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E Nivetha
PhD, Scholar, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

N Chandra Sekaran
Professor, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

S Meena
Professor, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

P Irene Vethamoni
Professor, Department of Horticulture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

T Kalaiselvi
Professor, Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
N Chandra Sekaran
Professor, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Evaluating sulphur nutrition to improve the yield and quality of aggregatum onion (Allium cepa var. aggregatum) grown in Sulphur deficient soil

E Nivetha, N Chandra Sekaran, S Meena, P Irene Vethamoni and T Kalaiselvi

Abstract
A field experiment was conducted to assess the impact of sulphur fertilisation on the yield and quality of aggregatum onion (CO (On) 5) grown in S deficient black soil (Typic Ustropept) which was sandy loam in texture with available S content of 7 mg kg^{-1}. Ammonium sulphate and Single super phosphate were the two sources of sulphur applied along with recommended doses of N, P and K at the levels of 0, 20 and 40 kg S ha^{-1} with and without VAM. The bulb yield increased significantly both with the application of ammonium sulphate (with VAM - 4.70 t ha^{-1}, without VAM - 4.68 t ha^{-1}) and Single super phosphate (with VAM - 4.65 t ha^{-1}, without VAM - 4.63 t ha^{-1}) with recommended dose of fertilizers and at the higher level of 40 kg S ha^{-1} which were 26.6 and 26.3% increase over RDF alone application incase of application of Ammonium sulphate + RDF with and without VAM, respectively; and 25.8 and 25.5% increase over RDF alone application incase of single super phosphate + RDF application with and without VAM, respectively. Thus, application of VAM with ammonium sulphate and RDF at higher levels was also statistically on par with the same combination without VAM. The highest sulphur content (0.444%) and sulphur uptake in bulbs (6.23 kg ha^{-1}) were higher with application of ammonium sulphate @ 40 kg S ha^{-1} + RDF which was on par with the same combination without VAM and Single super phosphate @ 40 kg S ha^{-1} + RDF with and without VAM. The quality parameters of aggregatum onion like ascorbic acid and pyruvic acid were also higher with the application of ammonium sulphate and recommended dose of fertilizers @ 40 kg S ha^{-1} which was on par with the same combination without VAM and Single super phosphate @ 40 kg S ha^{-1} + RDF with and without VAM.

Keywords: Sulphur, ammonium sulphate, single super phosphate, pyruvic acid, ascorbic acid, VAM.

Introduction
Onion (*Allium cepa* L.) "Queen of kitchen" is one of the most important commercial crop not only in India but also in the world. Onion is a sulphur loving plant and the requirement is high for its proper growth and yield. Sulphur is recognised as an important nutrient for higher yield and better quality of onion bulbs (Tripathy *et al.*, 2013). No sulphur application in sulphur deficient soils has often resulted in low yield of onion. Keeping in view the significance of sulphur in the production of onion crop, the present investigation on onion was undertaken.

Materials and Methods
A field experiment was conducted in Putthur village of Narasipuram block, Coimbatore district, where soil was found to be deficient in available sulphur with the value of 7.00 mg kg^{-1}. The soil was sandy loam in texture, black coloured with neutral pH (7.15) and non-saline (0.19 dS m^{-1}). The soil texture was analysed by following the international pipette method (Piper, 1966) [8], pH by potentiometry (Jackson, 1973) [3] and EC by conductometry (Jackson, 1973) [3]. The treatments of this study (T_1 to T_{10}) include absolute control, Recommended doses of fertilizers (NPK 60:60:30 kg ha^{-1}) alone, Ammonium sulphate @ 20 kg S ha^{-1} + RDF, Ammonium sulphate @ 20 kg S ha^{-1} + RDF + 200.0 g VAM, Ammonium sulphate @ 40 kg S ha^{-1} + RDF, Ammonium sulphate @ 40 kg S ha^{-1} + RDF+ 200.0g VAM, Single super phosphate @ 20 kg S ha^{-1}+ RDF, Single super phosphate @ 20 kg S ha^{-1}+ RDF + 200.0 g VAM, Single super phosphate @ 40 kg S ha^{-1}+ RDF and Single super phosphate @ 40 kg S ha^{-1}+ RDF + 200.0 g VAM. These ten treatments were laid out in RBD with 3 replications. The matured bulbs were harvested at 100 DAT, shade dried, weighed and then expressed as yield in kg ha^{-1}. The harvested bulbs were then again oven dried at 70 °C to a constant weight and their dry weights were recorded. These oven dried bulbs were then ground finely and sulphur content analysis was carried out by turbidimetry method (Chesnin and Yien, 1951) [2] and sulphur uptake was computed by multiplying the contents with dry weights.

The harvested bulbs were also analysed for quality parameters like pyruvic acid (Randle and Bussard, 1993) [9] and ascorbic acid (A.O.A.C, 1975) [1] contents. The results were statistically analysed using Aggress software at 5% level of significance.

Results and Discussion

S content and uptake in bulb

The highest sulphur content (0.444%) and sulphur uptake in bulbs (6.23 kg ha^{-1}) were higher with application of ammonium sulphate @ 40 kg S ha^{-1} + RDF which was on par with the same combination without VAM and Single super phosphate @ 40 kg S ha^{-1} + RDF with and without VAM (Fig.1). This was an increase of 50.45 and 33.49% over the RDF alone application, in case of sulphur content in bulbs and its uptake, respectively. The sulphur content and sulphur uptake in bulbs of control plots registered the least values of 0.109% and 4.00 kg ha^{-1}, respectively. Also, it was observed that there was an increase in S uptake with increase in S levels from 20 to 40 kg S ha^{-1} which might be due to the highest sulphur content in bulbs at this level of 40 kg S ha^{-1}. Nasreen and Imamul Huq in 2005 [7], also reported that an increase in S levels from 0 to 45 kg S ha^{-1} increased the S content in bulbs which was 142-165% higher over the control. These might be due to higher availability of applied sulphur and its more absorption and translocation to bulbs and also dilution effect.

Bulb Yield

The highest bulb yield of 4.7 t ha^{-1} was noted with the application of AS @ 40 kg S ha^{-1} + RDF, which was on par with the same combination without VAM and Single super phosphate @ 40 kg S ha^{-1} + RDF with and without VAM (Table.1). Jana and Kabir (1990) [4] also reported that application of 40 kg S ha^{-1} resulted in higher bulb yield of onion. Khalid *et al.* (2009) [5] also noticed that the yield of rapeseed were increased in the order of AS>SSP>Gypsum, though non-significant and discussed that crops respond to sulphur application and the magnitude of response depends on the extent of soil S deficiency (< 10 mg kg^{-1}).

Pyruvic acid and ascorbic acid

Though, the highest amount of pyruvic acid (2.51µmol g^{-1}) and ascorbic acid contents (9.24 mg100g^{-1}) in bulb were higher with AS @ 40 kg S ha^{-1} + RDF it was also on par with, the same combination without VAM and Single super phosphate @ 40 kg S ha^{-1} + RDF with and without VAM (Table.1). This indicated that the application of sulphur to S deficient soils in the form of ammonium sulphate and single super phosphate enhances the quality of onion bulbs due to their higher water soluble nature. Higher S release in AS treated plots might be due to relatively higher solubility of AS as compared to SSP (Scherer, 2001). Pungency intensity is controlled by genetic and environmental factors, especially soil S content, temperature, and water availability (McCallum *et al.*, 2001) [6].

Table 1: Effect of sources and levels of sulphur on Bulb Yield (t ha^{-1}), ascorbic acid (mg 100 g of $bulb^{-1}$) and pyruvic acid (µmol g^{-1} of bulb) contents in bulbs

Treatments	Bulb Yield (t ha^{-1})	Ascorbic acid (mg 100 g of $bulb^{-1}$)	Pyruvic acid (µmol g^{-1} of bulb)
T1	2.90	6.20	1.00
T2	3.45	6.25	1.05
T3	4.00	8.54	2.24
T4	3.98	8.52	2.22
T5	4.70	9.24	2.51
T6	4.68	9.21	2.48
T7	3.95	8.41	2.18
T8	3.94	8.39	2.15
T9	4.65	9.18	2.45
T10	4.63	9.15	2.42
Mean	4.09	8.31	2.07
SEd	0.24	0.50	0.12
CD (0.05)	0.51	1.04	0.26

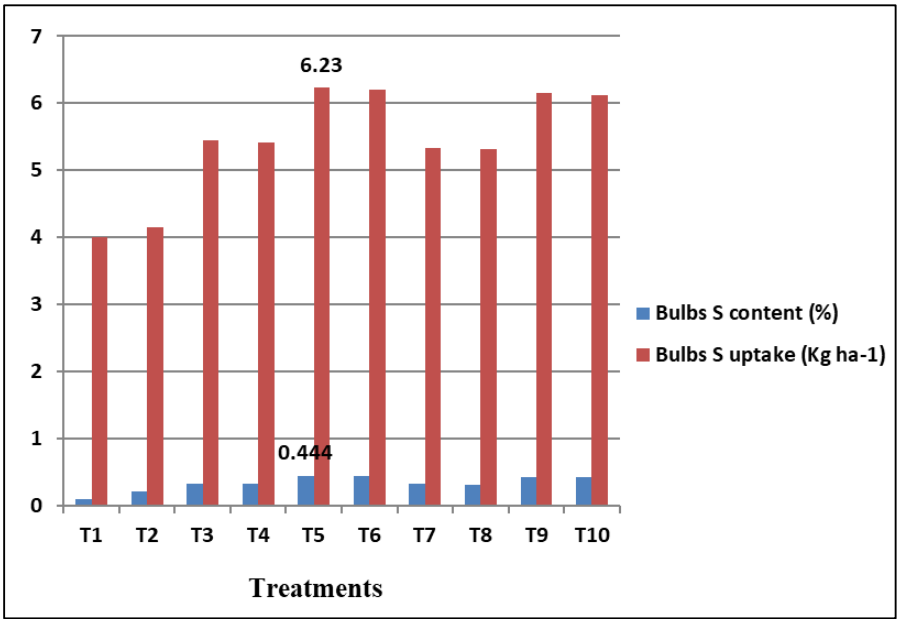

Fig 1: Effect of sources and levels of sulphur on S content (%) and S uptake (Kg ha^{-1}) in bulbs

Conclusion

The results from the present field investigation infer that the application of Ammonium sulphate @ 40 kg S ha^{-1} + RDF and Single super phosphate @ 40 kg S ha^{-1} + RDF can be recommended as the suitable and best sulphur source and dosage for enhancing the onion yield and quality grown in sulphur deficient soils through sulphur nutrition. Since, the VAM treatments had similar response to the same

combinations without VAM and also owing to the higher cost of VAM, the treatments without VAM can be recommended as the best sulphur nutrition package for aggregatum onion production.

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