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EFFECT OF GYPSUM AND PHOSPHOGYPSUM ON THE GROWTH, YIELD AND QUALITY PERFORMANCES OF RICE

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ABSTRACT

Results obtained from a pot experiment suggest that gypsum and phosphogypsum at the rate of 0, 15 and 30 μg S g^{-1} soil significantly increased the growth parameters (height, tiller numbers, panicle length) of BR-3 rice at maximum, panicle initiation and harvesting stages. Yield components (straw, grain, number of grains/panicle, weight/1000 grains and % filled grains) also improved significantly. Quality of straw and grain (content of N, P, K and S) improved significantly except S content in grain.

INTRODUCTION

Rice is one of the most important among the food yielding crops. The growth and yield of plant is limited by a number of nutrients. Besides, N, P and K, S has also a dominant role to improve the quality and quantity of rice grain. Literature suggests that volume of works has been published on response of rice to NPK fertilization. Very recently, S is generating attention as a growth and yield limiting nutrient in Bangladesh([1-2]). However, the prediction of the response of S to soil has proved to be a difficult task, owing to dynamic nature of S that it can be transformed from available to unavailable pools over a short period of time and variety of sources of S to be applied to plants ([3]). Ammonium sulphate, gypsum, sulphide (pyrite) and elemental S has been reported effective as S sources in wetland rice ([4-8]).

This pot experiment was, therefore, conducted to investigate the effectiveness of gypsum and phosphogypsum on growth, yield and quality performances of rice.

EXPERIMENTAL

Materials : Collected sample of soil (0-15 cm), Kalma series, Dhaka is clay loam with pH 6.8, organic matter 1.32%, total N 0.06%, available N,P,K and S 7.1, 5.8, 30 and 14.0 μg g^{-1} soil.

Method: Air-dried soil sample (2 mm) was weighed at the rate of 4 kg per pot (plastic pot of 20 cm × 18 cm size) and mixed thoroughly with fertilizers as per treatment combinations. The treated samples were allowed to submerge for 24 hrs. to bring into equilibrium.

Doses: Two rates (15 and 30 μg S g^{-1} soil) of each of gypsum (contains 0.0% P and 18.6% S as sulphate) and phosphogypsum (contains 2.0% P and 16.0% S as sulphate) together with a control were included in the experiment. A basal dose of N, P and K in the form of urea, TSP and MP at the rate of 68, 30 and 45 μg g^{-1} was applied. In addition, gypsum receiving pots were also supplemented with CaO to equalize Ca. The experiment was arranged in a completely randomized design with three replications.

Cultural practices: Four weeks old healthy rice (*Oryza sativa*, BR-3) seedlings of uniform size were transplanted at the rate of three per pot. The soil samples were kept submerged (4-5 cm standing water) throughout the experimental period. The pots were weeded and insecticide (malathion) was applied as and whenever needed.

Agronomic data were recorded at maximum tillering, panicle initiation and harvesting stages of growth. One hill was collected randomly during sampling. During harvesting the plants were cut off carefully at the ground level. Chemical analysis for both straw and rice grain was done for samples oven dried for 48 hrs. at 80°C and grounded to 1 mm size.

Analytical techniques: The pH of the sample was measured electrochemically in a soil-water suspension (1:2.5) by using a corning pH meter with glass electrode. Determinations were made of mechanical analysis by hydrometer method[9], organic matter by wet oxidation method ([10]), N by Kjeldahl digestion, P by vanadomolybdophosphoric yellow colour method using a Coleman Junior II Spectrophotometer, K flame photometrically using a EEL Flame Photometer and S as complex of $BaSO_4$ spectrophotometrically([11]).

Standard methods were used to extract available N (2M KCl), P (0.002 N H_2SO_4), K (2M NaCl) and S (500 μg P ml^{-1} $Ca(H_2PO_4)_2$([12]) of the soil. Plant and grain samples were digested with conc. H_2SO_4, and mixture of conc. H_2SO_4 and $HClO_4$ (72%) (4:1, v/v) for N and K estimation. Conc. HNO_3, and mixture of conc. HNO_3 and $HClO_4$ (72%) (4:1, v/v) digest was used for P and S analysis.

RESULTS AND DISCUSSION

S applied from gypsum and phosphogypsum significantly increased the growth parameters recorded at three stages of growth (Table 1). Increasing amount of S failed to increase the height of the plant significantly in the maximum tillering stage. However, in the harvesting stage, higher dose of S rather decreased the height significantly as compared to lower dose. The performance of gypsum as a carrier of S was significantly better in this respect. Increased rate of S either as gypsum or phosphogypsum increased the tiller numbers significantly in the final stage of growth. Favourable effect of gypsum

on height and tiller numbers of rice was reported by Islam([13]). Similar results were also reported by Ismunadji([4]). Panicle length varied nonsignificantly due to increase in rate from 15 to 30 μg S g^{-1} soil.

TABLE 1

EFFECT OF GYPSUM AND PHOSPHOGYPSUM ON GROWTH AND YIELD COMPONENTS OF RICE

Growth component	*μg S g^{-1} Soil* / *Stages of growth*	*0*	*15 G*	*30 G*	*15 PG*	*30 PG*	*LSD at 5% level*
Height (cm)	Maximum tillering	57.96	64.04	64.17	63.00	64.50	2.36
	Panicle initiation	72.50	82.33	79.50	76.16	68.50	1.61
	Harvesting	75.42	80.08	77.50	77.33	75.66	1.10
No. tillers/hill	Maximum tillering	4.00	6.16	6.75	6.00	6.16	0.26
	Panicle initiation	4.50	5.16	5.58	5.25	4.99	0.28
	Harvesting	2.83	3.46	3.60	3.66	3.90	0.14
Panicle length (cm)		20.01	21.12	21.43	21.08	21.56	0.44
Yield component	Straw yield (g)	5.96	8.04	9.30	8.12	8.61	0.60
	Grain yield (g)	4.75	7.79	9.08	7.99	8.33	0.21
	No. grains/ panicle	102.40	115.73	120.81	121 53	124.06	1.73
	Wt. 1000 grains (g)	16.51	18.16	18.42	16.81	17.82	1.13
	% Filled grain	53.81	63.92	68.57	55.83	62.10	2.02
	Grain/Straw ratio	0.78	0.97	0.98	0.98	0.97	

Legend : G=gypsum, PG= phosphogypsum

S application significantly improved the yield components such as grain and straw, number of grains per panicle, weight of 1000 grains and per cent filled grains (Table 1). Supply of S could improve the yield of rice grain from 2-3 tons/ha to 5-6 tons/ha([5]) and up to 1.0-1.3 ton/ha ([14]). Blair *et al.* ([7]) and Neller ([15]) observed that gypsum could be a effective supplement of S to boost up rice yield particularly in flooded soils. Increase in weight of 1000 grains was not appreciable due to increase in quantity of applied S from 15 to 30 μg g^{-1} soil. Grain/straw ratio in S treated plants remained almost constant indicating the positive effect of S in grain and straw production. Gypsum—S played better role than phosphogypsum-S to stimulate most of the growth components. This might be due to easily hydrolyzable nature of the former source.

Chemical composition of straw varied significantly with S application (Table 2). Contents of N, P, K and S changed appreciably in all the stages of growth with increasing amount of S. Addition of S from various sources stimulated the content of N in alfalfa ([15]), barley grain([16]), corn ([17]), rice ([4–8]) P in Indian mustard([18]), rice([4]), soybean ([19-20]); K in rice([4]); and S in alfalfa([21]), rice([4]). It is possible that, S being an anion, uptake might increase the uptake of a cation like K.

S supply showed an increased uptake of N, P and K along with S. This variation was due mainly to variation in single parameter, dry matter yield. Both the sources of S were found to be equally effective to stimulate nutrient uptake.

TABLE 2

EFFECT OF GYPSUM AND PHOSPHOGYPSUM ON CHEMICAL COMPOSITION OF RICE STRAW AT DIFFERENT STAGES OF GROWTH

Treatments $\mu g\ S\ g^{-1}$ *Soil*		*0*	*15 G*	*30 G*	*15 PG*	*30 PG*	*LSD at 5% level*
% N	Maximum tillering	2.36	2.49	2.28	2.81	2.93	0.044
	Panicle initiation	1.58	1.71	1.45	1.76	1.63	0.088
	Harvesting	0.74	0.93	0.92	0.88	0.94	0.044
% P	Maximum tillering	0.11	0.18	0.18	0.16	0.17	0.025
	Panicle initiation	0.10	0.20	0.14	0.13	0.14	0.046
	Harvesting	0.10	0.12	0.14	0.13	0.14	0.032
% K	Maximum tillering	2.56	3.10	3.46	2.46	3.06	0.082
	Panicleinitiation	2.10	2.35	2.30	1.96	2.11	0.054
	Harvesting	1.90	1.90	2.08	1.96	2.20	0.042
% S	Maximum tillering	0.24	0.29	0.31	0.24	0.31	0.021
	Panicle initiation	0.20	0.23	0.24	0.22	0.23	0.030
	Harvesting	0.16	0.19	0.21	0.18	0.24	0.018
Uptake (mg/hill)							
N		35.2	72.2	83.5	70.3	78.3	5.65
P		4.8	9.3	12.7	10.4	11.7	1.25
	Harvesting						
K		90.3	148.0	188.9	156.6	183.3	10.55
S		7.6	14.8	19.1	14.4	20.0	1.20

Legend same as Table 1

Content of N and P in grains was significantly improved (Table 3). Application of S could significantly increase the S and P content and uptake in cotton, berseem, soybean, rice and wheat ([22–23]). Similar views were expressed by other workers too([24-26]). Moreover, S supply can metabolize more N resulting the synthesis of protein in plant tissues ([27–29]). S content remained unaffected from S application. Uptake of N, P and S increased with increasing level of applied S. This apparent variation was purely due to variation in grain yield. The results further showed that contents of N, P, K and S in straw decreased with the increase of plant age (Table 2). This is possibly due to dilution effect of the nutrients.

TABLE 3

EFFECT OF GYPSUM AND PHOSPHOGYPSUM ON N, P AND S CONTENT AND UPTAKE OF RICE GRAIN

Treatments $\mu g\ S\ g^{-1}$ *Soil*	*N*		*P*		*S*	
	Content (%)	*Uptake mg/hill*	*Content* (%)	*Uptake mg/hill*	*Content* (%)	*Uptake mg/hill*
0	1.10	52.2	0.19	9.0	0.08	3.8
15 G	1.15	89.6	0.20	15.6	0.08	6.2
30 G	1.20	109.0	0.22	20.0	0.10	9.1
15 PG	1.29	103.1	0.23	18.4	0.08	6.4
30 PG	1.19	99.1	0.22	18.3	0.10	8.3
LSD at 5% level	0.05	5.5	0.04	1.5	N.S.	1.2

Legend same as Table 1

REFERENCES

1. M.M.J. Abedin and M. Eaqub, *Bangladesh J. Agric. Sci.*, 9(1), 41, 1982.
2. M. Idris and M. Jahiruddin, *I.R.C. New Letter*, 32(1), 28, 1983.
3. G. J. Blair, C.P. Mamaril and E.O. Momuant, *IRRI Res. Series.*, 21, 12, 1978.
4. M.M. Ismunadji, *Japan Agric. Res. Quart.*, 3, 180, 1978.
5. C.H. Wang, T.H. Lien and D.S. Mikkelson, *IRRI Tech. Bul.*, 47, 46, 1976.
6. C.H. Wang, T.H. Lien and D.S. Mikkelson, *IRRI Tech. Bul.*, 48, 38, 1977.
7. G.J. Blair, C.P. Mamaril, A.P. Umar, E.O. Momuant and C. Momuant, *Indonesia Agron. J.*, 71, 473, 1979.
8. R. Islam, A. Islam, S. Haque and F. Ahmed, *Dhaka Univ. Stud.*, Part B, XXX(2), 93, 1982.
9. G.J. Bouyoucos, *Soil Sci.*, 26, 233, 1928.
10. A. Waikley and C.A. Black, *Soil. Sci.*, 37, 29, 1934.
11. H. Sakai, *Workshop on Sulphur Nutrition in Rice*, BRRI, Dhaka, 41, 35, 1978.
12. R.L. Fox, Olsen and H. F. Rhodes, *Soil Sci. Soc. Amer. Proc.*, 28, 243, 1964.
13. A.J.M. Islam, *Workshop on Sulphur Nutrition in Rice*, BRRI, Dhaka, 41, 20, 1978.
14. M.Z. Hoque and P.R. Hobbs, *Workshop on Sulphur Nutrition in Rice*, BRRI, Dhaka, 41, 15, 1978.
15. J.R. Neller, *Ind. Land Eng. Chem.*, 18, 72, 1926.
16. A.J. Leseune and J.H. Parker, *Amer. Soc. Brew. Chem. Proc.*, 11, 5, 1954.
17. W. Thomas, *Agron. J.*, 51, 572, 1959.
18. S.M. Virmani and H.C. Gulathi, *Ind. J. Agric. Sci.*, 41, 143, 1971.
19. V. Singh and J.P. Singh, *Madras Agric. J.*, 55, 129, 1968.
20. V. Kumar and M. Singh, *Soil Sci.*, 13, 25, 1980.
21. M.E. Hardward, T.T. Chao and S.C. Fang, *Agron. J.*, 54, 101, 1962.
22. B. Sacchidanand, N.J. Sawarkar, R.S. Ghurrayya, D.A. Shinde and S.B. Sinha, *Ind. Soc. Soil Sci.*, 28(2), 189, 1980.
23. A.S. Marok and G. Dev, *Ind. Soc. Soil Sci.*, 28, 184, 1980.
24. A.B. Phillips and J.R. Webb, *Fert. Tech. Usage*, 3, 271, 1971.
25. N. Acharyya, *Oryga*, 10(1), 41, 1973.
26. S.M. Virmani and H. C. Gulathi, *Ind. J. Agric. Sci.*, 41, 143, 1971.
27. W. Dijkshoorn, J.E.M. Larup and R.E.J.V. Burg, *Plant and Soil*, 13, 227, 1960.
28. G. Dev, R.C. Jaggi and M.S. Aulakh, *J. Ind. Soc. Soil. Sci.*, 27, 302, 1979.
29. G. Dev, S. Saggar and M.S. Bajwa, *J. Ind. Soc. Soil Sci.*, 29(3), 397, 1981.