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Effect of different sources and levels of sulphur on soil nutrient status of aerobic rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during 2015 at the college of agriculture, V.C. Farm, Mandya, University of Agriculture sciences, Bangalore to study the effect of sources and levels of sulphur fertilization on soil nutrient status of aerobic rice. The results revealed that the application of different sulphur sources at different rates did not exert any significant influence on pH, available nitrogen, exchangeable potassium and exchangeable calcium content of soil. However the electrical conductivity varied significantly with different growth stages of plant. The organic carbon, available phosphorus, exchangeable magnesium and available sulphur status of soil at 30, 60, 90 days after sowing and at harvest was significantly, higher under RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment). In the effect among sources of sulphur, Ammonium sulphate had a significant influence and relatively better than other sources. As regards to levels the highest nutrient status in soils were recorded with highest level of sulphur application @ 26 kg ha^{-1}.

Keywords: Aerobic rice, sulphur sources, sulphur levels, soil nutrient status

Introduction
Asia's rice production mainly depends on irrigated rice fields which produce three fourth of all rice harvested. Water is becoming increasingly scarce and most of the Asian countries including India are expected to face serious water shortage in next 10-15 years, thus threatening the sustainability of irrigated rice production. Hence alternate ways of growing rice using minimum water must be explored to safeguard the food security and to preserve precious water resources. Aerobic rice production is one such alternate method which is known to use less water than lowland rice (Tabbal *et al*., 2002) [1]. Aerobic rice can save as much as 50 per cent of irrigation water in comparison with lowland rice.

Sulphur is now recognized as fourth essential nutrient element after nitrogen, phosphorous, and potassium (Morris, 2007) [2]. Crop requires sulphur generally as much as phosphorous and one tenth of nitrogen. Sulphur is essential for plant growth and development, since it is a constituent of certain amino acids such as cystine, cysteine, and methionine. It is essential for the synthesis of chlorophyll, vitamins, glycosides, ferrdoxins and certain disulphide linkages besides activation of proteolytic enzymes and ATP-sulphurylase enzyme (Rahman *et al.*, 2007) [3].

Sulphur status of soils is influenced by several factors and total sulphur in soil is present in organic combinations. In paddy under anaerobic conditions, when the availability of free air is completely cut off, partially oxidized chemicals such as NO_3^- and SO_4^- are reduced and utilized by organisms like desulphovibrio and desulphotomaculam. In the process these SO^-_4 ions are reduced to sulphites and sulphides. The end product may not be always H_2S because under anaerobic condition iron and manganese are reduced to Fe^{2+} and Mn^{2+} which react with sulphide to form relatively less soluble sulphides of this element. Under aerobic condition during decomposition of organic matter, organic sulphide compounds are transformed or oxidised to sulphates and availability of S is higher under aerobic condition. Therefore under aerobic conditions sulphur sufficiency may be expected however the effects of S application to aerobic rice is wanting. Keeping this in view the present research was conducted to know the effects of S application on soil chemical properties including pH, Electrical conductivity, organic carbon and availability of selected plant nutrients.+

Materials and Methods

A Field experiment was carried out at College of Agriculture, V.C. Farm, Mandya, during *kharif* season of 2015. It is located between 12^0 32' N latitude and 76^0 53' E longitude and 695 meters above mean sea level. The soil was sandy loam in texture with neutral reaction (pH 7.4), Electrical conductivity was 0.14 dSm^{-1} and organic carbon content was medium (7.5g kg^{-1}). The soil was medium in available nitrogen (439 kg ha^{-1}), medium in available phosphorus (53.86 kg ha^{-1}), medium in exchangeable potassium (176.4 kg ha^{-1}), with low available sulphur (5.21 mg kg^{-1}).

The experiment was laid out in Randomized Complete Block Design (RCBD) with twelve treatments and three replications. The treatment combinations consisting of five sources of sulphur fertilizers (viz. Gypsum, Ammonium Sulphate, Elemental Sulphur, 20:20:0:13 (Amophos) and SSP) and two levels of sulphur (13 and 26 kg Sulphur) ha^{-1} from each source along with one absolute control and recommend dose of fertilizers. Here 13 and 26 kg S ha^{-1} was fixed mainly because the complex used in the experiment was 20:20:0:13 and based on 5 kg S $acre^{-1}$ as standard was fixed. Recommended quantity of FYM at the rate of 10 t ha^{-1} was applied and mixed into the soil two weeks before sowing. As per the treatments fifty per cent of nitrogen was applied as basal dose and entire quantity of phosphorus, potassium, and sulphur were supplied at the time of sowing as a basal dose to each plot and remaining fifty per cent of nitrogen was applied as top dress at 30 days after sowing. The contribution of N and P from applied S sources viz Ammonium sulphate and SSP was made good by reducing the quantity of fertilizer nutrient in respective treatment. Good quality seeds of cultivar (Rashi) were sown manually at rate of one seed per hill with spacing of 25 cm × 25 cm as inter and intra row spacing. Irrigation was given as per requirement. Usually every 4 to 5 days once irrigation was given based on the moisture prevailing in the field as per the recommendation for aerobic rice to keep optimum moisture. Three hand weeding was done to keep the plots free from weeds at 30, 45 and 60 DAS.

Results and Discussion

Application of different levels through different sources of Sulphur significantly influenced the Physico chemical properties of soil of aerobic rice.

pH, electrical conductivity and organic carbon

The data related to Soil reaction, electrical conductivity (dSm^{-1}) and Organic carbon (g kg^{-1}) content of soils of aerobic rice as influenced by different levels and sources of sulphur recorded at 30, 60, 90 DAS and at harvest are presented in Table 1. The application of different sulphur sources at different rates did not exert any significant influence on pH of soil. The electrical conductivity was noticed significantly higher (0.14 dSm^{-1}) at 30 DAS in T_6, T_{10}, T_{12} and T_1 treatments which was on par with T_2, T_4, T_5, T_7, T_8, and T_{11} treatments.(0.13 dSm^{-1}). However, T_3 and T_9 treatments registered lower electrical conductivity (0.12dSm^{-1}).

At 60 DAS, T_4, T_6, T_8, T_{10} and T_{12} treatments recorded significantly higher electrical conductivity (0.15dSm^{-1}) and were on par with T_5, T_7, T_9 and T_{11} treatments (0.14 dSm^{-1}). However the lowest electrical conductivity was recorded in T_1 treatment (0.11dSm^{-1}). At 90 DAS, significantly highest electrical conductivity (0.0.16 dSm^{-1}) was observed under T_6, T_{11}, T_{12} and T_1 treatments followed by T_2, T_4, T_5, T_8 and T_{10} treatments (0.15dSm^{-1}). The lowest electrical conductivity was recorded in T_3, T_7 and T_9 treatments (0.14dSm^{-1}). At harvest, significantly highest electrical conductivity (0.16dSm^{-1}) was observed under T_6, T_8, T_{10} and T_{12} treatments, followed by T_1, T_4,T_5, T_7, (0.15 dSm^{-1}) and lowest electrical conductivity was recorded in T_2, T_3, and T_9 treatments.

Organic carbon (g kg^{-1}) in soils under aerobic rice was significantly influenced by different levels and sources of sulphur treatments at all the growth stages (Table 1). At 30 DAS, significantly higher organic carbon (8.6 g kg^{-1}) was recorded with RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) which was on par with T_5, T_8, T_9, T_{10}, T_{11} and T_{12} treatment). However absolute control registered lower organic carbon (7.2 g kg^{-1}). Similarly, at 60, 90 and at harvest, organic carbon varied significantly among all the treatments. RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) recorded significantly highest organic carbon (8.2, 7.9, and 7.8 g kg^{-1} respectively) and was on par with T_5, T_8, T_9, T_{10}, T_{11} and T_{12} treatment). However absolute control recorded significantly lower organic carbon at 60, 90 and at harvest (6.7, 6.5 and 6.4g kg^{-1} respectively).

Available nitrogen, phosphorus and potassium

The data on available nitrogen, phosphorus and exchangeable potassium (kg ha^{-1}) of aerobic rice as influenced by different levels and sources of sulphur recorded at 30, 60, 90 DAS and at harvest are presented in Table 2.

Available nitrogen in soils under aerobic rice did not vary significantly with different levels and sources of sulphur application at 30, 60, 90 DAS and at harvest. However T_6 treatment recorded numerically highest average N at all the growth stages (483.78, 458.69, 451.17 and 442.8 kg ha^{-1} respectively at 30, 60, 90 DAS and harvest).

Available phosphorus in soils of aerobic rice varied significantly among different levels and sources of sulphur from 30 DAS to harvest. At 30 DAS significantly highest available phosphorus (66.75 kg ha^{-1}) was recorded in RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) followed by T_{12}, which was on par with all other treatments. However absolute control (T_1 treatment) recorded lowest available phosphorous (51.44 kg ha^{-1}).

Table 1: Effect of different sources and levels of sulphur on soil reaction (pH), electrical conductivity (dSm^{-1}) and soil organic carbon ($g\ kg^{-1}$) of aerobic rice at different growth stages

Treatments	Soil reaction (pH)				electrical conductivity (dSm^{-1})				Soil organic carbon ($g\ kg^{-1}$)			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Absolute control	7.34	7.36	7.38	7.43	0.14	0.11	0.16	0.15	7.2	6.7	6.5	6.4
T_2 -RDF+FYM	7.35	7.37	7.42	7.44	0.13	0.13	0.15	0.14	7.6	7.2	6.7	6.6
T_3- T_2+13 kg S ha^{-1} (Gypsum)	7.25	7.35	7.43	7.43	0.12	0.13	0.14	0.14	7.7	7.4	7.0	6.9
T_4-T_2+26 kg S ha^{-1} (Gypsum)	7.23	7.36	7.45	7.46	0.13	0.15	0.15	0.15	8.0	7.5	7.2	7.1
T_5- T_2+13 kg S ha^{-1} (Ammonium sulphate)	7.24	7.38	7.45	7.46	0.13	0.14	0.15	0.15	8.1	7.7	7.4	7.3
T_6- T_2+26 kg S ha^{-1} (Ammonium sulphate)	7.23	7.39	7.46	7.47	0.14	0.15	0.16	0.16	8.6	8.2	7.9	7.8
T_7- T_2+13 kg S ha^{-1} (Elemental sulphur)	7.25	7.36	7.43	7.44	0.13	0.14	0.14	0.15	7.7	7.4	7.0	6.9
T_8- T_2+26 kg S ha^{-1} (Elemental sulphur)	7.24	7.37	7.43	7.45	0.13	0.15	0.15	0.16	8.1	7.7	7.4	7.2
T_9- T_2+13 kg S ha^{-1} (20:20:0:13)	7.25	7.35	7.40	7.42	0.12	0.14	0.14	0.14	8.1	7.7	7.2	7.1
T_{10}- T_2+26 kg S ha^{-1} (20:20:0:13)	7.24	7.36	7.42	7.43	0.14	0.15	0.15	0.16	8.3	7.9	7.5	7.4
T_{11}- T_2+13 kg S (SSP)	7.25	7.37	7.44	7.45	0.13	0.14	0.16	0.15	8.1	7.7	7.4	7.2
T_{12}- T_2+26 kg S (SSP)	7.24	7.38	7.46	7.45	0.14	0.15	0.16	0.16	8.5	8.1	7.7	7.5
F	NS	NS	NS	NS	*	*	*	*	*	*	*	*
SEm±	-	-	-	-	0.01	0.01	0.001	0.001	0.2	0.2	0.2	0.2
CD (p=0.05)	-	-	-	-	0.02	0.02	0.01	0.01	0.7	0.7	0.7	0.7

Similarly at 60 DAS the T_6 treatment (RDF + 26 kg sulphur per hectare through ammonium sulphate) recorded significantly higher available phosphorous (59.37 kg ha^{-1}) followed by T_{12}, T_4 and T_8 treatments which were at par (59.15, 59.04, and 58.82 kg ha^{-1} respectively). The lowest available phosphorous was recorded by T_1 treatment absolute control (45.60 kg ha^{-1}).

At 90 DAS Significantly highest available phosphorus (54.85 kg ha^{-1}) was recorded in RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) which was on par with T_{12},T_{10},T_4 and T_8 treatments (54.52, 54.30, 54.30 and 54.08 kg ha^{-1}). However absolute control (T_1 treatment) recorded lower available phosphorous. (40.42 kg ha^{-1}).Similarly at harvest the T_6 treatment (RDF + 26 kg sulphur per hectare through ammonium sulphate) recorded significantly higher available phosphorous (51.33kg ha^{-1}) followed by T_{12}, T_8, T_{10} and T_4 treatments (51.0, 50.89, 50.78 and 50.78 kg ha^{-1} respectively). The lowest available phosphorous was recorded by T_1 treatment absolute control (36.9 kg ha^{-1}).

Exchangeable potassium (kg ha^{-1}) in aerobic rice did not vary significantly with different levels and sources of sulphur recorded at 30, 60, 90 DAS and at harvest. Numerically highest exchangeable K was recorded in T_6 treatment and least in T_1 treatment at all the growth stages of aerobic rice.

Exchangeable calcium, magnesium and Available sulphur

The data on exchangeable calcium, magnesium (c mol kg^{-1}) and Available sulphur (mg kg^{-1}) of aerobic rice as influenced by different levels and sources of sulphur recorded at 30, 60, 90 DAS and at harvest are presented in Table 3.

Effect of different levels and sources of sulphur application on Exchangeable calcium (c mol kg^{-1}) in aerobic rice recorded at 30, 60, 90 DAS and at harvest showed no significant influence on Exchangeable calcium(c mol kg^{-1}) and was non-significant.

At 30 DAS significantly higher exchangeable magnesium (2.63 cmol kg^{-1}) was found in T_6 and T_8 treatments and was on par with T_2,T_3, T_4, T_5, T_7,T_9, T_{10},T_{11} and T_{12} treatments. However the least exchangeable magnesium was recorded under absolute control treatment T_1 (2.2 cmol kg^{-1}). Similarly at 60 DAS the T_6 treatment (RDF + 26 kg sulphur per hectare through ammonium sulphate) recorded significantly higher exchangeable magnesium (2.43 cmol kg^{-1}) followed by T_{12} and was on par with all other treatment except for T_2 and T_1 treatments. However lowest exchangeable magnesium was recorded by absolute control treatment T_1 (1.93 cmol kg^{-1}).

At 90 DAS significantly highest exchangeable magnesium (2.37 cmol kg^{-1}) was recorded in RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) followed by T_{12}, T_5 and T_8 treatments (2.33, 2.30and 2.30cmol kg^{-1}respectively) and was on par with T_3, T_4, T_7, T_9, T_{10} and T_{11} treatments. The lowest exchangeable magnesium was recorded by absolute control treatment T_1 (1.87 cmol kg^{-1}). Similarly at harvest the T_6 treatment (RDF + 26 kg sulphur per hectare through ammonium sulphate) recorded significantly higher exchangeable magnesium (2.30 cmol kg^{-1}) followed by T_{12}, T_5 and T_8 treatments (2.27, 2.23 and 2.23 cmol kg^{-1}respectively) and was on par with T_4, T_7, T_9, T_{10} and T_{11} treatments. However the lowest exchangeable magnesium was recorded by absolute control treatment T_1 (1.83 cmol kg^{-1}).

Table 2: Effect of different sources and levels of sulphur on soil available nitrogen, available P_2O_5 (kg ha^{-1}) and exchangeable K_2O (kg ha^{-1}) of aerobic rice at different growth stages

Treatments	Available nitrogen (kg ha^{-1})				Soil available P_2O_5 (kg ha^{-1})				exchangeable K_2O (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Absolute control	436.95	416.46	409.77	400.99	51.44	45.60	40.42	36.9	171.0	159.0	148.77	145.50
T_2 - RDF+FYM	463.71	436.95	427.75	422.31	61.35	54.85	49.79	46.27	187.5	178.5	168.00	165.00
T_3- T_2+13 kg S ha^{-1} (Gypsum)	472.91	442.39	434.44	431.10	65.55	56.39	51.00	46.70	192.0	183.0	172.50	168.00
T_4- T_2+26 kg S ha^{-1} (Gypsum)	478.76	454.93	447.40	438.20	65.65	59.04	54.30	50.78	196.5	187.5	178.50	174.00
T_5- T_2+13 kg S ha^{-1} (Ammonium sulphate)	475.84	449.27	443.22	435.69	64.55	55.96	51.55	47.03	195.0	184.5	174.00	171.00
T_6- T_2+26 kg S ha^{-1} (Ammonium sulphate)	483.78	458.69	451.17	442.80	66.75	59.37	54.85	51.33	199.5	189.0	180.00	175.50
T_7- T_2+13 kg S ha^{-1} (Elemental sulphur)	474.58	448.66	440.71	433.19	63.67	56.29	50.78	46.81	193.5	183.0	170.83	168.00
T_8- T_2+26 kg S ha^{-1} (Elemental sulphur)	479.60	454.93	447.82	440.29	65.76	58.82	54.08	50.89	198.0	186.0	174.00	169.50
T_9- T_2+13 kg S ha^{-1} (20:20:0:13)	472.91	445.31	438.20	429.00	64.22	56.18	51.33	46.71	190.5	181.5	175.50	168.00
T_{10}- T_2+26 kg S ha^{-1} (20:20:0:13)	480.02	454.51	447.82	439.88	64.11	56.84	54.30	50.78	195.0	184.5	174.00	169.50
T_{11}- T_2+13 kg S (SSP)	475.84	449.08	441.13	434.44	63.23	56.40	51.44	46.81	193.5	184.5	172.50	168.00
T_{12}- T_2+26 kg S (SSP)	480.85	457.02	449.49	441.13	66.09	59.15	54.52	51.00	198.0	187.5	178.50	174.00
F	NS	NS	NS	NS	*	*	*	*	NS	NS	NS	NS
SEm±	-	-	-	-	1.90	1.73	1.50	1.85	-	-	-	-
CD (p=0.05)	-	-	-	-	5.63	5.14	4.45	5.50	-	-	-	-

At 30 and 60 DAS significantly highest available sulphur (9.49 and 9.31mg kg^{-1}) was recorded in RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) which was on par with other treatments except to T_2 and T_1 treatments. However absolute control (T_1 treatment) recorded lowest available sulphur (5.38 and 5.73 mg kg^{-1} respectively).

At 90 DAS and at harvest RDF + 26 kg sulphur per hectare through ammonium sulphate (T_6 treatment) recorded Significantly highest available sulphur (9.2 and 9.09 mg kg^{-1} respectively) which was on par with T_2, T_3, T_4, T_5, T_7, T_8, T_9, T_{10}, T_{11} and T_{12} treatments both at 90 DAS and harvest. However absolute control (T1 treatment) recorded lowest available sulphur (5.62 and 5.50 mg kg^{-1} respectively).

The pH of the soil at different stages of the plant growth did not differ significantly due to different sources and levels of sulphur application. However the pH @ 30 days was decreased than the initial soil pH and then slightly increased at 60, 90 and @ harvest of aerobic rice. The reason for slight increase in soil acidity @ 30DAS might be attributed to the acidifying effect of sulphur and other fertilizers. Similar results were also reported by Fageria *et al.* (2011) [4].

Though EC of soil at all the stages of crop growth significantly varied due to sulphur application, but EC of the soil did not differ with greater values with sulphur fertilizers and levels; this might be due the aerobic condition of soil (alternate wetting and drying) which does influence the soluble salts to greater extent. The highest EC value was recorded in ammonium sulphate treated plots (26 kg S ha^{-1}) compared to all other treatments. The increased EC in treated plots could be due to application of S and fertilizers. The highest EC was observed at the time of harvest could be due to salts loaded through applied irrigation water. Bhagyalakshmi (2006) [5] observed that application of sulphur resulted in slight increase in EC compared to control where no S was added under low land rice conditions; Mariswamy Gowda (1992) [6] and Ashok (2001) [7] have also reported an increase in the total soluble salt concentration of soils due to an increase in the levels of sulphur application.

Application of sulphur resulted in significant changes in organic carbon content of the soil throughout the experiment. The highest organic carbon content was recorded in ammonium sulphate treated plots, compared to all other treatments. The significant increase in the organic carbon in all the treatments when compared to control was due to slower mineralization in the treated plots due to applied fertilizers and sulphur, which may have resulted in reduced microbial activity in the rhizosphere of plant. The organic carbon content of the soil was highest @ 30 DAS and decreased thereafter. The highest OC @ 30 DAS might be due to the initial decomposition of FYM, and decreased thereafter because of mineralization process and uptake by plant during its successive growth period. Bhagyalakshmi, (2006) [5] reported a small increase in the organic carbon than control under low land rice and this increase was due to slower decomposition rate because of absence of oxygen. Mariswamy Gowda (1992) [6] and Ashok (2001) [7] have also reported an increase in the organic carbon of soils due to an increase in the levels of sulphur application.

Table 3: Effect of different sources and levels of sulphur on soil exchangeable calcium (C mol kg^{-1}), soil exchangeable magnesium (C mol kg^{-1}) and available sulphur (mg kg^{-1}) of aerobic rice at different growth stages

Treatments	Soil exchangeable calcium (C mol kg^{-1})				Soil exchangeable magnesium (C mol kg^{-1})				available sulphur (mg kg^{-1})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	30 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Absolute control	6.43	6.17	6.03	5.93	2.20	1.93	1.87	1.83	5.38	5.73	5.62	5.50
T_2 - RDF+FYM	6.47	6.23	6.13	6.03	2.47	2.10	2.03	1.97	8.14	8.56	8.45	8.33
T_3- T_2+13 kg S ha^{-1} (Gypsum)	6.50	6.27	6.17	6.07	2.50	2.23	2.17	2.07	9.09	8.86	8.74	8.62
T_4- T_2+26 kg S ha^{-1} (Gypsum)	6.53	6.30	6.20	6.10	2.53	2.33	2.27	2.20	9.26	9.09	8.97	8.86
T_5- T_2+13 kg S ha^{-1} (Ammonium sulphate)	6.53	6.30	6.23	6.13	2.57	2.37	2.30	2.23	9.25	9.02	8.97	8.89
T_6- T_2+26 kg S ha^{-1} (Ammonium sulphate)	6.57	6.33	6.30	6.23	2.63	2.43	2.37	2.30	9.49	9.31	9.20	9.09
T_7- T_2+13 kg S ha^{-1} (Elemental sulphur)	6.50	6.23	6.20	6.10	2.53	2.27	2.23	2.13	9.20	9.03	8.91	8.80
T_8- T_2+26 kg S ha^{-1} (Elemental sulphur)	6.53	6.27	6.23	6.13	2.63	2.37	2.30	2.23	9.37	9.20	9.09	8.97
T_9- T_2+13 kg S ha^{-1} (20:20:0:13)	6.47	6.27	6.23	6.13	2.50	2.23	2.17	2.10	9.26	9.03	8.91	8.79
T_{10}- T_2+26 kg S ha^{-1} (20:20:0:13)	6.50	6.30	6.27	6.17	2.53	2.30	2.23	2.13	9.41	9.26	9.14	9.03
T_{11}- T_2+13 kg S (SSP)	6.43	6.30	6.23	6.13	2.57	2.33	2.27	2.20	9.20	9.36	8.91	8.80
T_{12}- T_2+26 kg S (SSP)	6.57	6.33	6.30	6.20	2.60	2.40	2.33	2.27	9.43	9.26	9.15	9.03
F	NS	NS	NS	NS	*	*	*	*	*	*	*	*
SEm±	-	-	-	-	0.07	0.07	0.07	0.07	0.284	0.263	0.335	0.344
CD (p=0.05)	-	-	-	-	0.22	0.22	0.22	0.22	0.84	0.78	0.99	1.02

The nutrient composition of soil was significantly influenced by the different sources and levels of sulphur application except for the N, K and Ca. However the available phosphorous, exchangeable magnesium and available sulphur were significantly influenced by S fertilization at all the stages of crop.

The available nitrogen and exchangeable potassium were not significantly influenced by sulphur fertilizers and this might be due to the forms of sulphur which did not influence the availability of N and K under aerobic conditions. The available phosphorous was however significantly influenced by S fertilization. The synergistic effect of S on P has been reported by Sarkunan *et al*. (1998) [9] in rice crop. Imran *et al*. (2014) [8] also reported that P content in soil at silking and post-harvest stage was maximum with application of 50 kg sulphur ha^{-1} in Maize. This could be due to increased plant biomass in sulphur applied treatments and also due to competition on the adsorption sites for sulphates and phosphates (Barrow, 1970). [10]

Among the Calcium, Magnesium and Sulphur content of the soil, calcium was not significantly influenced by sulphur application, however the magnesium and sulphur content of the soil are greatly influenced by the application of sulphur. The increased application of sulphur increased the soil available S by 4 ppm at different growth stages and at harvest. Singh *et al*. (2012) [11] had also observed the similar results by application of sulphur in rice. The Study helped that application of sulphur in higher doses not only increases the yield but also improves the availability of the nutrients to crop and better uptake of nutrients and accumulation of these nutrients in plant parts in sulphur deficit soils

References

1. Tabbal DF, Bouman BA, Safdos MA. On farm strategies for reducing water input in irrigated rice. Agric. Water Mang. 2002; 56(2):93-112.
2. Morris RJ. Sulfur in agriculture-international perspective. In Proceedings TSI/FAI/IFA workshop on sulfur in Balanced Fertilization. (R.K Tewatia, R.S. Choudhary, S.P. Kalwe Eds.), 4–6 October, 2006, New Delhi: The Fertilizer Association of India, 2007, 1-7.
3. Rahman MN, Islam MB, Sayem SM, Rahman MA, Masud MM. Effect of different rates of sulphur on the yield and yield attributes of rice in old Brahmaputra floodplain soil. J Soil. Nature. 2007; 1(1):22-26.
4. Fageria NK, Moreira A, Coelho AM. Yield and yield components of upland rice as influenced by nitrogen sources. J plant nutrition. 2011; 34:361-370.
5. Bhagyalakshmi T. Evaluation of use efficiency of different sulphur sources for rice and maize and their effect on soil properties. M.*Sc.* (agri.) Thesis, univ of agri. sci. GKVK, Bengaluru, 2006.
6. Mariswamy Gowda SM. Role of sulphur on yield and quality of Soybean (*Glycine max* L.) Merr. under intensive manuring and cropping programme in Alfisol of Bangalore. M.Sc. (Agri.) Thesis, Univ of Agri. Sci., Bengaluru, 1992.
7. Ashok BL. Sulphur status of selected soil series of Karnataka and studies on direct and residual effect of graded levels of Sulphur on crops. Ph. D. Thesis, univ of agri. sci., Bengaluru, 2001.
8. Imran, M., Parveen S, Ali A, Wahid F, Arifullah, Ali F. Influence of sulphur rates on phosphorous and sulphur content of maize crop and its utilization in soil. Int. J. farming and allied Sci. 2014; 3(11):1194-1200.
9. Sarkunan V, Misra AK, Mohapatra AR. Effect of phosphorous and sulphur on yield and uptake of P and S by rice. J. Indian Soc. Soil Sci. 1998; 46:776-777.
10. Barrow NJ. Comparison of the adsorption of molybdate, sulphate and phosphate by soils. Soil Sci. 1970; 109:282-289.
11. Singh AK, Manibhushan, Meena MK, Upadhyaya A. Effect of sulphur and zinc on rice performance and nutrient dynamics in plants and soil of Indo gangetic plains. J Agri. Sci. 2012; 4:162-170.