琉球大学学術リポジトリ

沖縄の酸性土壌におけるソルゴー幼植物の生育に及ぼすスラッグと窒素施用の影響

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Growth of Young Sorghum Plant on Two Okinawan Acid Soils Treated with Slag and Nitrogen

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I. Introduction

The acid soils cover 4,588 million hectares (41.7%) of the world total land usable for agriculture according to the estimation by Nagaoka [2]. Because of the extent and distribution of the acid soils, proper management practices are requested on these soils in agricultural production of the respective regions.

In Okinawa Islands, the area more than 33% of the arable upland is occupied by the acid soils or by the soils so-called poor in nutrients [3]. Recommended practices on these soils are to apply such soil amendments as lime and magnesium-calcium silicate to neutralize soil acidity and provide basic elements. Analyses show that the slag contains various basic elements and indicate that the slag is a useful material as soil amendment. The slag is, however, not commonly used in Okinawa, and therefore, invsetigations are necessary to test its effectiveness on Okinawan soils.

In order to test the effect of the slag application coupled with nitrogen on the plant growth in acid soils of Okinawa, conducted was a pot expriment, which was done as a part of the experiments in the JICA training program the "Effective Utilization of Tropical Agriculture and Forestry Resources" held at

the College of Agriculture, University of the Ryukyus from November, 1985 to April, 1986.

Ⅱ. Materials and Methods

1. Soil

Two acid soils were used for the pot experiment, one was a Red soil and the other was a Dark-Red soil. A surface layer (0～15 cm) of a Red Soil which was being developed from slate was collected from a fallow land in Oku, Kunigami at the northern part of Okinawa Island. The site had such vegetation as *Imperata cylindrica var.* (Chigaya in Japan.), *Miscanthus sinensis* (Susuki in Japan.) and *Melastoma candidum* (Nobotan in Japan.) after tea cultivation. A Dark-Red soil was collected from the surface layer (0～15 cm) of the university farm No. 17. The soil was being formed on the sediment related to limestone. The both soils were heavy clay in texture.

The collected soils were sieved through a wire screen with 5 mm holes, air-dried, mixed thoroughly, and treated with slag and fertilizers as stated later.

2. Analysis of soil and plant material

Aliquots of the two soils were analyzed to determine some of their chemical properties after crushing and sieving with a 2 mm screen. The results of the analysis were shown in Table 1. The soil pH was measured in a 1 : 2.5 soil-water (or *N* KCl) suspension. Exchange acidity was titrated with the barium chloridetriethanolamine method. Cation exchange capacity (CEC) was determined by the *N* ammonium acetate method, and exchangeable bases were measured in an acetate leachate with an atomic absorption unit. Total carbon was determined by the wet combustion method. Total nitrogen was determined by the Kjeldhal procedure. Available phosphate was extracted with 0.002 *N* sulfuric acid and determined by the molybdenum blue method.

Nitrogen of the plant material after harvesting was determined as those applied for the soil analysis, and phosphorus was determined by the vanadate yellow method in a sample solution resulting from nitric acid-perchloric acid digestion.

Table 1. Chemical properties of the Red and Dark Red soils used in the pot experiment

	pH		Exchange acidity	CEC	Exchangeable base				Base saturation	Total carbon*	Total nitrogen	Available phosphate*
	H_2O	KCl	me/100g	me/100g	Ca	Mg	K	Na	%	%	mgN/100g	mgP_2O_5/100g
					me/100g							
Red soil	4.77	3.80	13.8	10.01	0.52	0.62	0.13	0.10	13.7	2.13	169.4	0.46
Dark Red soil	5.74	5.36	2.3	11.53	10.26	1.22	0.73	0.25	108.1	0.62	73.1	8.49

* Based on the supplementary analysis done by N. Yamauchi.

Table 2. Slag and fertilizer treatments for the soils in the experiment (per 3 kg soil/pot)

Treatment number	Slag (g)	Ammonium sulfate (g)	Super-phosphate (g)	Potassium chloride (g)
S0 − N0.5	0	2.5	4	1
S0 − N1.0	0	5.0	4	1
S1 − N0.5	30	2.5	4	1
S1 − N1.0	30	5.0	4	1

3. Treatment

The combination of the treatment was as indicated in Table 2. Slag was given to the soil at a rate of 0 and 30 g per pot, of which size was 1/500,000 ha (16 cm D. × 19.5cm H.) containing 3 kg of soil on the dry weight basis. And the soils were treated with ammonium sulfate at a rate of 2.5 and 5.0 g. Phosphorus and potassium were applied by 4 g of superphosphate and 1 g of potassium chloride. The treatment was replicated twice.

The chemical composition of slag was indicated as 30~41% of SiO_2, 35~45% of CaO, 3~7% of MgO, 0.3~1.7% of Mn, 0.3~1.7% of FeO, 12~20% of Al_2O_3, and 0.004~0.05% of P_2O_5 in general [1].

4. Growing plant

A fodder crop sorghum (*Sorghum sudanese* ×*Sorghum succharatum*; Culti. Diasorghum) was grown for 35 days in the greenhouse (Photo. 1). About 30 seeds of the sorghum were sown on the treated soils in the pots on December 20, 1985. Thinning was done to leave 26 plants per pot on January 8, 1986. Water was given to keep soil moisture at 70% of the water capacity of the respective soils. Cloudy days were dominant and the air temperature was rather low for the crop flactuating between about 12 and 20℃ during the period of this experiment. The aerial portions of the sorghum plant was harvested by cutting near the ground on January 24, 1986 (Photo. 2). The fresh weight of the plant material was recorded immediately after harvesting and the dry weight was determined after drying at 70℃ for overnight.

Ⅲ. Results and Discussion

1. Growth of the sorghum plant

The fresh and dry weights of the sorghum plant were recorded as a measure of the growth perfomance on the treated soils and were shown in Table 3 where the values were the means of 2 replications. It was recognizable from Table 3 that the sorghum plant had better growth on the Dark Red soil than on the Red soil. This was proved by an analysis of variance, which indicated the difference between the 2 soils was significant at the 0.1% probability level for both the fresh and dry weights of the plant. The better plant growth on the Dark Red soil resulted evidently from the chemical properties of the soil, which were as shown in Table 1 superior to those of the Red soil in every aspect except for nitrogen.

Photo.1. The pot experiment was conducted in the greenhouse.
(From left to right : Clement C. Moredo, Jr., Pensri Choovoravech, Rawiwan Artsamang, Teani M. Wijerante and K. Oya)

Photo.2. Growth defermination of the sorghum plant after growing for 35 days.

2・Effects of slag and nitrogen on the plant growth

The slag application was effective on the plant growth in the Red soil. It was deemed that basic elements such as Ca and Mg were supplied with the Red soil from the slag and resulted in a rise of soil pH. According to Yamauchi [4] who worked on the same soil, the soil pH rose to 5.1 by incorporation of 0.4g of the slag with 40g of the soil, the ratio equivalent to 30g slag per 3kg soil in the treatment of the present experiment. Yamauchi [4] showed that the soil test value decreased in 0.002 N sulfuric acid soluble phosphate when the slag was applied. Therefore, it was not expected that the pH rise by the slag application improved phosphorus availability in this soil, but the effect was to depress activity of H^+, Al^{3+} ions and other acidic groups which were harmful to the plant roots at a lower soil pH. The slag application would also have improved microbial processes leading to availability of nitrogen.

Table.3. Fresh and dry weigh of the sorghum plant

Nitrogen treatment	Red soil		Dark Red soil	
	Slag 0	Slag 1	Slag 0	Slag 1
	—Fresh weight, g/pot—			
N 0.5	4.39	21.26	41.56	35.89
N 1.0	1.83	15.68	41.54	36.65
	— Dry weight, g/pot —			
N 0.5	0.98	3.10	4.83	5.92
N 1.0	0.54	2.49	7.26	5.74

Increased application of nitrogen did not effect on the plant growth in the Red soil. The nitrogen content of the soil was 0.17%. With this level of nitrogen the slag application seemed to be more important than nitrogen in the case of the present experiment. If the period of the plant growth was made longer than this experiment or the conditions of light and temperature were better for the sorghum

plant like in the summertime when the sorghum plant usually become vigorous, the plant growth would have been favorably affected by the increased application of nitrogen as well as by the slag.

In contrast to the Red soil the slag application did not show any favorable effect on the growth of the sorghum plant in the Dark Red soil. The soil had a pH (H_2O) value of 5.7, was relatively rich in bases and showed very high base saturation percentage. It was deemed that the soil chemical properties as such were suitable enough for the plant and applying the soil amendment slag was not needed for this soil. The analysis of variance showed the interaction between the soil and slag factors was significant at the 5% probability level for both the fresh and dry weights of the plant. This meant that the effect of the slag application on the plant growth was different between the 2 soils, practically the application of slag had a favorable effect in the Red soil but not in the Dark Red soil.

The increment of nitrogen application resulted in an increase of the dry weight of the plant on the Dark Red soil without the slag application. This, however, was overshadowed by the plant yield which did not show any increase with the slag and the increment of nitrogen applied, and was not indicated sinificant in the analysis of variance. About the efficacy of nitrogen the discussion done for the Red soil would apply here, too.

3. Absorption of nitrogen and phosphorus of the sorghum plant.

The contents of nitrogen and phosphate of the sorghum plant were shown in Table 4 on the dry weight basis. Phosphate analysis was not able to do on some treatments due to insufficiency of the plant tissue samples and resulted was a lack of data in Table 4.

The level of nitrogen was higher in the sorghum plant grown on the Red soil than on the Dark Red soil. The Red soil had a higher soil test value for total nitrogen, and that seemed to have caused the higher nitrogen level in the plant. The analysis of variance also showed significant difference in the nitrogen level of the plant between the soils at the 5% probability level.

Table.4. Contents of nitrogen and phosphate of the sorghum plant

Nitrogen treatment	Red soil		Dark Red soil	
	Slag 0	Slag 1	Slag 0	Slag 1
	% N			
N 0.5	3.32	4.13	3.41	2.71
N 1.0	4.48	4.79	3.29	3.19
	% P_2O_5			
N 0.5	0.56	0.50	0.45	0.44
N 1.0	—	0.44	0.45	0.47

Table.5. Absorption of nitrogen and phosphate of the sorghum plant

Nitrogen treatment	Red soil		Dark Red soil	
	Slag 0	Slag 1	Slag 0	Slag 1
	N, mg/pot			
N 0.5	33	128	164	161
N 1.0	24	129	241	192
	P_2O_5, mg/pot			
N 0.5	7.0	15.3	21.7	26.1
N 1.0	—	12.0	32.6	27.5

The nitrogen content of the plant tended to increase with the slag application and with the nitrogen increment applied on the Red soil. On the other hand the plant tended to decrease in the nitrogen level with the slag application. Much difference was not indicated in the phosphate level of the plant by any of the soil and treatment factors.

Absorption of nitrogen and phosphate by the plant was obtained by multiplying the dry wight of the plant by percent of the elements in the plant. And the results were shown in Table 5.

In the Red soil the nitrogen absorption of the plant was excellently affected by the slag application which gave a favorable effect on the plant growth by raising soil pH to some extent and by depressing activity of H^+, Al^{3+} ions and other acidic groups to be harmful for the plant roots. It could be assumed that the phosphate absorption of the plant being increased by the slag application, though this was not claimed strongly because of insufficiency of data.

In the Dark Red soil neither the slag application nor the increment of nitrogen applied was found to be efficient in the plant absorption of nitrogen and phosphate.

IV. Summary

An pot experiment was conducted in order to investigate effects of slag (a soil amendment) and nitrogen applied to two Okinawan acid soils on the growth and the absorption of nitrogen and phosphate of the sorghum plant (*Sorghum sudanese* x *Sorghum succharatum*; Culti. Diasorghum). The experiment was three factorial; namely the soils used were a Red soil (pH 4.8) and a Dark Red soil (pH5.7). The slag was applied at a rate of 0 and 30 g par 3 kg (per pot) of soil, and ammonium sulfate as a source of nitrogen was applied at a rate of 2.5 and 5.0 g per 3 kg of soil.

The weight of the aerial portions of the plant was determined as a measure of the plant growth. Significant difference in the fresh and dry weights of the plant was found between the two soils; namely the plant growth was much better on the Dark Red soil which had chemical properties superior to the Red soil in every aspect except for nitrogen content.

There was also a significant interaction of the soil and slag factors indicating that the slag application was effective on the plant growth in the Red soil but not in the Dark Red soil. The increment of nitrogen applied tended to increase in the dry weight of the plant grown on the Dark Red soil though statistical significance was not found on the nitrogen factor.

The level of nitrogen in the plant was significantly higher on the Red soil than on the Dark Red soil. It was deemed that this was due to the higher nitrogen content of the Red soil. The level of phosphate in the plant was found not affected by any of the soil and treatment factors.

The quantity of nitrogen absorbed by the plant related closely to the extent of the plant growth and tended to be more in the Dark Red soil than in the Red soil. On the Red soil the nitrogen absorption of the

plant increased with the slag application which improved the plant growth. Because of the better plant growth on the Dark Red soil, the quantity of phosphate absorbed by the plant also tended to be more on the Dark Red soil than on the Red soil.

Litrature Cited

1) Nippon Tekko Renmei 1977 Tekko-no Suraggu (The Slag), pp56. (in Japanese)

2) Okagawa, Nagao 1984 Distribution and Use of Acid Soils in the World, in Akira Tanaka (ed.) 1984 Acid Soils and Their Use in Agriculture, pp21-49. Hakuyu-sha, Tokyo. (in Japanese)

3) Oya, Kazuhiro 1984 Characteristics and fertility of Okinawan soils; Symposium on the Upland Farming of Okinawa. Jap. Jour. Crop Sci., 53(3):340-346. (in Japanese)

4) Yamauchi, Noriko 1986 Personal communication.

摘　　要

沖縄の酸性土壌におけるソルゴー幼植物の生育に及ぼすスラッグと窒素施用の影響

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沖縄島の2種類の酸性土壌における土壌改良剤スラッグと窒素の施用がソルゴーの生育と窒素及びリン酸の吸収に及ぼす影響を調べる目的でポット試験を行った。土壌は赤色土(pH 4.8), 暗赤色土(pH 5.7), スラッグはポット(5,000分の1aワグネル，土3kg)当たり0又は30g施用，窒素は硫安を2.5g又は5.0g施用の3因子実験で，繰り返しを2回とした。植物は飼料用ダイヤソルゴーを用い，1985年12月20日に播種し，35日間ガラス室で栽培した。

土壌分析によると養分含量は赤色土より暗赤色土において高いことが示されたが，ソルゴー地上部の刈り取り生重と乾物重を測定した結果，生重，乾物重ともに暗赤色土で大きく，土壌肥沃度の違いがソルゴーの生育にも反映された。この土壌間の差は1%有意であった。赤色土においてはスラッグ施用によりソルゴー生重は増加したが，暗赤色土においてはその効果がなかった。この土壌とスラッグ間の交互作用は5%有意であった。乾物重については統計的な有意性は示されなかったが，暗赤色土におけるスラッグ無施用の場合，窒素の増施によりソルゴー乾物重は増加する傾向を示した。

ソルゴーの窒素%は赤色土において高かった(5%有意)が，これはこの土壌の窒素含量が暗赤色土より高いことに起因すると思われた。ソルゴーのリン酸%については土壌間及び処理間に大きな差は認められなかった。

ソルゴーの窒素及びリン酸吸収量を乾物重×養分%により求めたが，それぞれの吸収量は生育量に大きく影響され，窒素及びリン酸共に暗赤色土において多く吸収された。赤色土においてはスラッグ施用による生育量増加に起因して，窒素，リン酸ともスラッグ施用区で多く吸収される傾向が見られた。

以上よりスラッグは土壌改良剤として供試赤色土におけるソルゴーの栽培に極めて有効であると考えられる。