International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 2556-2560

Received: 04-09-2018
Accepted: 08-10-2018

A Sangwan
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Kuldeep Singh
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

PS Sangwan
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

RP Sasanwal
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

BS Duhan
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Correspondence
A Sangwan
Dept. of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Effect of different sources of sulphur on micronutrient concentration and uptake by wheat

A Sangwan, Kuldeep Singh, PS Sangwan, RP Sasanwal and BS Duhan

Abstract

A pot experiment was conducted at Choudhary Charan singh Haryana Agricultural University to study the effect of different sources of sulphur on micronutrient concentration and uptake by wheat. Various levels of sulphur significantly increased zinc content in grain over control. The increase in zinc content was more pronounced at highest level of sulphur as compared to lower levels. The increase was 5.0, 8.5 and 10.6 per cent over control at 20, 40 and 60 mg/kg sulphur application, respectively. The maximum uptake (558.07 µg/pot) was observed at highest level and the magnitude of increase was 18.8, 27.2 and 33.0 µg/pot at 20, 40 and 60 mg/kg sulphur application over control (419.28 µg/pot).

The copper concentration in grain significantly increased with increasing level of sulphur over control (6.82%). The gradual increase of sulphur from 20 to 40 and 40 to 60 mg/kg also resulted in significant increase in uptake of copper. With regard to various sources of sulphur, the copper uptake in grain was found to be significantly at par. The concentration of manganese in grain also increased significantly with graded dose of sulphur application over control (83.53%). The uptake of manganese in grain was also influenced significantly with respect to various level of sulphur over control (632.50 µg/pot) recording maximum (817.45 µg/pot) at highest level i.e. 60 mg/kg sulphur application. In grain, the iron content also increased significantly with respect to different doses of sulphur and this increased was 4.2, 6.4 and 10.6 per cent at 20, 40 and 60 mg/kg sulphur application over control (97.39%). Uptake of iron by wheat grain was found to be positively and significantly increased with increasing level of sulphur. The increase was 17.9, 25.0 and 33.0 per cent at 20, 40 and 60 mg/kg sulphur application, respectively over control.

Keywords: micronutrient, wheat, sulphur and uptake

Introduction

Sulphur (S), one of the most important nutrients for all plants and animals, is considered as the fourth major nutrient after nitrogen, phosphorous and potassium for agricultural crop production. Sulphur is a structural constituent of organic compounds, some of which are uniquely synthesized by plants, providing human and animals with essential amino acids (methionine cystine and cysteine). It is involved in chlorophyll formation, activation of enzymes and is a part of vitamins biotin and thiamine (B_1) (Hegde and Sudhakara babu, 2007) [3]. There are many other sulphur containing compounds in plants which are not essential, but may be involved in defense mechanisms against herbivores, pest and pathogens, or contribute to the special taste and odour of food plants. Sulphur improves oil and protein contents, flour quality for milling and baking, quality of tobacco and nutritive value of forages, etc. The efficiency of sulphur sources for various crops have been found different in upland and water logged conditions. The use of cheap sulphur sources like gypsum and pyrites have attracted the attention during last two decades. Although the information on agronomic efficiency of these sources is available for few crops in selected areas, however, their efficiency need to be verified under different agroclimatic conditions and different types of crops and soils. Therefore, the study becomes more important for those areas which are deficient in sulphur. Soils of south western districts of Haryana are sandy in texture with organic carbon less than 0.2 per cent and marginal in available sulphur, therefore, sulphur application in these areas is essential. In addition to the crop responses to sulphur application in different crops, the information on leaching behavior of sulphur in different soils is limited, particularly under field conditions in presence of standing crops. Sulphur is leached in soils as sulphate due to its anionic nature and solubility of its common salts. The leaching loss of sulphate is generally high in light textured soils. Distribution of different forms of sulphur and their interrelationship with some important soil characteristics decide the sulphur supplying power of a soil by influencing its release and dynamics in soils. Several soil factors influence the availability of sulphur and hence the status of different forms of sulphur in soils varies widely with soil type. Transformation/mineralization of sulphur in soil is another important aspect of sulphur availability and supply to the crops. Sulphur transformation is a bio-chemical reaction carried out by the micro-organisms present in the soil. Apart from the micro-organisms mineralization and transformation is influenced by many factors such as soil texture, structure, moisture content, temperature etc. Information regarding the transformation and mineralization of sulphur is very meagre in literature. Therefore, effects of these factors like organic matter and source of sulphur on sulphur transformation and mineralization need to be studied in more detail. When S is applied in the soil either through fertilizers or added incidentally it undergoes many chemical changes, and micro-organism are involved in the principle transformations. Organic form present in soils gets mineralized into inorganic ones. Transformation of S depends on many factors such as moisture content, aeration, temperature, pH, amount and nature of organic matter, soil type and time of reaction.

Wheat (*Triticum aestivum* L.), which triggered Green revolution in the Indian subcontinent, is an important food grain providing nourishment nearly to 35 per cent people of the world. On global scale, the crop is grown over an area of 211.06 million ha with a production of 566.8 million tonnes. India is the second largest producer of wheat in the world next only to China and the crop has provided the fastest pace of growth to Indian agriculture. Among cereals, wheat is next to rice in area (24.23 million ha) and production (75.6 million tonnes) (Jagshoran *et al.*, 2004). Wheat contributes about 60 per cent of daily protein requirement and more calories to world diet than any other food crop (Mattern *et al*., 1970) [5]. As main staple food, wheat continues to assume greater significance in the years to come both from grain productivity as well as quality point of view. Providing required quantity of quality grains to the growing population is an ever lasting challenge to the researchers. India will have to produce 105 million tonnes of wheat by 2020. To sustain productivity, integrated nutrient management must be followed and for this, the study of interaction of different nutrients with organic manure becomes essential. So far, there have been many studies on interaction of major element like nitrogen and phosphorus with the different organic manures but the information on interaction between sulphur and organic manure is scanty. It is considered that the presence of organic material improves the transformation of elemental sulphur as well as availability of native and applied sulphur.

Materials and Methods

Collection and processing of soil samples

Bulk surface sandy soil samples (0-15 cm) was collected from village Balsamand, district Hisar. The soil sample was air dried ground and passed through 2 mm sieve. After mixing thoroughly, the soil was used for laboratory and screen house studies. The physico-chemical properties of soil are presented in Table 1.

Collection and processing of organic manures

Farm yard manure, poultry manure, pressmud, vermicompost was collected from Department of Agronomy, CCS Haryana Agricultural University, Hisar. It was first air dried at room temperature then ground and passed through 2 mm sieve before use.

Sulphur level : 0, 20, 40 and 60 mg kg^{-1} soil

Sulphur sources : (a) Elemental sulphur, (b) Gypsum, (c) Potassium sulphate (d) Pyrite

Table 1: Physico-chemical properties of the soil

Characteristics	Value
Texture	Sandy
Sand (%)	70.10
Silt (%)	17.80
Clay (%)	12.10
$CaCO_3$ (%)	0.40
pH (1:2)	8.11
$EC_{1:2}$ (dSm^{-1})	0.50
Organic C (%)	0.20
Available N (mg kg^{-1})	50.10
Available P (mg kg^{-1})	15.01
Available K (mg kg^{-1})	125.60
Available S (mg kg^{-1})	6.00
Available Zn (mg kg^{-1})	0.52
Available Mn (mg kg^{-1})	6.80
Available Cu (mg kg^{-1})	0.47
Available Fe (mg kg^{-1})	9.10

Imposition of treatments

To accomplish the objectives of the study, a screen house experiment was conducted in pots. Five kg air dried soil was spread on polyethylene sheet and required amount of either fertilizer, organic manure or in combinations as per above schedule were applied and thoroughly mixed. Half of nitrogen was applied through urea solution at the time of sowing and another half was applied 21 days after sowing. A basal dose of P, K and Zn @ 60, 75 and 25 mg kg^{-1} soil was added through potassium dihydrogen orthophosphate and Zn SO_4 $7H_2O$ solutions.

Sowing of wheat crop

Before sowing of wheat crop about 200g of soil was removed from each pot. The pot was irrigated with one litre of deionized water. On disappearance of free water from the surface, 10 seeds of wheat were placed eight in circle and two in centre of the pot. Then, these seeds were covered by spreading 200g of soil. Therefore, the pots were covered with newspaper to prevent drying out of soil. After 12 days, five plants in each pot were maintained. Intercultural operations and irrigation with deionized water were done as and when requires.

Harvesting and threshing

Crop was harvested at maturity. The plants were thoroughly washed with distilled water. The excess of water was removed by gentle shaking and pressing between two filter papers and then dried in oven at 50 ^{0}C. The grains and straw was separated and weighed separately from each pot.

Preparation of plant samples

The grains and straw were ground in willey mill using stainless steel sieve. Each sample was mixed thoroughly after grinding and stored in polythene bags. Then these samples were analyzed for micronutrients in laboratory by following standard procedures.

Postharvest soil sampling

After harvesting the crop, one litre of distilled water was added to ach pot. When the surface of the pot appeared to be moist, a representative soil sample were taken and air dried, ground an passed through two mm sieve and stored in bags with proper numbers for further analysis.

C. Statistical analysis

All the experimental data was statistically analyzed by the method of analysis of variance (ANNOVA) as described by Panse and Shukhatme (1985). The significance of treatment effects were putted with the help of 'F' test and to judge the significance of difference between means of two treatments and critical differences (CD) were worked out as described by Cochran and Cox (1963).

Results and Discussion

Micronutrient concentration and uptake

Zinc:

A perusal of data (Table 1) showed that various level of sulphur significantly increased zinc content in grain over control (54.58%). The increase in zinc content was more pronounced at highest level of sulphur as compared to lower levels. The increase was 5.0, 8.5 and 10.6 per cent over control at 20, 40 and 60 mg/kg sulphur application, rspectivley. The successive level of sulphur from 20 to 40 mg/kg and 40 to 60 mg/kg also increased the zinc content significantly with regard to various levels of sulphur. It was observed that the zinc content under treatment of elemental sulphur, gypsum and pyrite was significantly at par whereas, potassium sulphate as a source of sulphur increased the zinc content significantly as compared to other sources of sulphur. The interaction between both sulphur levels and sources were found to be non-significant. The zinc content in grain was observed to be less as compared to straw. More or less similar trend with respect to zinc content was observed in case of straw.

The uptake of zinc in grain also increased significantly with increasing sulphur levels. The maximum uptake (558.07 µg/pot) was observed at highest level and the magnitude of increase was 18.8, 27.2 and 33.0 µg/pot at 20, 40 and 60 mg/kg sulphur application over control (419.28 µg/pot).

The zinc uptake also found to be increased significantly within two successive levels of sulphur i.e. 20 to 40 and 40 to 60 mg/kg sulphur application. Within various sources of sulphur it was found that sulphur as a source of elemental sulphur, gypsum and potassium sulphate increased the zinc uptake significantly over pyrite. The maximum (584.91 µg/pot) zinc uptake was recorded when potassium sulphate used as a source of sulphur followed by elemental sulphur and gypsum. The least zinc uptake (492.6 µg/pot) was observed under the treatment of pyrite and the interaction between sulphur levels and sources was found to be non-significant (Table 2). In case of straw, similar behaviour was observed with regard to zinc content.

Table 1.1: Effect of different sources and levels of sulphur on zinc content (%) in wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	53.91	54.72	54.87	54.81	54.58
20	57.10	56.31	58.01	57.93	57.34
40	59.23	58.63	59.83	58.21	59.23
60	60.31	60.72	61.21	59.20	60.36
Mean	57.64	57.60	58.48	57.31	
CD (p=0.05) Sulphur levels and Sulphur sources = 0.73 Sulphur levels × Sulphur sources = NS					
Straw					
0	33.11	33.87	33.01	33.18	33.29
20	37.03	37.16	37.09	36.97	37.06
40	41.17	40.12	41.23	40.99	40.88
60	46.02	46.13	46.27	46.13	46.14
Mean	39.33	39.32	39.40	39.32	
CD (p=0.05) Sulphur levels and Sulphur sources = 1.31 Sulphur levels × Sulphur sources = NS					

Table 2: Effect of different sources and levels of sulphur on zinc uptake (µg/pot) by wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	415.64	422.43	417.01	422.03	419.28
20	496.77	488.77	512.80	494.72	498.27
40	531.88	525.91	558.82	516.90	533.38
60	555.45	554.98	584.91	536.94	558.07
Mean	499.9	498.0	518.4	492.6	
CD (p=0.05) Sulphur levels and Sulphur sources = 2.45 Sulphur levels × Sulphur sources = NS					
Straw					
0	376.12	484.08	374.33	376.59	402.78
20	467.68	467.47	471.41	463.23	467.45
40	565.67	549.24	570.21	559.10	561.06
60	677.87	677.18	685.25	673.95	678.56
Mean	521.80	544.50	525.30	518.20	
CD (p=0.05) Sulphur levels and Sulphur sources = 21.41 Sulphur levels × Sulphur sources = 42.44					

Copper

The copper concentration in grain significantly increased with increasing level of sulphur over control (6.82%). This significant increased in copper content was also observed in 60 mg/kg sulphur application when compared with 20 mg/kg sulphur application. The increase was 14.8, 27.8 and 36.5 per cent over control (6.82%) at 20, 40 and 60 mg/kg sulphur application, respectively (Table 3).

The effect of various sources of sulphur resulted in significant increase in copper content however maximum value was observed under the treatment of elemental sulphur closely followed by pyrite. The content of copper was found to be least when potassium sulphate was used as source of sulphur. Non-significant interaction was observed between sulphur levels and various sources of sulphur.

Similar trend of copper content was observed in wheat straw except that there was significant increase between each successive level of sulphur application. There was no significant improvement in its content with respect to various sources of sulphur and the interaction between level and sources of sulphur was found to be non-significant. The data presented in Table 4 showed significant improvement in copper uptake by grain. The gradual increase of sulphur from 20 to 40 and 40 to 60 mg/kg also resulted in significant increase in uptake of copper. With regard to various sources of sulphur, the copper uptake in grain was found to be significantly at par.

In case of straw, there was not much variation in copper uptake and found to be significantly at par. The concentration of copper and its uptake was found higher in grain as compared to straw.

Table 3: Effect of different sources and levels of sulphur on copper content (%) in wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	6.89	6.75	6.83	6.81	6.82
20	7.82	7.84	7.81	7.84	7.83
40	8.86	8.69	8.54	8.78	8.72
60	9.37	9.37	9.09	9.40	9.31
Mean	8.24	8.16	8.07	8.21	
CD (p=0.05) Sulphur levels and Sulphur sources = 0.18 Sulphur levels × Sulphur sources = 0.25					
Straw					
0	4.50	4.50	4.52	4.50	4.51
20	4.80	4.77	4.79	4.77	4.78
40	5.02	5.04	5.04	5.02	5.03
60	5.44	5.46	5.47	5.47	5.45
Mean	4.94	4.94	4.93	4.95	
CD (p=0.05) Sulphur levels and Sulphur sources = 0.14 Sulphur levels × Sulphur sources = 0.19					

Table 4: Effect of different sources and levels of sulphur on copper uptake (μg/pot) by wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	53.12	52.11	51.90	52.43	52.39
20	68.08	68.10	69.12	67.01	68.08
40	79.63	78.03	79.35	78.01	78.76
60	86.32	85.67	87.01	85.34	86.09
Mean	71.80	71.00	71.80	70.70	
CD (p=0.05) Sulphur levels and Sulphur sources = 3.7 Sulphur levels × Sulphur sources = NS					
Straw					
0	51.12	51.09	51.25	51.30	51.19
20	60.17	60.06	60.88	59.76	60.22
40	69.02	69.01	69.70	68.47	69.05
60	80.19	80.11	81.01	79.18	80.12
Mean	65.10	65.10	65.70	64.70	
CD (p=0.05) Sulphur levels and Sulphur sources = 2.33 Sulphur levels × Sulphur sources = NS					

Manganese

The concentration of manganese in grain also increased significantly with graded dose of sulphur application over control (83.53%). It was further observed that manganese concentration increased significantly when the dose of sulphur increased from 20 to 40 mg/kg however further increased from 40 to 60 mg/kg sulphur did not influence manganese content significantly. The increase in manganese content was 3.6, 6.1 and 6.2 per cent at 20, 40 and 60 mg/kg sulphur application over control (Table 5). Amongst various sources of sulphur, the increased in manganese content was found to be significantly at par. The interaction between sulphur level and its sources was observed to be non-significant. Manganese concentration in straw also followed the same trend as it was observed in case of grain.

Table 5: Effect of different sources and levels of sulphur on manganese content (%) in wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	83.92	83.19	83.72	83.29	83.53
20	85.87	86.98	86.77	86.76	86.60
40	88.23	88.39	88.43	89.54	88.65
60	88.98	88.73	88.88	86.98	88.69
Mean	86.75	86.82	86.95	86.64	
CD (p=0.05) Sulphur levels and Sulphur sources = 1.81 Sulphur levels × Sulphur sources = NS					
Straw					
0	42.91	42.77	42.96	42.99	42.91
20	46.71	45.78	46.76	47.76	46.62
40	49.45	46.83	45.98	48.45	47.68
60	47.83	48.88	48.77	47.39	48.22
Mean	46.59	46.07	46.12	46.65	
CD (p=0.05) Sulphur levels and Sulphur sources = 1.11 Sulphur levels × Sulphur sources = NS					

The uptake of manganese in grain was also influenced significantly with respect to various level of sulphur over control (632.50 μg/pot) recording maximum (817.45 μg/pot) at highest level i.e. 60 mg/kg sulphur application. It was further observed that manganese uptake did not vary significantly between any two successive levels of sulphur application.

The magnitude of increase was 8.9, 26.5 and 29.2 per cent at 20, 40 and 60 mg/kg sulphur application respectively over control. There was no significant improvement in manganese uptake amongst various sources of sulphur. However, maximum (850.58 μg/pot) manganese uptake was observed in potassium sulphate treatment. The interaction between sulphur levels and its sources was observed to be insignificant (Table 6).

More or less similar trend was observed in case of wheat straw with regard to manganese uptake except that there was significant improvement in manganese uptake between any two successive levels of sulphur application.

Table 6: Effect of different sources and levels of sulphur on manganese uptake (μg/pot) by wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	647.02	642.22	599.43	641.33	632.50
20	747.06	754.98	767.04	740.93	752.50
40	792.30	792.85	821.51	795.11	800.44
60	819.50	810.99	850.58	788.72	817.45
Mean	751.50	750.30	759.60	741.50	
CD (p=0.05) Sulphur levels and Sulphur sources = 67.34 Sulphur levels × Sulphur sources = NS					
Straw					
0	487.45	485.01	487.16	487.93	486.89
20	583.12	575.91	594.31	598.43	587.94
40	679.44	641.10	635.90	660.85	654.32
60	704.53	717.06	722.28	692.36	709.06
Mean	613.60	604.80	609.90	609.90	
CD (p=0.05) Sulphur levels and Sulphur sources = 21.42 Sulphur levels × Sulphur sources = NS					

Iron

In grain, the iron content also increased significantly with respect to different doses of sulphur (Table 7) and this increased was 4.2, 6.4 and 10.6 per cent at 20, 40 and 60 mg/kg sulphur application over control (97.39%). It was further observed that the increase in sulphur dose from 20 to 40 mg/kg didn't increase iron content however the increase was significant with further increasing of dose of sulphur from 40 to 60 mg/kg. No significant interaction was recorded between sulphur level and its sources.

Similar trend with respect to levels of sulphur and it sources was observed in respect of iron content in wheat straw with the exception that content of iron varied significantly within levels of sulphur.

Table 7: Effect of different sources and levels of sulphur on iron content (%) in wheat grain and straw

Sulphur levels (mg/kg)	Grain				
	Sulphur sources				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	97.44	97.12	97.78	97.23	97.39
20	101.32	100.21	100.45	104.20	101.55
40	103.32	102.46	102.99	105.60	103.59
60	107.65	106.23	105.69	111.50	107.77
Mean	102.43	101.51	101.73	104.63	
CD (p=0.05) Sulphur levels and Sulphur sources = 2.66 Sulphur levels × Sulphur sources = NS					
Straw					
0	126.91	126.97	126.93	126.98	126.95
20	134.45	132.31	133.87	141.99	135.66
40	140.79	139.46	141.46	149.47	142.80
60	143.91	143.01	143.77	152.87	145.89
Mean	136.52	135.44	136.51	142.83	
CD (p=0.05) Sulphur levels and Sulphur sources = 1.82 Sulphur levels × Sulphur sources = NS					

Uptake of iron by wheat grain was found to be positively and significantly increased with increasing level of sulphur. The increase was 17.9, 25.0 and 33.0 per cent at 20, 40 and 60 mg/kg sulphur application, respectively over control.

It was further observed that with each increment of sulphur dose, the uptake of iron increased significantly (Table 8). No significant improvement in uptake of iron was recorded to various sources of sulphur. However, maximum (1008.38 µg/pot) uptake of iron was noticed under the treatment of potassium sulphate followed by pyrite. The iron uptake was recorded minimum in case of gypsum. The uptake of iron in straw also showed similar trend as it was observed in wheat grain. Phogat *et al.* (2004) [7] found that the total productivity of rice-wheat system increased significantly with green manure and FYM compared to control, and with FYM over green manure in all the years. In a study, Debtanu and Das (2005) [2] obtained highest grain yield of rice and wheat (4.25 and 4.78 t ha^{-1}) with NPK + Zn + FYM + S treatment. Tufemkci *et al.,* (2005) [8] reported that in chickpea grown under green house conditions, application of 80 mg S kg^{-1} resulted in increased uptake of Zn, Cu, Fe and Mn but decreased the concentration of Ca and Mg in the plant tissues. Islam *et al.* (2009) [9] while studying the effect of integrated application of phosphorus and sulphur on yield and micronutrient uptake by chickpea (*Cicer arietinum*) reported almost similar observations regarding effect of S application on various micronutrients content and their uptake. On a sandy loam soil in Kanpur, Niranjan and Singh (2005) [6] observed that the application of various organic sources and inorganic fertilizers significantly increased the grain yield of rice and wheat. The highest grain yield was recorded with green manure, followed by FYM. Similar observations have also been made by Chaudhary and Thakur (2007) [1].

Table 8: Effect of different sources and levels of sulphur on iron uptake (µg/pot) by wheat grain and straw

Sulphur levels (mg/kg)	Sulphur sources				
	Grain				
	Elemental sulphur	Gypsum	Potassium sulphate	Pyrite	Mean
0	751.26	749.76	743.12	748.67	748.20
20	881.48	869.82	887.97	889.86	882.28
40	927.81	919.06	956.77	937.72	935.34
60	991.45	970.94	1008.28	1011.30	995.49
Mean	888.00	877.40	899.00	896.90	
CD (p=0.05) Sulphur levels and Sulphur sources = 51.02 Sulphur levels × Sulphur sources = NS					
Straw					
0	1441.69	1439.83	1439.38	1441.22	1440.53
20	1698.10	1664.45	1701.48	1779.13	1710.79
40	1934.43	1909.20	1956.39	2038.77	1959.70
60	2119.79	2097.95	2129.23	2233.43	2145.10
Mean	1798.50	1777.90	1806.60	1873.10	
CD (p=0.05) Sulphur levels and Sulphur sources = 95.30 Sulphur levels × Sulphur sources = NS					

References

1. Chaudhary SK, Thakur RB. Efficient farm yard manure management for sustained productivity of rice-wheat cropping system. Ind. J. Agri. Sci. 2007; 77:443-444.
2. Debtanu M, Das DK. Influence of manures and fertilizers on the yield and fertility build up of soil under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) irrigated ecosystem. Ind. J. Agri. Sci. 2005; 75(6):343-345.
3. Hegde DM, Sudhakara Babu SN. Correcting sulphur deficiencies in soils and crops. Indian J Fert. 2007; 3(1):65-79.
4. Islam M, Ali S, Hayat R. Effect of Integrated Application of Phosphorus and Sulphur on Yield and Micronutrient Uptake by Chickpea (*Cicer arietinum*). Int. J Agri. and Bio. 2009; 11(1):33-38.
5. Mattern PPJ, Schmidt JW, Johnson VA. Screening for high lysine content in wheat. Cereal Sci. Today. 1970; 15:409.
6. Niranjan RK, Singh B. Effect of organic and inorganic fertilizers on yield and uptake of rice and their residual response on wheat crop. Farm Sci. J. 2005; 14(2):23-24.
7. Phogat SB, Dahiya IS, Hooda RS, Sangwan NK, Solanki YPS. Studies on residual effect of green manuring and farmyard manure for sustained productivity of rice-wheat cropping sequence and on soil health under shallow ground water table conditions. Annals of Biology. 2004; 20:161-165.
8. Tufemkci S, Somnez F, Sensoy RIG. Effects of Arbuscular mycorrhiza fungus inoculation and sulphur and nitrogen fertilization on some plant growth parameters and nutrient contents of chickpea. J Biol. Sci. 2005; 5:738-743.