International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1687-1689

Received: 12-05-2020
Accepted: 14-06-2020

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Effect of level and sources of sulphur on yield of rice

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4q.9853

Abstract
Sulphur is a multivalent non-metal, abundant, tasteless and and odorless. In its native form sulphur is a yellow crystalline solid. In nature it occurs as the pure element or as sulfide and sulfate minerals. Sulphur occurs in volcanic and sedimentary deposits, as well as being a constituent of many minerals and petroleum. It is normally a bright yellow crystalline solid, but several other allotropic forms can be made. Sulphur is an ingredient of gunpowder, and is used in making matches and as an antiseptic and fungicide. Rice (*Oryza sativa*), edible starchy cereal grain and the grass plant (family Poaceae) by which it is produced. Roughly one-half of the world population, including virtually all of East and South east Asia, is wholly dependent upon rice as a staple food,95 percent of the world's rice crop is eaten by humans. Rice is cooked by boiling, or it can be ground into a flour. It is eaten alone and in a great variety of soups, side dishes, and main dishes in Asian, Middle Eastern, and many other cuisines. Other products in which rice is used are breakfast cereals, noodles, and such alcoholic beverages as Japanese sake.

Keywords: Sulphur, methionine, cysteine, cysteine, Bentonite-S, compex-ferrodoxin, sulphur glycosides and coenzyme-A.

Introduction

Sulfur is now recognized as the fourth essential plant nutrient after nitrogen (N), phosphorus (P), and potassium (K) (Morris, 2007) [11] and crop responses to sulfur (S) have been reported from several parts of the world: United States of America (USA) (Mitchell and Mullins, 1990; Thompson *et al*., 2007, 2008) [10, 26, 25], Canada (Malhi *et al*. 2012) [7], Europe (Messick, 2003; Rathke *et al*., 2005; Jarvan *et al*., 2008; Gallejones *et al*., 2012; Zhao *et al*., 1999a; Zhao *et al*., 1999b) [8, 18, 6, 5, 28, 29], Central America (Raun and Baretto, 1992) [19], China (Messick, 2003) [8], India (Biswas *et al*., 2004) [3], and Pakistan (Rashid *et al*., 1992) [17]. About 42% of Indian soils are deficient in S (Singh, 2001) [23] and a good response of rice to S has been reported (Prasad, 2005) [12]. In 53 out of 85 on-farm trials in India under the TSI/FAI/IFA Project, rice yield increase due to S application was 25% or more above baseline. (Tewatia *et al*., 2007). Response of rice is expected both under flooded as well as under alternate wet and dry conditions. Sulfur availability may be more in aerobic rice systems (Prasad, 2011). In China, more than 30% soils are deficient in S and S application is recommended for cereals at 20-40 kg ha^{-1}. The causes of increasing S deficiency include: i) Use of high analysis fertilizers, such as, urea in place of ammonium sulfate and ammonium phosphates in place of ordinary super phosphate (OSP); ii) Increased crop uptake due to increased area under high yielding varieties; iii) Increased intensity of cropping in several Asian and African countries (Prasad and Power, 1997) [13]

Rice (*Oryza sativa* L.), belonging to the family Poaceae (Gramineae) is the most staple food crop of the world. It is the rich source of energy that contains reasonable amount of protein (6-10%), carbohydrate (70-80%), mineral (1.2-2.0%) and vitamins. More than 90 per cent of the world's rice is grown and consumed in Asia (rice bowl of the world), where 16 per cent of the earth's people and two third of world's poor. According to (FAO 2014) global statistically data, the worldwide production of rice 719.74 million tonnes with acreage of 160.6 mha of production of 475.5 mt. In India it is cultivated over an area of about 43.9 mha with an annual production 106.10 mt (Anonymous 2015) [2]. Uttar Pradesh is the largest rice growing state after west Bengal where it is grown over an area of 5.964 mha and production of 12.91 mt with 1862 kg ha-1 average productivity. The present situations indicate that our population would be 1.5 billion (of the world population of 11 billion) by2050. Rising population and per capita increase are pushing up the demand, which needs to be met through enhanced productivity per unit area, input and time. The annual increase in demand in India is estimated to be 2.6 millions tones in rice. The 10th plan has targeted growth rate of 4% plus in agriculture. This demands a concerted material effort considering that the food grain growth rate was only 1.95 per cent during the 10th plan. Sulphur has vital metabolic function in plants; it is required for synthesis in the form of sulphur containing amino acids (cystine, Cystein and methionine) i.e. essential components of proteins. Sulphur is absorbed by plants in the form of sulphate (SO4 2-) ion. Sulphur is an fourth essential plant nutrient after N, P and K and the third most widely deficient nutrient (Tondon, 2011) [26]. It plays pivotal role in oil and protein synthesis. Besides its contribution in greater proportion in synthesis of sulphur containing amino acid i.e. (methionine, cysteine and cystine), vitamins like thiamine and biotin, iron-sulphur protein compex-ferrodoxin, sulphur glycosides and coenzyme-A. About 2 per cent of the organic sulphur in the plant is present in the water-soluble thiol (-SH) fraction, and under normal conditions tripeptide glutathione accounts nearly for more than 90% of this fraction. Sulphur requirement for optimal growth varies between 0.1 and 0.5% on dry weight basis of plants and its relative requirement increases in the order of graminae <cruciferae.

Sources of sulfur

Sources of sulfur did not differ significantly in respect of panicle length, grain and straw yield, S content in grain and S harvest Index. Leaf area index (LAI) was the highest with Bentonite- S, followed by single superphosphate (SSP), gypsum and elemental S. Bentonite-S also gave the tallest plants at 75 days after sowing and at harvest (Table 1). At 75 days after sowing Bentonite-S, gypsum and SSP were at par and Bentonite-S produced significantly taller plants than elemental S. At harvest Bentonite-S was at par with SSP and produced significantly taller plants than elemental S. Effective tillers, grains panicle−1, and 1,000 grain weight were the highest with Bentonite-S, significantly more than other S sources (Table 1). Bentonite-S and SSP were at par and recorded significantly more S concentration and uptake in straw, S uptake in grain and total S uptake by rice (Table 2), nitrogen and crude protein concentration in grain and nitrogen uptake in grain and straw and significantly more than gypsum and elemental S (Table 3). In the case of nitrogen concentration and uptake by straw, Bentonite-S recorded significantly higher values than other three sources. With regards to AE, Bentonite-S, SSP, and gypsum were at par and significantly superior to elemental S, while in the case of CRE, Bentonite-S was significantly better than other three sources of S (Table 2). Different sulfur sources did not influence significantly the N:S ratio in rice grain (Table 3). Thus, in general, Bentonite-S was better than gypsum, SSP and elemental S for most growth characters, yield attributes, N and S concentration and uptake but these advantages did not show up in grain yield of rice (Yashbir Singh Shivay, IARI)

Results and discussion

Table 1: Effect of sulphur on plant height (cm) at different phenological stages

Treatments	Tillering	PI Stage	Anthesis	Maturity
S1(0kg)	47.2	57.6	76.3	81.2
S2(20kg)	49.4	61.0	83.5	91.6
S3(30kg)	52.3	68.4	88.7	95.6
S4(40kg)	53.8	70.8	92.6	97.3

Anil Kumar Singh, ICAR (2012) [1]

Table 2: Effect of sulphur and zinc nutrition on yield attributes and yields of rice

Treatments	Panicle/M2	Grains/panicle	Above Biomass (t/ha)	Grain (t/ha)	HI (%)	1000 seed (g)
S1(0kg)	271.4	191.8	17.23	7.23	0.41	15.9
S2(20kg)	287.9	199.5	17.57	7.38	0.42	16.0
S3(30kg)	303.6	204.9	17.71	7.44	0.42	15.9
S4(40kg)	300.1	205.6	18.32	7.43	0.41	16.0

Anil Kumar Singh, ICAR (2012) [1]

Table 3: Effect of sulphur on concentrations in rice grain and straw, Sulphur uptake in rice grain and straw and total uptake in rice.

Treatments	S concentration in rice grain	S uptake in rice grain	S uptake in rice straw	TotalSulphur uptake in rice
S1(0 kg)	0.12	4.90	9.36	14.26
S2(15 kg)	0.14	6.41	14.05	20.46
S3(30 kg)	0.15	7.35	16.37	23.72
S4 (45 kg)	0.16	8.40	19.26	27.66
SE±	0.0008	0.04	0.32	0.29
LSD(P=0.05)	0.0028	0.13	1.09	1.01

Yashbir singh shivay, IARI (2014) [27]

Discussion

Rice responses to added minerals i.e. sulphur were observed and recorded during all the growth and development stages. Stature of plant leads to structure and capacity to capture sun light to assimilate photosynthate by virtues of more leaves. As a plant grows taller there are better possibilities to have more number of effective’s leaves. Sulphur are known for precursor of growth as they play greater and crucial role during early phase of plant life.; Sulphur had significant influenced on concentration and uptake as they plays important role in growth and development. Both nutrients plays identical role in case of nitrogen content and uptake. PI Stage is onset of reproductive stage with full of green foliage, during this stage accelerated assimilation of photosynthate is utmost required, hence, plant height were notice highest at PI stages at all the level of sulphur and zinc as compare to other stages. Significant build ups in the soils were notice in case of sulphur which was initially low, become sufficient due to continuous addition to the soil. Improvement in fertility status leads to improvement in productivity status of the experimental plot (Sahaa *et al*., 2007; Muthukumararaja & Sriramachandrasekharan, 2012; Singh *et al*., 2011) [20, 11]. Sulphur played crucial role in diversion of photosynthate towards the shoot at every growth stages and marked variation was noticed at PI and maturity stages. It indicate role of sulphur is much more in signaling process of photosynthate especially after onset of reproductive stages (Rahamn *et al*., 2008; Charati & Malakouti, 2006) [14, 4]. Maximum 90.2% diversion of assimilation towards shoot portion was noticed in the plots treated with 40 kg sulphur at maturity. Randall *et al*. (2003) [16] reported a positive relationship between grain yield and sulfur concentration in rice grain due to sulfur fertilization. Total S uptake increased from 14.26 to 27.66 kg ha−1 as the level of S application was increased from 0 to 45 kg ha−1. Increases in S uptake due to S application were reported by Sarkar *et al*. (2007) [21].

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