DOI: 10.15740/HAS/AU/12.TECHSEAR(5)2017/1270-1274 *Agriculture Update*
Volume **12** | TECHSEAR-5 | 2017 | 1270-1274
Visit us : *www.researchjournal.co.in*

RESEARCH ARTICLE :

Comparative studies on the effect of different sources of sulphur in relation with forms of sulphur and soil properties in calcareous soil

K.K. AMRUTHA, M.V. RAVI, K. NARAYANA RAO, H.S. LATHA AND SOUMYA KULKARNI

ARTICLE CHRONICLE :
Received :
15.07.2017;
Accepted :
30.07.2017

SUMMARY : The effect of sulphur application on soil sulphur forms and physico-chemical properties was investigated in calcareous black soil under field capacity condition at soil science and agricultural chemistry laboratory in UAS Raichur in 2016. Among the different sources of sulphur ammonium sulphate was shown high effectiveness and followed by gypsum, elemental sulphur and pyrite. Sulphur fertilization improved the sulphur forms and physico-chemical properties in the calcareous soil.

How to cite this article : Amrutha, K.K., Ravi, M.V., Rao, K. Narayana, Latha, H.S. and Kulkarni, Soumya (2017). Comparative studies on the effect of different sources of sulphur in relation with forms of sulphur and soil properties in calcareous soil. *Agric. Update*, **12**(TECHSEAR-5) : 1270-1274; **DOI: 10.15740/HAS/AU/12.TECHSEAR(5)2017/1270-1274.**

KEY WORDS :
Calcareous soil,
Sulphur fertilizers,
Forms of sulphur,
Physico-chemical properties

Author for correspondence :

K.K. AMRUTHA
Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Sulphur is one of the most important nutrient for plants as well as for animals and it is fourth major nutrient element after N, P, and K. sulphur has major role in chlorophyll formation, activation of enzymes, defense mechanism against pests and contribute special taste and odour to allium plants (Jamal *et al.*, 2009). Role of sulphur in Indian agriculture is now gaining importance due to increasing in crop production not only in oil seeds, legumes and forage but also in cereals (Singh *et al.*, 2000). Now days, deficiency of sulphur is prevalent, about 41% cultivated area in India is deficient in sulphur (Singh, 2009). It could be due to continuous use of sulphur free fertilizers, adoption of intensive farming, shifting of use of organic to inorganic fertilizers etc. Removal of sulphur by crops in India is about 1.26 million tones, whereas its replenishment through fertilizers is only about 0.76 million tons (Tiwari and Gupta, 2006). Further, the recovery of added sulphur through external sources is only 8-10%.

Sulphur is applied through various sources like elemental-S, gypsum, pyrite, ammonium sulphate, potassium sulphate and through other sulphate containing salts. The effective source of sulphur in black calcareous soils is important in the view of dissolution of excess $CaCO_3$ in these soils. Apart from that, how it will effect on organic carbon, pH, EC, $CaCO_3$ and different forms of sulphur is also important.

Sulphur in soils is present both inorganic and organic forms and the proportion of inorganic to organic sulphur varies widely depending upon the nature of soil, its depth and management factors. Total soil sulphur, which comprises inorganic and organic binding forms, ranges between 250 and 2500 kg ha^{-1} in most top soils of arable land. Inorganic S composed of water soluble and adsorbed SO_4 is generally believed to be the immediate source for plants (Sharma *et al.*, 2014).This element received little attention for many years; thereby sulphur deficiency is increasing day by day due to extensive mining and non-application of sulphur. Thus the knowledge of sulphur fertilization is important.

RESOURCES AND METHODS

A laboratory incubation experiment has been conducted for eight weeks in the department of Soil Science and Agricultural Chemistry, UAS Raichur in 2016, to study the effectiveness of different sources of sulphur in calcareous black soil at field capacity condition. The experiment comprised of nine treatments *viz.*, T_1: Control (No sulphur), T_2: 15 kg sulphur through elemental sulphur ha^{-1}, T_3: 30 kg sulphur through elemental sulphur ha^{-1}, T_4: 15 kg sulphur through gypsum ha^{-1}, T_5: 30 kg sulphur through gypsum ha^{-1}, T_6: 15 kg sulphur through pyrite ha^{-1}, T_7: 30 kg sulphur through pyrite ha^{-1}, T_8: 15 kg sulphur through ammonium sulphate ha^{-1}, T_9: 30 kg sulphur through ammonium sulphate ha^{-1}. The soil samples were analysed for different sulphur fractions *viz.*, total sulphur (Chapman and Pratt, 1961), Organic sulphur was estimated by the procedure described by Bardsley and Lancaster (1965). Sulphate sulphur and water soluble sulphur were analysed as described by Williams and Steinbergs (1959). Non-sulphate-S was computed by subtracting the sum of organic–S and SO_4-S from the total-S as given by Chesnin and Yein (1951). Soil samples were analysed for different physico-chemical properties *viz.*, pH, EC, organic carbon and $CaCO_3$ (Jackson, 1973). Soil was clay in texture and pH showed alkaline (8.65) along with EC was found normal (0.47 dSm^{-1}).The calcium carbonate content (24.88%) was high in soil whereas, organic carbon was low (3.43 g kg^{-1}). Different forms of sulphur *viz.*, SO_4-S (11.88 ppm), water soluble-S (9.35 ppm), organic-S (98.70 ppm), non-sulphate-S (412.75 ppm) and total-S (532.69 ppm).

OBSERVATIONS AND ANALYSIS

Effect of different sources and levels of sulphur on different forms of sulphur were analysed and presented in Table 1. This is revealed that, added doses of sulphur through different sources enhanced the sulphur forms (SO_4-S, water sol-S, organic-S, non-sul-S and total-S) in calcareous soil. The similar results were reported by Intodia and Sahu (1999) on effect of sulphur fertilization on distribution of sulphur in alkaline calcareous soils of South Rajasthan with different sources of sulphur

Table 1 : Effect of different sources and levels of sulphur on different S fractions at 0 (one day after incubation) and 8th week after incubation

Treatments	SO_4-S	0 (one day after) week of incubation			Total-S	SO_4-S	8th week of incubation			Total-S
		Water sol-S	Organic-S	Non-SO_4-S			Water sol-S	Organic-S	Non SO_4-S	
T_1: Control (No sulphur)	11.88	9.35	98.70	412.76	532.69	11.20	7.79	95.90	383.94	497.39
T_2 :15 kg sulphur through elemental sulphur ha^{-1}	31.49	28.49	122.20	783.16	936.85	31.20	26.05	116.90	691.83	839.93
T_3: 30 kg sulphur through elemental sulphur ha^{-1}	36.97	30.28	126.00	793.25	956.23	36.73	27.81	119.70	696.42	852.85
T_4: 15 kg sulphur through gypsum ha^{-1}	40.90	34.73	137.90	932.49	1111.29	40.51	32.28	134.40	794.23	969.15
T_5: 30 kg sulphur through gypsum ha^{-1}	43.11	37.40	147.00	972.84	1162.98	42.75	34.95	139.30	806.48	988.53
T_6: 15 kg sulphur through pyrite ha^{-1}	29.31	27.83	105.70	692.70	827.01	28.92	25.15	100.80	593.91	723.63
T_7: 30 kg sulphur through pyrite ha^{-1}	31.40	28.72	112.00	709.46	852.85	31.05	25.82	107.80	617.08	755.94
T_8: 15 kg sulphur through ammonium sulphate ha^{-1}	43.19	42.08	210.70	1044.78	1298.66	42.84	38.96	206.50	971.04	1221.13
T_9: 30 kg sulphur through ammonium sulphate ha^{-1}	44.35	44.53	242.20	1109.03	1395.58	43.91	41.63	235.20	961.40	1240.519

(gypsum, elemental sulphur, gypsum + elemental sulphur). The highest amount of sulphur forms were reported from the ammonium sulphate treatments (30 and 15 kg S ha^{-1}). This might be due to the increased availability of sulphur over and above better solubility and contributing effect of nitrogen from the ammonium sulphate (Diwakar *et al.*, 2014). Among the different sources and levels of sulphur pyrite showed lowest amount of sulphur forms. This may be due to the slower oxidation of pyrite as compared with other sources (Pandey *et al*., 2015). The amount of sulphur forms decrease at the end of the incubation period from 0 to 8th week. This could be due to transformation of one form to another form under favorable condition. Ammonium sulphate treatment were superior over the other sources and followed the decreasing trend gypsum > elemental sulphur > pyrite.

Physico-chemical properties improved after the application of different source of sulphur at different levels (Table 2). Soil pH decreased from 8.6 to 8.29 in ammonium sulphate 30 kg S ha^{-1} treatment. This might be due to the acid forming ability of ammonium sulphate in the soils as well as less anion adsorption ability of calcareous black soils. The results were corroborated with the findings of Ganeshamurthy and Sathisha (2012) and anion adsorption has been seen in the order: kaolinite > illite > montmorillonite. Dissolution of calcium carbonate was also observed in the added doses of sulphur treatments as compared with untreated control. Formation of the sulphuric acid wills takes place during the application of sulphur sources (ammonium sulphate, gypsum, elemental sulphur and pyrite), this leads to the dissolution of calcium carbonate in the calcareous soil. Sharma and Jaggi (2001) reported that, presence of $CaCO_3$ raises the soil pH, which decrease the sulphur adsorption in soil. The negative relation with $CaCO_3$ content and S fractions revealed that the presence of H^+ and OH^-ions on soil complex, where SO_4^{2-} ions are attracted to H^+ ions and forms insoluble compounds (Dhamak *et al*., 2014). Whereas electrical conductivity of the soil got increased (0.47 to 0.99 dSm^{-1}) due to the contributing effect of salts along with the application of sulphur fertilizers. Organic carbon status of the soil also increased while application of different sources and levels of sulphur and decreased towards end of the incubation

Table 2 : Effect of different sources and levels of sulphur on physico-chemical properties at 0 (one day after incubation) and 8th week after incubation

Treatments	0 (one day after) week of incubation				8th week of incubation			
	pH	EC	OC	$CaCO_3$	pH	EC	OC	CaCO3
T_1: Control (No sulphur)	8.60	0.47	4.59	24.88	8.58	0.52	4.19	24.80
T_2 :15 kg sulphur through elemental sulphur ha^{-1}	8.55	0.79	4.19	24.85	8.40	1.20	3.19	23.98
T_3: 30 kg sulphur through elemental sulphur ha^{-1}	8.58	0.78	4.19	24.85	8.39	1.30	3.39	23.60
T_4: 15 kg sulphur through gypsum ha^{-1}	8.57	0.79	3.59	24.83	8.34	1.30	3.19	22.90
T_5: 30 kg sulphur through gypsum ha^{-1}	8.56	0.80	3.39	24.80	8.30	1.28	3.39	22.65
T_6: 15 kg sulphur through pyrite ha^{-1}	8.60	0.76	4.39	24.85	8.46	1.24	3.39	23.75
T_7: 30 kg sulphur through pyrite ha^{-1}	8.59	0.80	3.99	24.85	8.40	1.27	3.59	23.63
T_8: 15 kg sulphur through ammonium sulphate ha^{-1}	8.48	0.69	3.39	24.80	8.37	0.98	2.99	22.75
T_9: 30 kg sulphur through ammonium sulphate ha^{-1}	8.51	0.70	3.19	24.78	8.29	0.99	2.19	22.73

Table 3 : Effect of different sources and levels of sulphur on available sulphur (ppm) at different intervals of incubation in calcareous and non calcareous soils

Treatments	0 week	1st week	2nd week	3rd week	4th week	5th week	6th week	8th week
T_1: Control (No sulphur)	11.88	11.79	11.74	11.69	11.59	11.50	11.40	11.20
T_2 :15 kg sulphur through elemental sulphur ha^{-1}	31.49	31.45	31.44	31.40	31.39	31.34	31.29	31.20
T_3: 30 kg sulphur through elemental sulphur ha^{-1}	36.97	36.92	36.92	36.92	36.88	36.88	36.83	36.73
T_4: 15 kg sulphur through gypsum ha^{-1}	40.90	40.85	40.81	40.76	40.71	40.66	40.61	40.51
T_5: 30 kg sulphur through gypsum ha^{-1}	43.11	43.09	43.04	42.99	42.95	42.94	42.89	42.75
T_6: 15 kg sulphur through pyrite ha^{-1}	29.31	29.26	29.26	29.21	29.16	29.11	29.01	28.92
T_7: 30 kg sulphur through pyrite ha^{-1}	31.40	31.39	31.37	31.35	31.29	31.29	31.20	31.05
T_8: 15 kg sulphur through ammonium sulphate ha^{-1}	43.19	43.15	43.14	43.11	43.09	43.04	42.94	42.84
T_9: 30 kg sulphur through ammonium sulphate ha^{-1}	44.35	44.25	44.30	44.25	44.20	44.15	44.06	43.91

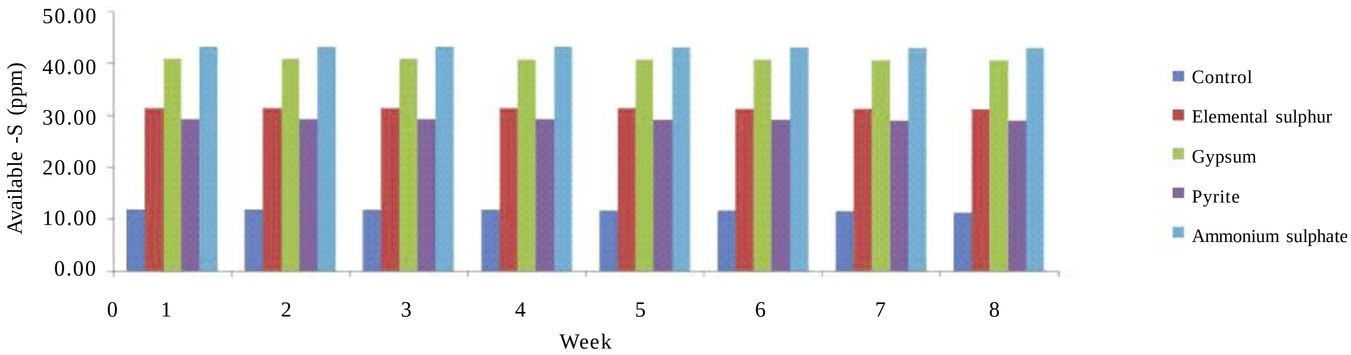

Fig. 1 : Effect of different sources of sulphur on available-S at 15 kg

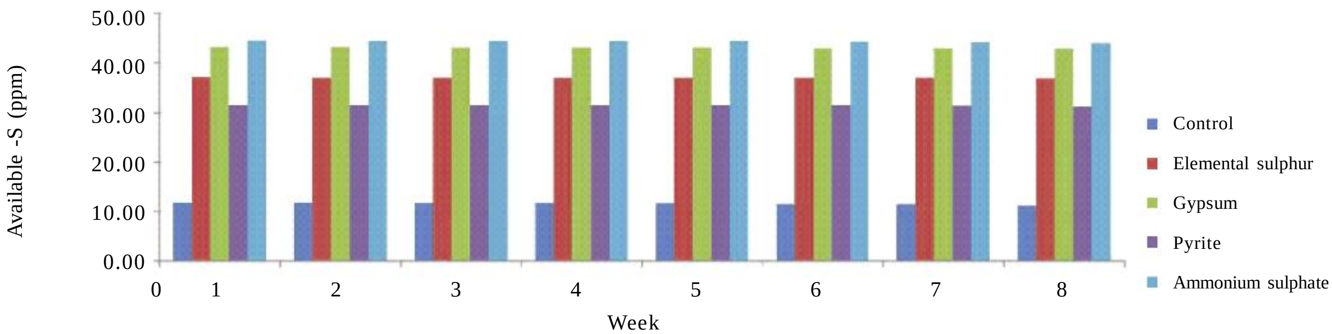

Fig. 2 : Effect of different sources of sulphur on available-S at 30 kg

period.

Added doses of sulphur through different sources and levels increased the available sulphur content in the soil (11.88 to 44.35 ppm) are presented in Table 3 and Fig. 1 and 2. This fraction is available for the plant uptake and more prone to leaching, erosion and percolation losses from the soil. Highest amount of available sulphur reported from the ammonium sulphate 30 kg

S ha^{-1} (T_9) followed by ammonium sulphate 15 kg S ha^{-1} (T_8). The decreasing order of treatments were follows; T_5: 30 kg sulphur through gypsum ha^{-1} (42.65 to 41.73 ppm) > T_4: 15 kg sulphur through gypsum ha^{-1}(40.47 to 39.79 ppm) > T_3: 30 kg elemental sulphur ha^{-1} (36.54 to 35.90 ppm) > T_2: 15 kg elemental sulphur ha^{-1}(30.91 to 30.52 ppm) > T_7: 30 kg sulphur through pyrite ha^{-1} (30.91 to 30.08 ppm) > T_6: 15 kg sulphur through pyrite ha^{-1} (28.97 to 28.24 ppm). Superiority of SO_4-S containing source like ammonium sulphate and gypsum over those with reduced forms like elemental S and pyrites is widely reported (Jena *et al.*, 2006).

Conclusion :

– Ammonium sulphate is the best source of sulphur in calcareous soil and follows the order; gypsum > elemental sulphur > pyrite.

– Application of sulphur improved the sulphur forms, physico-chemical properties and available sulphur status in the soil.

– Highest dissolution of calcium carbonate was noticed in ammonium sulphate 30 kg S ha^{-1}and lowest in pyrite 15 kg S ha^{-1}.

Acknowledgement :

The authors are very thankful to Dr. M.V. Ravi (Programme co-ordinator, KVK Raichur)for his valuable suggestion and guidance throughout research work and UAS, Raichur providing facilities to conduct this investigation is great fully acknowledged

Authors' affiliations :

M.V. RAVI, K. NARAYANA RAO, H.S. LATHA AND SOUMYA KULKARNI, Department of Soil Science and Agricultural Chemistry, College of Agriculture, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

REFERENCES

Bardsley, C.E. and Lancaster, J.D. (1965). Sulphur, In *Methods of Soil Analysis*, ed. C. A. Black, *Amer. Soc. Agron.*, 1102–1116.

Chapman, H.D. and Pratt, P.F. (1961). *Methods of analysis for soils, plants and waters*, Univ. of California, Div. Agric. Sci. California. Chesnin, L., Yein, C. H., 1951, Turbidimetric determination of available sulphate. *Soil Sci. Soc. Amer., Pro.*, **15**: 149-151.

Dhamak, A.L., Mcbhram, M.C. and Waiker, S.L. (2014). Comparative studies on dynamics soil properties and forms of sulphur in oilseed growing soils of Ambajogai Tahsil of Beed district. *J. Agri. Sci. Vet. Sci.*, **7** : 98-102.

Diwakar, H.G., Dhanajaya, B.C., Jayanthi, T., Ravi, M.V. and Siddaramappa, R. (2014). Transformation of S fractions under field conditions with groundnut (*Arachis hypogaea* L.) in Alfisols of Karnataka. *Commun. Soil Sci. Plant Annl*., **45** : 1269-1277.

Ganeshamurthy, A.N. and Sathisha, G.C. (2012). Sulphur nutrition to horticultural crops. *Indian J. Fert.*, **8** (12): 124-134

Intodia, S.K. and Sahu, M.P. (1999). Effect of sulphur fertilization on distribution of sulphur in alkaline calcareous soils of South Rajasthan, *J. Indian Soc. Soil Sci.*, **47**(3): 442-445.

Jackson, M.L. (1973). *Soil chemical analysis*, Prentiss Hall of India Pvt. Ltd., New Delhi. 7-10.

Jamal, A., Ko, K., Kim, H.S., Cho, Y.K., Joung, H. and Ko, K. (2009). Role of genetic factors and environmental conditions in recombinant protein production for plant molecular farming. *Biotech. Adv.*, **27**(6): 914–23.

Jena, D., Sahoo, R., Sarangi, D.R. and Singh, M.V. (2006). Effect of different sources and levels of sulphur on yield and nutrient uptake by groundnut-rice cropping system in an Inceptisols of Orissa. *J. Indian Soc. Soil Sci.*, **54** : 126-129.

Pandey, Manoj, Chaturvedi, B.K., Singh, Sandeep and Shukla, P.K. (2015). Status and response of sulphur in alluvial soils for higher yield of potato. *J. Indian Soc. Soil Sci.*, 63(1):107-111.

Sharma, Rakesh and Jaggi, R.C. (2001). Relationships of forms and availability indices of sulphur with properties of soils of Kangra, Himachal Pradesh. *J. Indian Soc. Soil Sci.*, **49**(4): 698-702.

Singh, S.P., Ram, J. and Singh, N. (2000). Forms of sulphur in relation to soil characteristics in some soil series of Nagaland. *J. Maharashtra Agric. Univ.*, **25**(1) : 3-8.

Singh, M.V. (2009). Effect of trace element deficiencies in soil on human and animal health. *Bull. Indian Soc. Soil Sci.*, **27**: 75- 101.

Tiwari, K.N. and Gupta, B.R. (2006). Sulphur for sustainable high yield agriculture in Uttar Pradesh. *Indian J. Fert.*, **1** : 37-52.

Sharma, Upinder, Subehia, S.K., Rana, S. S., Sharma, S. K. and Negi, S.C. (2014). Soil sulphur fractions and their relationship with soil properties and rice (*Oryza sativa* L.) yield under long-term integrated nutrient management in an acid Alfisol. *Res. Crops*, **15**(4): 738-745.

Williams, C.H. and Steinbergs, A. (1959). Soil sulphur fractions as chemical indices of available sulphur in some Australians soils. *Austn. J. Agric.Res.*, **10** : 340-352.

12th Year
★★★★★ of Excellence ★★★★★