J. Farm Sci., 30(1): (20-23) 2017

Yield, uptake of nutrients and economics of transplanted rice (*Oryza sativa* L.) as influenced by different sources and levels of sulphur

B. G. MASTHANA REDDY

Department of Agronomy, Agriculture Research Station, Gangavati
University of Agricultural Sciences, Raichur - 583 227, Karnataka, India
E-mails: bgmreddy2006@gmail.com

(Received: March, 2015 ; Accepted: December, 2016)

Abstract: A field experiment was conducted during *kharif,* 2012 at ARS, Gangavathi, UAS, Raichur to study the effect of different sources and levels of sulphur on growth and yield of irrigated transplanted rice (*Oryza sativa* L.). The results revealed that application of sulphur in the form of gypsum recorded better yield parameters such as panicles per m^2 (322),number of filled grains per panicle (107.5), grain filling percentage (87.8) and test weight (15.1 g) and resulted in significantly higher grain yield (4752 kg ha^{-1}).Gypsum application also recorded higher uptake of nitrogen (132.9 kg ha^{-1}), phosphorus (32.6 kg ha^{-1}), potassium (98.2 kg ha^{-1}) and sulphur (24.1 kg ha^{-1}). The gross returns (₹.80681 ha^{-1}), net returns (₹ 46426 ha^{-1}) and B:C ratio (2.35) were also higher over other sources. Among the different levels, application of sulphur @ 40 kg ha^{-1} recorded significantly higher grain yield (4914 kg ha^{-1}) and better yield parameters and resulted in higher net returns(₹ 48389 ha^{-1}) and BC ratio(2.38).

Key words: Ammonium sulphate, Bentonite sulphur, Gypsum, Sulphur

Introduction

Rice is the major staple food for 70 per cent of the Indian population, and is being cultivated over an area of 43.95 m.ha with a production of 106.54 m.t. In Karnataka, rice is grown under a variety of soils and occupies an area of 1.42 m.ha, with an annual production of 3.94 m.t (Anon., 2014). Among the different nutrients, sulphur forms one of the most important nutrients for rice. Sulphur is considered as the fourth major nutrient after nitrogen, phosphorous and potassium for agricultural crop production. Sulphur deficiency in rice is gradually becoming widespread due to continuous use of sulphur free fertilizers, high yielding crop varieties, intensive multiple cropping systems, coupled with higher productivity. However, studies concerning the efficacy of different S sources and their application rates in black soils are meager. The present investigation was, therefore, initiated to study effect of sources and levels of sulphur on growth and yield of transplanted rice.

Material and methods

A field experiment was conducted on medium deep black soil during *kharif* 2012-13 at Agricultural Research Station, Gangavathi situated at a latitude of 15° 15' 4" N latitude and 76° 31' 40" E longitude and at an altitude of 419 meters above the mean sea level. The status of soil indicates low available N, medium available P_2O_5, high available K_2O and medium available S content.

The experiment was laid out in split plot design with sulphur sources as main plot treatments- *viz.,* M_1- Gypsum (S- 18.6 %) M_2- Single super phosphate (S-12.0 %) M_3- Ammonium sulphate (S-23.0 %), M_4- Bentonite sulphur (S-80.0 %), M_5- Cosavet sulphur (S-90.0 %) and levels of sulphur as sub plot treatments *viz.,* S_1- 0 kg S ha^{-1} (control), S_2- 20 kg S ha^{-1}, S_3-30 kg S ha^{-1}, and S_4- 40 kg S ha^{-1} and replicated thrice. The crop was fertilized at the rate of 200:100:100 kg N, P_2O_5 and K_2O ha^{-1}. At the time of transplanting 50 per cent N and 100 per cent of P and K were applied. The remaining 50 per cent N was applied in two equal splits at active tillering and panicle initiation stages. N, P and K were supplied in the form of urea, DAP and muriate of potash. Sulphur was applied as per the treatment. Zinc was applied in the form of zinc EDTA. Need based plant protection measures were taken up. Observations on growth and yield parameters, ,grain and straw yield were recorded, statistically analysed and presented.

Results and discussion

Among the sources, gypsum recorded significantly higher grain yield (4752 kg ha^{-1}) than cosavet sulphur (4440 kg ha^{-1}), bentonite sulphur (4513 kg ha^{-1}) and SSP (4556 kg ha^{-1}), representing 6.5, 5.0 and 4.1 per cent increased yields, respectively. However, grain yields remained on par with ammonium sulphate application (4637 kg ha^{-1}). The gypsum application had significantly more number of panicles m^{-2}(322), filled grains per panicle(107.5 m2), better filling percent (87.8%) and test weight (15.1 g) than other sources such as Cosavet Sulphur and contributed for higher grain yield. The ammonium sulphate appeared the next best treatment. These results are in agreement with the findings of Jena *et al.* (2006), Yashbirsingh shivay *et al.* (2013), Kumar Rakesh *et al.* (2014) Asharamsirvi *et al.* (2016), who reported increased rice grain yield due to sulphur application through gypsum or phosphogypsum.

Among different levels, application of 40 kg S ha^{-1} recorded significantly higher grain yield (4914 kg ha^{-1}) than all other levels, where in grain yield varied from 4157 kg ha^{-1} in the case of no sulphur control to 4689 kg ha^{-1} in the case of 30 kg S ha^{-1}. Application of 40 kg S ha^{-1} recorded 15.4, 7.3 and 4.6 per cent higher grain yield over 0, 20 and 30 kg S ha^{-1} , respectively. Among the levels of sulphur, application of 40 kg S ha^{-1} recorded significantly higher number of panicles per m^2 (311),

Table 1. Grain yield (kg ha^{-1}), number of panicles m^{2} and filled grains per panicle of rice as influenced by different sources and levels of sulphur

Treatments	Grain yield (kg ha^{-1})						Panicles (m^{-2})						Filled grains per panicle					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	4235	4160	4148	4104	4139	4157	235	230	232	229	228	231	93.0	89.3	91.7	87.7	85.0	89.3
S_2	4637	4594	4599	4481	4477	4558	336	289	315	282	265	297	104.8	95.2	100.0	90.9	87.9	95.8
S_3	4860	4646	4727	4674	4537	4689	350	302	317	295	271	307	111.9	99.7	103.3	95.2	91.8	100.4
S_4	5274	4825	5075	4792	4607	4914	367	310	325	299	254	311	120.3	105.2	115.0	98.7	95.0	106.8
Mean	4752	4556	4637	4513	4440		322	283	297	276	254		107.5	97.3	102.5	93.1	89.9	

	S.Em±	C.D. at 5%	S.Em±	C.D. at 5%	S.Em±	C.D. at 5%
Sources of sulphur (M)	46.70	152.30	7.91	25.80	2.44	7.97
Levels of sulphur (S)	32.18	92.94	4.22	12.20	1.65	4.76
S at same M	71.96	207.82	9.45	27.28	3.69	NS
M at the same or different S	77.87	230.08	11.38	33.52	4.02	NS

NS: Non Significant

M_1: Gypsum (S-18.61%)
M_2: SSP (Single Super Phosphate) (S-12%)
M_3: Ammonium sulphate (S-23%)
M_4: Bentonite sulphur (S-90%)
M_5: Cosavet sulphur (S-80%)

S_1: 0 kg S ha^{-1}
S_2: 20 kg S ha^{-1}
S_3: 30 kg S ha^{-1}
S_4: 40 kg S ha^{-1}

Table 2.Grain filling (%), test weight(g) and total sulphur uptake (kg ha^{-1}) of rice as influenced by different sources and levels of sulphur

Treatments	Grain filling (%)						Test weight(g)						Total sulphur uptake (kg ha^{-1})					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	79.9	80.38	81	79.5	77.7	79.8	14.7	13.9	14.0	13.7	13.2	13.9	11.6	11.2	11.2	10.9	10.8	11.2
S_2	88.1	84.3	86.4	82.6	80.1	84.3	15.2	14.6	15.0	14.3	13.6	14.5	21.7	18.5	19.9	17.5	16.4	18.8
S_3	90.9	86.8	88.7	84.7	82.2	86.7	15.3	14.7	15.1	14.4	14.0	14.7	29.0	23.4	25.1	21.6	20.4	23.9
S_4	92.3	88.4	90.3	86.3	84.5	88.3	15.4	15.0	15.2	14.7	14.2	14.9	34.2	26.6	28.3	24.3	22.4	27.2
Mean	87.8	85.1	86.6	83.3	81.1		15.1	14.5	14.8	14.3	13.7		24.1	19.9	21.1	18.6	17.5	

	S.Em±	C.D. at 5%	S.Em±	C.D. at 5%	S.Em±	C.D. at 5%
Sources of sulphur (M)	1.25	4.09	0.27	0.87	0.72	2.34
Levels of sulphur (S)	0.82	2.38	0.25	0.72	0.76	2.20
S at same M	1.84	NS	0.56	NS	1.70	NS
M at the same or different S	2.03	NS	0.55	NS	1.64	NS

NS: Non Significant

M_1: Gypsum (S-18.61%)
M_2: SSP (Single Super Phosphate) (S-12%)
M_3: Ammonium sulphate (S-23%)
M_4: Bentonite sulphur (S-90%)
M_5: Cosavet sulphur (S-80%)

S_1: 0 kg S ha^{-1}
S_2: 20 kg S ha^{-1}
S_3: 30 kg S ha^{-1}
S_4: 40 kg S ha^{-1}

Table 3. Total uptake of nitrogen, phosphorous and potassium (kg ha^{-1}) by rice as influenced by different sources and levels of sulphur

Treatments	Nitrogen (kg ha^{-1})						Phosphorous (kg ha^{-1})						Potassium (kg ha^{-1})					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	109.4	106.3	106.3	103.8	102.4	105.7	25.8	27.1	25.1	24.5	26.1	25.8	80.7	75.8	76.7	73.3	70.9	75.5
S_2	128.1	120.9	124.1	118.1	114.5	121.1	28.4	30.0	27.6	27.1	28.9	28.4	96.1	84.5	87.9	82.3	76.8	85.5
S_3	142.0	129.8	135.4	127.8	120.5	131.1	29.3	31.5	28.7	27.5	30.1	29.3	103.1	90.4	95.7	86.6	79.5	91.1
S_4	151.9	137.2	144.3	131.3	124.6	137.9	30.7	33.5	29.4	28.0	31.7	30.7	112.9	96.6	101.5	90.2	85.1	97.3
Mean	132.9	123.6	127.6	120.2	115.5		28.5	30.5	27.7	26.8		28.5	98.2	86.9	90.5	83.2	78.1	
		S.Em±		C.D. at 5%			S.Em±			C.D. at 5%			S.Em±			C.D. at 5%		
Sources of sulphur (M)		1.65		5.39			0.71			2.32			1.82			5.94		
Levels of sulphur (S)		2.20		6.37			0.78			2.26			1.48			4.28		
S at same M		4.93		NS			1.75			NS			3.31			NS		
M at the same or different S		4.58		NS			1.67			NS			3.40			NS		

NS: Non Significant

M_1: Gypsum (S-18.61%)
M_2: SSP (Single Super Phosphate) (S-12%)
M_3: Ammonium sulphate (S-23%)
M_4: Bentonite sulphur (S-90%)
M_5: Cosavet sulphur (S-80%)

S_1: 0 kg S ha^{-1}
S_2: 20 kg S ha^{-1}
S_3: 30 kg S ha^{-1}
S_4: 40 kg S ha^{-1}

Table 4. Gross returns (₹ ha^{-1}), net returns (₹ ha^{-1}) and B: C ratio of rice as influenced by different sources and levels of sulphur

Treatments	Gross returns (₹ ha^{-1})						Net returns (₹ ha^{-1})						B:C ratio					
	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean	M_1	M_2	M_3	M_4	M_5	Mean
S_1	71833	70554	70373	69618	70192	70514	37913	36634	36453	35698	36272	36594	2.12	2.08	2.07	2.05	2.07	2.08
S_2	78782	77946	78062	76074	76016	77376	44742	43872	43874	41354	40896	42947	2.31	2.29	2.28	2.19	2.16	2.25
S_3	82582	78907	80315	79346	77048	79640	48082	44756	45993	44226	41328	44877	2.39	2.39	2.34	2.26	2.16	2.29
S_4	89528	81918	86089	81297	78198	83406	54968	47690	51633	45777	41878	48389	2.59	2.39	2.50	2.29	2.15	2.38
Mean	80681	77331	78710	76484	75363		46426	43238	44488	41764	40094		2.35	2.27	2.30	2.20	2.14	
		S.Em±		C.D. at 5%			S.Em±			C.D. at 5%			S.Em±			C.D. at 5%		
Sources of sulphur (M)		784.08		2557.01			784.08			2557.01			0.02			0.07		
Levels of sulphur (S)		547.04		1579.97			547.04			1579.97			0.02			0.05		
S at same M		1223.22		NS			1223.22			3532.93			0.04			0.10		
M at the same or different S		1317.95		NS			1317.95			3894.54			0.04			0.11		

NS: Non Significant

M_1: Gypsum (S-18.61%)
M_2: SSP (Single Super Phosphate) (S-12%)
M_3: Ammonium sulphate (S-23%)
M_4: Bentonite sulphur (S-90%)
M_5: Cosavet sulphur (S-80%)

S_1: 0 kg S ha^{-1}
S_2: 20 kg S ha^{-1}
S_3: 30 kg S ha^{-1}
S_4: 40 kg S ha^{-1}

more number of filled grains per panicle(106.8), better filling percent(88.3%) and higher test weight(14.9 g) than other levels. The higher yield parameters inturn had contributed for higher grain yield. Interaction effect of sources and levels of sulphur revealed that application of gypsum at 40 kg S ha^{-1} (5274 kg ha^{-1}) was significantly superior than all the treatment combinations in respect of grain yield, except with application of ammonium sulphate at 40 kg S ha^{-1} (5075 kg ha^{-1}). Significantly lower grain yield (4104 kg ha^{-1}) was recorded with no sulphur control, irrespective of sources. Gypsum at 40 kg S ha^{-1} (5274 kg ha^{-1}) had more number of panicles m^{-2} (367) than other combinations and contributed for higher grain yield in this treatment. Significantly lower number of panicles per m^{-2} (228) was recorded with no sulphur control, irrespective of sources. Earlier Mercy Varughese *et al.* (2006), Sreedevi *et al.* (2006), Anilkumar singh *et al.* (2012),Yashbir Singh Shivay *et al.* (2013), Kumar Rakesh *et al.* (2014) and Asharam sirvi *et al.* (2016) reported increased rice grain yields due to S application at levels ranging from 30 to 45 kg ha^{-1}

Gypsum application recorded significantly higher plant uptake of N (132.9 kg ha^{-1}) P (28.5 kg ha^{-1}), K (98.2 kg ha^{-1}) and S (24.1 kg ha^{-1}) than other sources such as cosavet sulphur and bentonite sulphur, but remained on par with ammonium sulphate application. This indicated close relation between higher uptake of N, P, K and S and higher grain yield.

Among the levels, application of 40 kg S ha^{-1} recorded higher uptake of N (137.9 kg ha^{-1}) P(31.7 kg/ha), K(97.3 kg/ha) and S (27.2 kg/ha) than other levels except, 30 kg S ha^{-1} in case of P indicating close association between grain yield and uptake of nutrients.

Application of gypsum recorded significantly higher gross returns (₹ 80681 ha^{-1}) than cosavet sulphur (₹ 75363 ha^{-1}), bentonite sulphur (₹ 76584 ha^{-1}) and SSP (₹ 77331 ha^{-1}) representing 6.8, 5.0 and 4.1 per cent increased gross returns respectively. However, it remained on par with application of ammonium sulphate (₹ 78710 ha^{-1}).

Gypsum application also recorded higher net returns (₹ 46426 ha^{-1}) than cosavet sulphur (₹ 40093 ha^{-1}), bentonite sulphur (₹41764 ha^{-1}) and SSP (₹ 43238 ha^{-1}) representing,13.6, 10.0 and 6.8 per cent higher net returns respectively, but remained on par with ammonium sulphate (₹ 44488 ha^{-1}). Among levels of sulphur higher net returns was recorded with 40 kg S ha^{-1} (₹ 48389 ha^{-1}) than all other levels, where in net returns varied from ₹ 36594 ha^{-1} in the case of no sulphur control to ₹ 44877 ha^{-1} in the case of 30 kg S ha^{-1}. Application of 40 kg S ha^{-1} recorded 24.4, 11.2 and 7.2 per cent higher net returns over no sulphur control, 20 kg S ha^{-1} and 30 kg S ha^{-1}, respectively.

Interaction effect of sources and levels of sulphur revealed that application of gypsum at 40 kg S ha^{-1} (₹ 54968 ha^{-1}) recorded significantly higher net returns over all the treatment combinations, except with ammonium sulphate at 40 kg S ha^{-1} (₹ 51633 ha^{-1}). Significantly lowest net return (₹ 35698 ha^{-1}) was recorded with 0 kg S ha^{-1}, irrespective of sources.

Among the different sources of sulphur, significantly higher benefit cost ratio (2.35) was recorded with application of gypsum than cosavet sulphur (2.14), bentonite sulphur (2.20) and single super phosphate (2.27). However, it remained on par with application of ammonium sulphate (2.30). Application of 40 kg S ha^{-1} had recorded significantly higher benefit cost ratio (2.38) over all other levels of sulphur where it varied from 2.08 in the case of no sulphur control to 2.29 in the case of 30 kg S. Significantly lower benefit cost ratio (2.05) was recorded with no sulphur control irrespective of sources. The interaction effect revealed that gypsum @ 40 kg S ha^{-1} recorded a benefit cost ratio of 2.59 which was significantly higher than all the combinations, except ammonium sulphate @ 40 kg S ha^{-1}(2.50).

The two year study can be concluded that application of Sulphur in the form of Gypsum equivalent to 40 kg S ha^{-1} recorded improved yield parameters and higher rice grain yield and resulted in higher plant uptake of N,P,K and S. Gypsum at 40kg S can be recommended to rice under medium deep black soils of Tungabadra command area.

References

Anonymous, 2013, India Stat.com

Anonymous, 2014, Ministry of Agriculture,Government of India

Anilkumar Singh, Manibhushan, Meena, M.K. and Ashuthosh Upadhyaya, 2012, Effect of sulphur and zinc on rice performance and nutrient dynamics in plants and soils of Indo-gangetic plains *J. Agric. Sci.,* 4(11):162-170.

Asharam Sirvi, Dineshkumar, Nain Singh and Anjali Anand, 2016, Relative efficacy of Sulphur sources at varying rate in aerobic rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian. J. Agric. Sci.,* 86(11):1399-1405.

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 Inceptisol of Orissa. *J. Indian Soc. Soil Sci.,* 54(1): 126-129.

Kumar Rakesh, Lal, J. K., Kumar Arvind, Agrawal, B. K. and Karmakar, S., 2014, Effect of different sources and levels of Sulphur on yield, S uptake and protein content in rice and pea grown in sequence on acid alfisol. *J. Ind. Soc.soil.Sci.,* 62(2):140-143.

Mercy, Varughese, Kins Varghese and Singh, S.S., 2006, Effect of different levels and sources of sulphur on growth and yield of Basmathi rice c.v., Pusa Basmathi-2 *Agric. Sci. Digest.,* 26(1): 39-41.

Sreedevi, B., Singh, S. P. and Subbaiah, S. V., 2006, Effect of sulfur application on conventional and hybrid rice cultivars. *Oryza,* 43(2): 112-115.

Yashbir Singh Shivay, Rajendraprasad and Madan pal, 2013, Effect of levels and sources of sulphur on yield, sulphur and nitrogen concentration and uptake and S-use efficiency in Basmathi rice. *Communications in Soil Sci. and Pl. Analysis,* 45(18): 2468-2479.