INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

IJPAES

Volume-6, Issue-2, April-June-2016 Coden: IJPAJX-CAS-USA, Copyrights@2016 ISSN-2231-4490

Received: 8th Feb-2016 *Revised: 25th Feb 2016* *Accepted: 25th Feb 2016*

Research article

EFFICIENCY OF SULPHUR SOURCE ON SESAME (*Sesamum indicum* L.) IN RED AND LATERITIC SOIL OF WEST BENGAL

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ABSTRACT: A field experiment was conducted to study the efficiency of sulphur source on Sesame (*sesamum indicum* L.) in red and lateritic soil of West Bengal with increasing levels of sulphur (0, 20, 40, 60 and 80 kg ha^{-1}) from three sources, namely, gypsum, magnesium sulphate and single super phosphate. Soil samples were analyzed for available-N, P, K, S and pH. Leaf chlorophyll content was estimated before and after flowering stage. Plant samples were analyzed for dry matter yield, grain yield, oil content and contents and uptake of nutrients *viz*., N, P, K and S. The stover yield of sesame was found to increase significantly with application of sulphur up to 20 kg ha^{-1}. Maximum seed yield was obtained with the application of sulphur @ 40 kg ha^{-1} as magnesium sulphate. Sulphur application increased oil content significantly irrespective of its sources up to 40 kg ha^{-1}. Oil yield was also increased with sulphur application up to 40 kg ha^{-1}. Chlorophyll content of leaves before flowering was increased due to application of magnesium sulphate only. After flowering, sulphur application in increased rates resulted in increased leaf chlorophyll content. Sulphur application from all the sources reduced nitrogen concentration in stover. Sulphur application increased p, K and S content in stover. Nitrogen content in seeds was increased with sulphur application @ 20 kg ha^{-1}. Sulphur application resulted in increased phosphorus content in grains and gypsum was found to be most efficient in increasing phosphorus content in grains. Potassium content in seed was also increased with increasing sulphur application irrespective of the sources. Sulphur content in seeds was decreased with sulphur application. The uptake values of nutrients were in accordance with seed and stover yields and their contents at different levels of those nutrients. There was an increase in crude protein content with application of sulphur @ 20 kg ha^{-1}.

Key words: Sesame, Source, level, Sulphur

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INTRODUCTION

In oilseeds, sulphur plays a significant role in the quality and development of seeds. Therefore, crops of oilseeds require a higher quantity of sulphur for proper growth and development for higher yields [1]. Among the oil crops, sesame (Sesamum indicum L.) has the highest oil content of 46 - 64% [2]. Since India is a net importer of sulphur for manufacturing some of the important nitrogenous, phosphatic and potassic fertilisers, alternative sulphur supply strategies must emphasize the use of indigenous sources of sulphur, the most dependable and cheaper such as magnesium sulphate and phosphogypsum. On the other hand, phosphogypsum (16% S, 21% Ca and 0.2 – 1.2% P_2O_5) is the byproduct gypsum obtained during the manufacture of wet process phosphoric acid. Phosphogypsum can thus serve as the source of sulphur and calcium for plant growth like mineral gypsum. On the other hand, magnesium sulphate which is produced and used most commonly in India, is the Epsom salt, $MgSO_4 .7H_2O$ containing 16% MgO and 13% S.

Only recently, magnesium sulphate has been included in the Fertiliser Control Order and given due recognition as a fertilizer. As attention has not been paid so far on the utility of these indigenous sulphur sources to crops in acidic red and lateritic soils of this region, therefore, an attempt to examine critically the phosphogypsum vis-a-vis magnesium sulphate as sources of sulphur on yield and quality characters of sesame (*Sesamum indicum* L.) hopefully could contribute to future sulphur management strategies in these soils.

MATERIALS AND METHODS

The treatments comprised five levels of sulphur (0, 20, 40, 60 and 80 kg ha^{-1}) from three sources, namely, gypsum, magnesium sulphate and single super phosphate during summer season, 2012. The experimental design was factorial RBD. Recommended doses of NPK were applied in all the plots. After harvesting, soil samples were collected from each plot to analyze for available-N, P, K, S and organic carbon contents. After harvesting, dry matter yield, grain yield, oil content and contents of nutrients *viz*., N, P, K and S in plant samples were analyzed and the nutrient uptake was calculated on the basis of dry matter production in the plots. The crude protein content was calculated on the basis of total nitrogen content.

RESULTS AND DISCUSSION

The stover yield of sesame ranged from 2459 to 3332 kg ha^{-1} (table 1). Among the sources, the maximum stover yield was obtained with gypsum @ 80 kg S ha^{-1}. It is interesting to note that stover yield was found to increase significantly with application of sulphur. However, increasing sulphur levels from 20 to 80 kg ha^{-1} was not found to be significant.

The seed yield of sesame varied from 1060 to 1442 kg ha^{-1}. The minimum yield was recorded in control plots. It was found to increase significantly with the application of sulphur. Amongst the sources magnesium sulphate application resulted in highest yield. However, all the sources were at par in increasing yield of sesame. Maximum seed yield was obtained with the application of sulphur @ 40 kg ha^{-1}. Sulphur application beyond this level was not found to be effective in increasing seed yield.

The increase in yield due to application of sulphur may be due to better metabolism and increased efficiency of other nutrients. Sesame is mainly grown in India both under rain fed and irrigated conditions. Fertilizer is seldom used in sesame cultivation. From limited studies Tandon [3] calculated the range of yield response to S application which was found to vary from 9.8 to 32.7%. Tiwari [4] obtained 32.7% yield increase in alluvial soils of Uttar Pradesh from 30 kg S/ha application. Singh and Sahu [5] observed that when elemental S is applied 3 weeks before sowing followed by two sprayings of 0.1% H_2SO_4, significant increase in seed yield was obtained in rainfed sesame under Rajasthan conditions.

Oil content of sesame ranged between 30.23 and 40.69%. Sulphur application increased oil content significantly irrespective of its sources. Maximum oil content was found in plots receiving sulphur @ 40 kg ha^{-1}. Increasing sulphur application beyond this level could not increase the oil content.

Oil yield was also increased with sulphur application up to 40 kg ha^{-1}. Sulphur application @ 80 kg ha^{-1} resulted in decreased oil yield. All the sources were at par in increasing oil yield. Increased oil content and oil yield due to application of nitrogen and sulphur was also reported by Das and Das, [6]. This could be attributed to the influence of sulphur in rapid conversion of nitrogen to crude protein and finally to oil. The acetic thiolinase, a sulphur based enzyme in the presence of S convert acetyl Co-A to malonyl Co-A, rapidly resulting in higher oil content in seed crops [7].

There was an increase in crude protein content with application of sulphur @ 20 kg ha^{-1} over control. This may be due to the role of sulphur in protein formation. Raja *et al*, [2] also observed substantial increase in crude protein content with gypsum application which might be due to increased availability of sulphur for subsequent synthesis of oil and crude protein**.** This kind of interpretation is in consonance to the report of Chitkala and Reddy [8]. They observed that not only the total quantity of protein was improved by sulphur addition but at the same time the quality of protein was also improved. They observed that relative proportion of all sulphur containing amino acids, viz., methionine, cystine and cysteine increased significantly from 0 to 75 kg S ha^{-1}. This indicates that synthesis of these amino acids is impeded without supply of a prime element i.e., sulphur and stimulated rapid metabolism at a faster rate with successive higher levels applied. Tisdale et al. [9] mentioned that 50 to 80% of total sulphur in oilseed crops is used for synthesis of S-containing amino acids and rest is required for other S-containing compounds. However sulphur application above 20 kg ha^{-1} resulted in a decreased crude protein content which may be due to the dilution effect due to higher yield.

Nitrogen uptake by stover (Table 2) was increased significantly with sulphur application irrespective of its sources up to its highest level. The maximum nitrogen uptake was recorded in plots receiving sulphur @ 60 kg ha^{-1} as gypsum. Sulphur application up to its highest dose resulted in increased phosphorus uptake. Magnesium sulphate application @ 60 kg ha^{-1} resulted in maximum phosphorus uptake by stover of sesame. There was a significant response of sulphur in potassium uptake by sesame stover. It was increased from 5.241 kg ha^{-1} in control plots to 9.369 kg ha^{-1} in the plots receiving sulphur @ 80 kg ha^{-1}. Magnesium sulphate was most efficient in increasing potassium uptake compared to gypsum and SSP. Sulphur uptake was also increased with sulphur application. Sulphur responded significantly up to its highest level. All the sulphur sources were at par in increasing sulphur uptake. The uptake of sulphur by sesame grain was higher than stover. This might be due to the mobilization of sulphur from plant parts to grain. On the other hand, sulphur containing amino acids viz. cystine, cysteine and methionine, are the constituents of grain protein.

Table 1: Effect of sources and levels of sulphur on yield and oil and crude protein content

S level (kg/ha)	Stover yield (kg ha^{-1})	seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Oil content in seed (%)	crude protein Content in seed (%)
Gypsum					
0	1060	1060	321.8	30.23	9.963
20	1263	1263	473.0	37.40	11.332
40	1348	1348	548.6	40.30	11.023
60	1359	1359	520.9	38.32	10.490
80	1229	1229	467.7	37.87	11.083
Mean	1252	1252	466.4	36.82	10.778
Magnesium sulphate					
0	2459	1060	321.8	30.23	9.963
20	3272	1131	416.1	36.80	11.720
40	3240	1442	553.9	38.39	9.047
60	3227	1438	557.3	38.81	9.890
80	3313	1356	533.7	39.26	10.348
Mean	3102	1285	476.6	36.70	10.194
SSP					
0	2459	1060	321.8	30.23	9.963
20	3211	1366	554.0	40.60	11.025
40	3021	1436	584.3	40.69	11.340
60	3239	1342	480.7	35.72	10.908
80	3190	1181	444.9	37.75	9.835
Mean	3024	1277	477.1	37.00	10.614
Mean					
0	2459	1060	321.8	30.23	9.963
20	3117	1253	481.0	38.27	11.359
40	3173	1409	562.3	39.79	10.470
60	3263	1380	519.6	37.62	10.429
80	3279	1255	482.1	38.29	10.422
CD(P=0.05)	Source= NS Level=256 Source x Level=NS	Source= NS Level=94 Source x Level=NS	Source= NS Level=0.894 Source x Level=NS	Source= NS Level=2.92 Source x Level=NS	Source= NS Level=61.82 Source x Level=NS

Table 2: Effect of sources and levels of sulphur on nutrient uptake by stover

S level (kg/ha)	N uptake by stover (kg ha^{-1})	P uptake by stover (kg ha^{-1})	K uptake by stover (kg ha^{-1})	S uptake by stover (kg ha^{-1})
Gypsum				
0	7.300	3.987	5.241	2.030
20	9.181	4.521	8.513	2.553
40	8.891	5.814	7.069	2.961
60	10.455	5.263	9.248	2.902
80	9.481	5.745	8.335	3.021
Mean	9.062	5.066	7.681	2.693
Magnesium sulphate				
0	7.300	3.987	5.241	2.030
20	9.300	5.350	9.054	2.905
40	9.260	5.236	8.419	3.526
60	8.309	7.101	9.899	3.529
80	9.558	5.179	9.942	3.326
Mean	8.746	5.371	8.511	3.063
SSP				
0	7.268	3.987	5.241	2.030
20	9.597	6.670	8.400	3.799
40	9.574	5.459	8.450	2.746
60	10.351	4.002	7.397	3.542
80	10.298	6.062	9.830	4.370
Mean	9.417	5.236	7.864	3.298
Mean				
0	7.289	3.987	5.241	2.030
20	9.359	5.514	8.656	3.086
40	9.242	5.503	7.979	3.078
60	9.705	5.455	8.848	3.324
80	9.779	5.662	9.369	3.572
CD(P=0.05)	Source= NS Level=0.14 Source x Level=NS	Source= NS Level=0.647 Source x Level=1.12	Source=0.455 Level=0.587 Source x Level=1.017	Source= NS Level=0.629 Source x Level=NS

Nitrogen uptake by seed (table 3) was increased with sulphur application above 40 kg ha^{-1} dose. Further increase in sulphur application @ 80 kg ha^{-1} resulted in a decrease in nitrogen uptake by seeds. SSP application resulted in higher nitrogen uptake compared to other two sources. Phosphorus uptake increased significantly with sulphur application up to 60 kg ha^{-1}. Further increase in sulphur application resulted in decreased phosphorus uptake by sesame seeds. All three sources acted similarly in affecting phosphorus uptake. The uptake values of nutrients were in accordance with seed and stover yields and their contents at different levels of those nutrients. These results are in agreement with findings of Mishra [10]. Furthermore, it is reported that optimum S increased nutrient uptake which help maximum metabolic activity in plants. Many authors reported that under field condition, the optimum sulphur dose for sesame cultivation was 30 - 60 kg/ha depending on the soil and cultivation techniques [2,11]. Judicious application of S significantly increased the uptake of N in straw and grain as reported by many workers.

From the present investigation it can b concluded that sulphur application up to 40 kg ha^{-1} increased stover, seed and oil yield and among the three sources of sulphur studied, magnesium sulphate was found to be a superior source of sulphur for sesame in Red and Lateritic soil of West Bengal.

Table 3: Effect of sources and levels of sulphur on nutrient uptake by seed

S level (kg/ha)	N uptake by seed (kg ha^{-1})	P uptake by seed (kg ha^{-1})	K uptake by seed (kg ha^{-1})	S uptake by seed (kg ha^{-1})
Gypsum				
0	16.839	3.257	4.731	1.207
20	22.811	4.516	5.641	1.037
40	23.768	4.983	6.384	0.633
60	22.849	4.824	6.875	1.640
80	21.746	4.873	5.664	1.108
Mean	21.603	4.490	5.859	1.125
Magnesium sulphate				
0	16.839	3.257	4.731	1.207
20	15.918	3.370	5.456	0.729
40	20.845	5.263	7.168	1.434
60	22.782	5.001	6.617	0.569
80	22.476	4.732	6.754	1.196
Mean	19.772	4.325	6.145	1.027
SSP				
0	16.839	3.257	4.731	1.207
20	24.105	4.802	5.952	1.156
40	26.060	5.603	6.908	1.585
60	23.438	3.995	7.557	1.434
80	18.534	4.444	5.776	0.783
Mean	21.795	4.420	6.185	1.233
Mean				
0	16.839	3.257	4.731	1.207
20	20.944	4.229	5.683	0.974
40	23.558	5.283	6.820	1.217
60	23.023	4.606	7.017	1.214
80	20.919	4.683	6.065	1.029
Mean	21.057	4.412	6.063	1.128
CD (P=0.05)	Source= 1.67 Level=2.15 Source x Level=3.73	Source= NS Level=0.65 Source x Level=NS	Source=NS Level=0.64 Source x Level=NS	Source= 0.103 Level=0.133 Source x Level=0.23

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INTERNATIONAL JOURNAL OF
PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

International Journal of Plant, Animal and Environmental Sciences