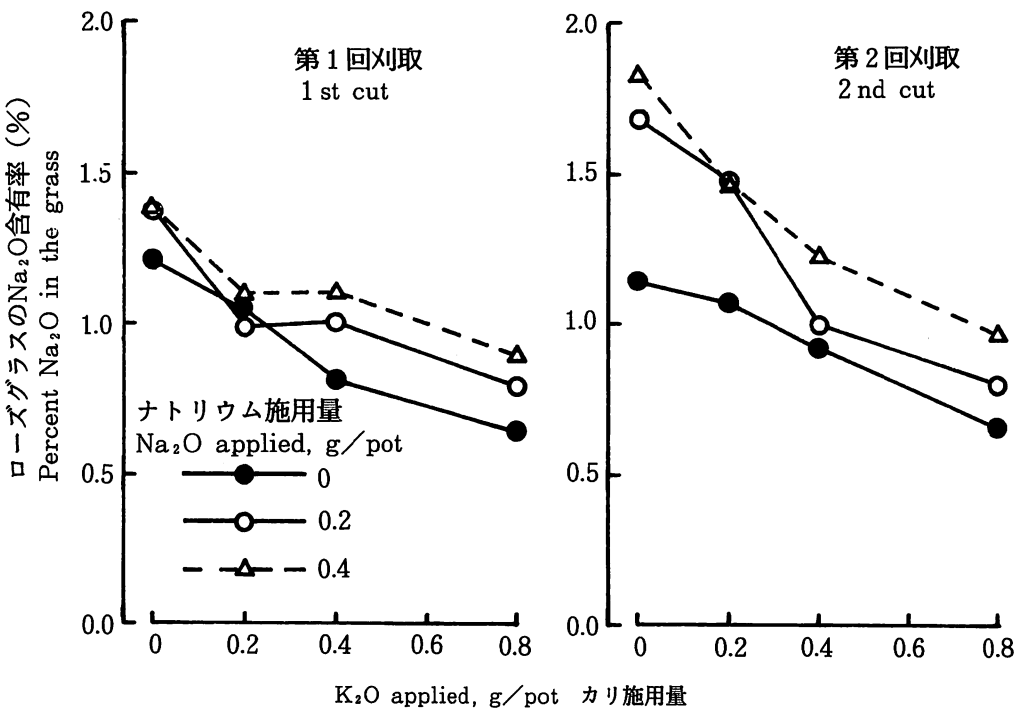

Fig. 4. Effect of potassium and sodium applications on sodium concentration of the Rhodesgrass Plant

第4図 ローズグラスのナトリウム吸収に及ぼすカリ及びナトリウム施用の影響

Table 4. Significance of F values in analysis of variance for the concentrations of potassium and sodium in the Rhodesgrass plant

第4表 ローズグラスのカリ及びナトリウム含有率に対する分散分析F値の有意性

Source of variance 要 因	1 st cut 第1回刈取	2 nd cut 第2回刈取
	Percent potassum カリ含有率	
Effect of K_2O application カリ施用の効果	1%	1%
Effect of Na_2O application ナトリウム施用の効果	N. s.[a)]	N. s.
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	N. s.
	Dry matter yield 乾物収量	
Effect of K_2O application カリ施用の効果	1%	1%
Effect of Na_2O application ナトリウム施用の効果	1%	1%
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	1%

a) N. s. Stands for "not significant". N. s. は有意性なしを示す。

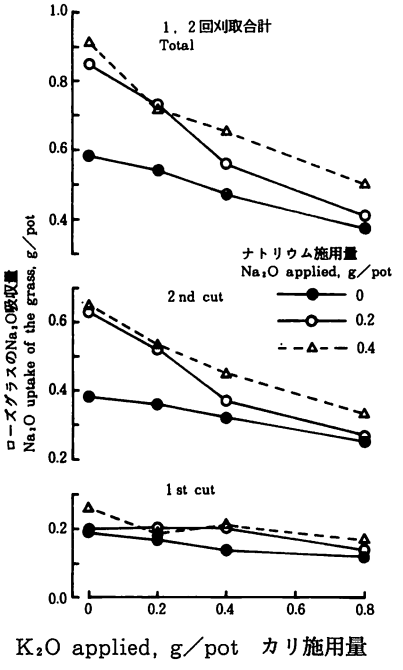

Fig. 5. Effect of potassium and sodium applications on sodium uptake of the Rhodesgrass plant

第5図 ローズグラスのナトリウム吸収に及ぼすカリ及びナトリウム施用の影響

summary

A pot experiment was carried out in order to investigate response in the yield and nutrient absorption of Rhodesgrass (*Chloris gayana* Kunth, Culti. var. KATAMBORA) to applied potassium and sodium on a Dark Red soil.

The Rhodesgrass plant was grown in the pot, which contained 2.2 kg soil, under the greenhouse conditions and cut twice with 40 to 60 day intervals. To each cut, potassium and sodium were applied at a rate of 0.0, 0.2, 0.4, and 0.8g K_2O/pot, and 0.0, 0.2, and 0.4g Na_2O/pot, respectively.

On the fresh matter yield of the Rhodesgrass plant, the 1 st cut received no effect from applied potassium and sodium. The 2 nd cut of the grass increased in the fresh matter by the application of sodium, but it received interaction between the applied potassium

Table. 5. Significcance of F values in analysis of variance for the potassium and sodium uptake of the Rhodesgrass plant

第5表 ローズグラスのカリ及びナトリウム吸収量にたいする分散分析F値の有意性

Source of variance 要 因	1 st cut 第1回刈取	2 nd cut 第2回刈取	Total 合計
		Potassium uptake カリ吸収量	
Effect of K_2O application カリ施用の効果	1%	1%	1%
Effect of Na_2O application ナトリウム施用の効果	N. s.[a)]	N. s.	N.s.
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	10%	5%
		Sodium uptake ナトリウム吸収量	
Effect of K_2O application カリ施用の効果	1%	1%	1%
Effect of Na_2O application ナトリウム施用の効果	1%	1%	N. S.
Interaction of K_2O and Na_2O カリとナトリウムの交互作用	N. s.	1%	1%

a) N. s. Stands for "not significant". N. s. は有意性なしを示す。

Table 6. Means and standard deviations for percent and uptake of Calcium and Magnesium of the Rhodesgrass plant in the whole treatment

第6表 全処理区におけるローズグラスのカルシウム及びマグネシウム含有率と吸収量の平均と標準偏差値

Cut number 刈取回	CaO	MgO
	Percent in the grass 含有率（%）	
1 st cut 第1回刈取	0.60±0.05	0.22±0.02
2 nd cut 第2回刈取	0.62±0.07	0.26±0.03
	Uptake by the grass 吸収量（g／pot）	
1 st cut 第1回刈取り	0.11±0.01	0.040±0.004
2 nd cut 第2回刈取り	0.22±0.03	0.091±0.009

and sodium. The effect of potassium and sodium was significant in addition to the interaction of applied these two elements, when the total of the 1 st and 2 nd cuts' fresh matter was taken into consideration.

On the dry matter of the grass, only the interaction of the potassium and sodium applications was found significant in the 2 nd cut and in the total of the 1 st and 2 nd cuts.

The concentrations of nitrogen, calcium, and magnesium in the Rhodesgrass plant were not much affected by the application of potassium and sodium. Consequently, the quantity of these nutrient elements absorbed by the grass varied only to a less extent by the treatment with potassium and sodium.

The concentration of potassium in the grass was significantly increased by the application of potassium. The increase in the potassium uptake of the grass was also significantly affected by the potassium applica-

tion, but this increase tended to encounter the interactiom of applied sodium.

The concentration of sodium in the Rhodesgrass plant was found to increase significantly by the application of sodium, but to decrease by the application of potassium. The interaction between the potassium and sodium applications was significant. The uptake of sodium by the grass was also significantly affected by the application of potassium and sodium in the similar way to the concentration of sodium.

From the results obtained in the present investigation, suggested was that an increase in the yield of Rhodesgrass will be effected by the application of potassium on the Dark Red soil used for this experiment, but the increase may be diminished when the grass is somewhat supplied with sodium. It was further suggestive that sodium, which is considered abandant as air-born salt in Okinawa, may be playing a role in potassium economy in the field, because the potassium absorption of the grass was depressed to some extent when sodium was supplied.

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摘　要

暗赤色土におけるカリとナトリウム施用がローズグラスの収量及び養分吸収に及ぼす影響

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飼料作物栽培に関し沖縄の各種土壌における施肥管理手法の改善に資するため実験を行っているが，今回は暗赤色土（通称島尻マージ）を用い，ポット試験によりローズグラス（カタンボラ系）に対するカリ及びナトリウムの施用が，ローズグラスの収量及び窒素，カリ，ナトリウム，カルシウム，マグネシウムなどの吸収に及ぼす影響を調べた。

土壌は琉球大学農学部附属農場の暗赤色土（pH 6.0, CEC 14.1 me／100g）を，栽培容器は5,000分の1アールワグネルポット（土壌2.2kg）を用いた。ポット試験は3連とし，ポット当り窒素（N）及びリン酸（P_2O_5）をそれぞれ0.4g，カリ（K_2O）を0.0, 0.2, 0.4, 0.8g，ナトリウム（Na_2O）を0.0, 0.2, 0.4g，の組合せでローズグラス刈取毎に施用した。栽培はガラス室で行い，刈取は2回とした。第1回刈取は播種後約60日，第2回刈取は第1回刈取後約40日で何れも出穂しかかる時に行った。

ローズグラスの生育は初回は全体的に貧弱であったが，第2回刈取には旺盛であった。このため第1回と第2回刈取の収量に対するカリとナトリウムの施用効果は多少異なって認められた。第1回と第2回刈取の合計収量についてみると、カリとナトリウムの施用はそれぞれ青刈収量に効果があり，またカリとナトリウムの交互作用も認められた。しかし乾物収量に関してはカリとナトリウムの交互作用のみが有意と認められた。このことはカリ施用によりローズグラスの収量は増加するが，ナトリウムの施用により収量増加が抑えられること，また逆にナトリウム施用によってもローズグラスの増収が得られるが，カリ施用によりこれが打ち消される可能性を示すものである。

ローズグラスの養分吸収についてみると，窒素，カルシウム，マグネシウムなどの含有率に対するカリ及びナトリウム施用の影響は少なかった。

カリ（K_2O）含有率は第1回刈取では2％強から3％弱の間でカリ施用の増加に伴い高くなった。第2回刈取では1％強から3％弱の間でカリ施用が増えるとカリ含有率も高くなった。何れの場合もナトリウム施用の影響は認められなかった。カリ施用によりローズグラスのカリ含有率が高くなることにより，ローズグラスのポット当りカリ吸収量も有意に増加した。しかし収量との関係でカリ吸収量の増加はナトリウム施用により抑えられる傾向が認められた。

ナトリウム含有率はナトリウム施用に伴い有意に増加し，カリ施用により有意に低下した。またこの交互作用は第1回刈取では有意でなかったが，第2回刈取では有意（1％レベル）であった。ローズグラスのポット当りナトリウム吸収量は含有率の影響でナトリウム施用に伴い有意に増加し，カリ施用により有意に減少した。この様なナトリウム吸収量に対するナトリウムとカリの交互作用は

有意であった。

以上より，供試暗赤色土におけるローズグラス栽培においてカリの施用はローズグラスの増収をもたらすことが期待されるが，ナトリウムが何らかの形で供給されると，カリ施用の効果は薄れてしまうと考えられる。またローズグラスのカリ吸収はナトリウムによって抑えられることから，風成塩の多い沖縄では，圃場条件下の栽培におけるカリ経済にナトリウムの及ぼす影響は少なくないと思われる。