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Influence of sulphur fertilization on nutrient uptake of onion (*Allium cepa* L.)

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ABSTRACT

Field experimentation conducted to examine the nutrient uptake in onion due to application of sulphur(S) was conducted at OUAT and found that application of sulphur(S) @ 45 kg ha^{-1} as gypsum significantly produced maximum bulb yield of 251.10 q ha^{-1} followed by S @ 30 kg ha^{-1} as gypsum (226.07 q ha^{-1}).Significantly maximum uptake of N, P, K, S (14.84, 0.66, 10.08 and 0.85 kg ha^{-1}, respectively) was observed by S @ 45 kg ha^{-1} as elemental sulphur followed by @30 and 45 kg ha^{-1} as gypsum. The results on nutrient uptake by bulbs indicated maximum of 74.66, 7.08, 35.62 & 9.02 kg ha^{-1} NPKS by application of S @ 45 kg ha^{-1} followed by 30 kg ha^{-1} as gypsum. Similar trend was also observed for total nutrient uptake. Thus, it may be concluded that application of S @ 30 or 45 kg ha^{-1} in the form of gypsum not only increases the bulb yield but also higher uptake of nutrients in onion.

Keywords: Bulb yield, elemental sulphur, gypsum, nutrient uptake and onion

Onion (*Allium cepa* L.*)* is one of the commercial vegetable and spice crops of India. India produces 159.30 lakh MT of onion from11.10 lakh hectares area (FAOSTAT, 2013). India ranks first in area, second in production and third in export in the world. In India, onion is predominantly cultivated during *Rabi* (60%) followed by 20% each in *Kharif* and late *Kharif* season. The higher productivity could be determined by selection of suitable varieties, balanced nutrition, optimum water management as well as need based plant protection measures. In recent times, the deficiency of sulphur is increasing in Indian soils as a result of indiscriminate use of fertilizers (Tondon, 1995). The onion responds to sulphur application (Singh *et al*., 1996). Sulphur is essential for synthesis of proteins, vitamins and sulphur containing essential amino acids and is also associated with nitrogen metabolism. Sulphur has been recognized as an important nutrient for higher yield, quality as well as nutrient uptake of onion. Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of onion (Ajay and Singh, 1994). Sulphur containing secondary compounds is not only important for nutritive value or flavours but also for resistance against pest and diseases. Insufficieny of sulphur is known to hamper N-metabolism and synthesis of sulphur containing amino acids and thus exerts adverse effects on both yield and quality of the crop (Hore *et al*., 2014) .Deficiency of sulphur is increasing due to continuous use of S-free fertilizers and increasing cropping intensity with high yielding cultivars. Information on effect of application of sulphur on uptake of nutrients in onion is rather limited. Therefore, keeping this in view, a field experiment was conducted at College of Horticulture (OUAT), Sambalpur, Odisha, India during *Rabi* 2012-13 to study about the effect of sulphur on uptake of nutrients in onion.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2012-13 at College of Horticulture, Orissa University of Agriculture and Technology, Odisha, India. Soil of the experiment area was sandy loam having pH of 5.89; available NPK 151.25:15.78:178.75 kg ha^{-1} with low sulphur content (9.75 ppm). The field trial was laid out by adopting RBD replicated thrice with seven treatments (Table 1). The gypsum as source of sulphur as per the treatments was applied at the time of transplanting while the elemental sulphur was applied after 20-25 days of transplanting. The recommended full dose of phosphorus, potassium and half dose of nitrogen were applied as basal dose while the remaining nitrogen was applied as top dressing at 30 days after transplanting. The seedlings of seven weeks old were transplanted at a spacing of 15 cm × 10 cm. All the recommended package of practices was adapted uniformly to all the treatments to raise a good onion crop of variety Agrifound Dark Red (ADR). The onion crop was harvested at full maturity. The bulb samples were collected for analysis of N, P, K and S. In ground bulb samples, nitrogen was estimated by Kjeldahl method. For P, K and S estimation bulb samples were digested in a diacid mixture (HNO_3 and $HClO_4$) and P in the extract was determined by vanadomolybdate yellow colour method (Jackson 1973). K and S content was

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determined by flame photometer and turbid metric method (Chesnin and Yien, 1951). The data recorded on various parameters were subjected to statistical analysis as per the procedure suggested by Sukhatme and Amble (1995).

RESULTS AND DISCUSSION

The results on average bulb weight of onion variety ADR revealed significant variations due to different treatments of sulphur. The fresh weight per bulb significantly increased from 50.35 g at control to 77.15 g with application of sulphur @ 30 kg ha^{-1} in the form of gypsum which was statistically at par with sulphur @45 kg ha^{-1} as gypsum and 30, 45 kg S ha^{-1} as elemental sulphur (Table 1). This might be ascribed adequate supply of sulphur that resulted in higher production of photosynthates and their translocation to sink, which ultimately increased the fresh yield of onion. Increasing sulphur availability has been associated with increasing bulb weight (Lancaster *et al.,* 2001). Similar report has been reported by Josephine *et al.* (2001) and Mazumdar *et al.* (2008). The bulb yield increased significantly with increasing doses of sulphur (Table 1). Addition of graded doses of sulphur significantly improved the bulb yield of onion over control. Addition of 45 kg S ha^{-1} as gypsum registered the highest bulb yield (251.10 q ha^{-1}) which was statistically *at par* with application of sulphur @ 30 kg ha^{-1} as gypsum and 45 kg S ha^{-1} as elemental sulphur. The increase in bulb yield of onion in sulphur applied plots might be due to higher production of metabolites and increase in meristematic activity. Besides, it could be attributed to improvement in nutritional environment in crop root zone and ultimately resulted in better vegetative growth and finally the bulb yield. The soil low in sulphur was unable to supply the nutrient significantly for optimum growth and yield of crop. The increase in bulb yield was mainly due to enhanced rate of photosynthates and carbohydrate metabolism as influenced by sulphur application. Kumar and Singh (2004) reported enhanced bulb yield due to sulphur application. Again these results might be attributed to the favourable effect of sulphur on reducing soil pH, increasing soli particles, thereby improving soil structure and increasing the availability of certain plant nutrients in soil. Another possibility could be due to either the fact that sulphur is required with greater supplies for onion than other crops for the synthesis of coenzyme and amino acid for protein elaboration and for the formation of certain disulphide linkages that have been associated with structural characteristics of plant protoplasm (Marschner, 1995). Similar results in increase in total bulb yield of onion with sulphur fertilization were also reported by (Attia,2001; Hariyappa, 2003; Channagouda, 2004; Nasreen *et al.*,2007; Hossain *et al.*,2009; Channagouda *et al.*, 2009; Meena *et al.*, 2009).

Table 1: Effect of sulphur fertilization in yield parameter in onion

Treatments	Average bulb weight (g)	Total bulb yield (q ha^{-1})
T_1: Recommended dose of fertilizer (RDF) (150-50-80 kg NPK ha^{-1})	50.35	101.58
T_2: RDF + Gypsum (S_G) @15 kg ha^{-1}	59.99	179.23
T_3: RDF + Gypsum (S_G) @30 kg ha^{-1}	77.15	226.07
T_4: RDF + Gypsum (S_G) @45 kg ha^{-1}	74.90	251.10
T_5: RDF + Elemental Sulphur (S_{ES}) @ 15 kg ha^{-1}	51.97	129.60
T_6: RDF + Elemental Sulphur (S_{ES}) @ 30 kg ha^{-1}	65.43	174.90
T_7: RDF + Elemental Sulphur (S_{ES}) @ 45 kg ha^{-1}	67.28	226.67
LSD (0.05)	**12.00**	**46.045**
CV (%)	**10.56**	**14.055**

The significant increase in uptake of N in onion leaves was noticed with the application of increased levels of sulphur; the highest content and uptake was noticed at 45 kg S ha^{-1} as gypsum and 45 kg S ha^{-1} as elemental sulphur respectively which was statistically *at par* with application of sulphur @30 and 45 kg ha^{-1} in form of gypsum. The in crease in N uptake was mainly due to increase in yield. Similar reports were reported by Rai *et al.*(2002). Again there was significant increase in the content and uptake of N in onion bulbs ranges from 1.46% (T_7) to 3.06% (T_4) and 24.30 kg ha^{-1} (T_1) to 74.66 kg ha^{-1} (T_4) respectively. However, there was significant variation in total N uptake by onion crop due to sulphur fertilization. The highest uptake 88.5 kg ha^{-1} was recorded with application of sulphur @ 45 kg ha^{-1} as gypsum, which was statistically *at par* with 30 kg S ha^{-1}

as gypsum and lowest in control (29.4 kg ha^{-1}). The corresponding increase in N uptake by onion was mainly due to greater production of onion bulbs.

Kumar and Singh (2004) also reported the similar results. Phosphorous content and uptake by onion leaves increased significantly with application of sulphur over control. The maximum P uptake to the extent of 0.66 kg ha^{-1} was observed with the application of sulphur @ 45 kg ha^{-1} as elemental sulphur and lowest 0.20 kg ha^{-1} in the plot receiving no sulphur. However, there is significant variation in the uptake of P by bulbs and ranges from 2.82 kg ha^{-1} (control) to 7.08 kg ha^{-1} at application of 45 kg S ha^{-1} as gypsum which was statistically *at par* with 30 kg S ha^{-1} as gypsum. Overall, there is significant increase in total P uptake by onion due to sulphur fertilization and it increased from 3.0 kg ha^{-1} at control to 7.4 kg ha^{-1} at 45 kg S ha^{-1} in form of gypsum which shows statistical *parity* with 30 kg S ha^{-1} as gypsum and 45 kg S ha^{-1} as elemental sulphur. The increase in P uptake was mainly due to greater bulb production and improved P content due to S addition. Similar result reported by Singh and Singh (2003).

Table 2: Content and uptake of nutrients by leaves in onion as influenced by sulphur fertilization

Treatments	Nutrient content (%)				Nutrient uptake (kg ha^{-1})			
	N	P	K	S	N	P	K	S
T_1	2.20	0.08	1.54	0.14	5.08	0.20	3.58	0.34
T_2	2.12	0.07	1.62	0.11	7.77	0.26	5.94	0.41
T_3	2.14	0.06	1.37	0.13	11.91	0.34	7.54	0.72
T_4	2.50	0.07	1.32	0.13	13.83	0.33	7.30	0.72
T_5	2.21	0.10	1.45	0.16	7.04	0.31	4.64	0.51
T_6	2.24	0.10	1.51	0.17	10.03	0.48	6.79	0.72
T_7	2.47	0.11	1.67	0.14	14.84	0.66	10.08	0.85
LSD (0.05)	**NS**	**0.02**	**NS**	**NS**	**4.07**	**0.15**	**2.6**	**0.24**
CV (%)	**9.73**	**14.69**	**NS**	**37.3**	**22.72**	**24.17**	**22.6**	**22.51**

Table 3: Content and uptake of nutrients by bulbs in onion as influenced by sulphur fertilization

Treatments	Nutrient content (%)				Nutrient uptake (kg ha^{-1})			
	N	P	K	S	N	P	K	S
T_1	2.23	0.25	1.31	0.19	24.30	2.82	14.60	2.14
T_2	2.96	0.27	1.30	0.34	51.92	4.92	23.53	6.20
T_3	2.94	0.28	1.36	0.31	69.66	6.53	31.46	8.16
T_4	3.06	0.28	1.46	0.37	74.66	7.08	35.62	9.02
T_5	2.02	0.23	1.40	0.18	29.77	3.54	20.63	2.65
T_6	2.00	0.23	1.30	0.14	33.76	3.88	21.93	2.36
T_7	1.46	0.21	1.17	0.13	35.16	5.06	28.18	3.13
LSD (0.05)	**0.38**	**NS**	**NS**	**0.07**	**9.73**	**0.98**	**5.2**	**1.01**
CV (%)	**8.96**	**15.71**	**NS**	**17.2**	**11.63**	**11.50**	**11.7**	**11.8**

Table 4: Total uptake of nutrients in onion as influenced by sulphur

Treatment	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
T_1	29.4	3.0	18.2	2.5
T_2	39.7	5.2	29.5	6.6
T_3	81.5	6.9	39.0	8.9
T_4	88.5	7.4	42.9	9.8
T_5	36.8	3.9	25.3	3.2
T_6	43.7	4.4	28.7	3.08
T_7	50.0	5.7	38.3	4.0
LSD (0.05)	**11.90**	**1.95**	**6.7**	**1.14**
CV (%)	**12.02**	**22.2**	**11.9**	**11.9**

Once again, application of sulphur increased potassium uptake in onion leaves significantly over control indicating a synergistic effect of sulphur on K nutrition in onion. K uptake by onion leaves increased significantly from 3.58 kg ha^{-1} at control to 10.08 kg ha^{-1} at application of sulphur @ 45 kg ha^{-1} as elemental sulphur which shows statistical *parity* with sulphur @30 kg ha^{-1} as gypsum. Again there is significant variation in K uptake by onion bulbs, and highest was recorded 35.62 kg ha^{-1} at application of S @ 45 kg ha^{-1} in form of gypsum which was statistically *at par* with 30 kg S ha^{-1} as gypsum. Finally, there was significant increase in total uptake of K by onion crop due to sulphur fertilization. The maximum uptake 42.9 kg ha^{-1} was recorded at 45 kg S ha^{-1} in form of gypsum which shows statistical *parity* with 30 kg S ha^{-1} as gypsum and lowest 18.2 kg ha^{-1} at control. This might be due to greater vegetative growth, translocation of stored material and bulb production. Similarly reported by Jaggi (2005).

The uptake of sulphur in leaves increased significantly with the increase in the doses of applied sulphur as gypsum and elemental sulphur. The highest uptake 0.85 kg ha^{-1} was recorded with the application of sulphur @ 45 kg ha^{-1} as elemental sulphur which was statistically *at par* with 30 kg S ha^{-1}, 45 kg S ha^{-1} as gypsum and 30 kg S ha^{-1} as elemental sulphur. On the other hand, the uptake of sulphur by onion bulbs shows significant increase and ranges from 2.14 kg ha^{-1}(control) to 9.02 kg ha^{-1} with application of 45 kg S ha^{-1} as gypsum which was statistically *at par* with 30 kg S ha^{-1} (8.16 kg ha^{-1}) as gypsum. However, the total uptake of sulphur by onion crop through sulphur fertilization shows significant increase with increase doses of sulphur and highest uptake of 9.8 kg ha^{-1} was observed with the application of 45 kg S ha^{-1} as gypsum which exhibit *statistical parity* with 30 kg S ha^{-1} (8.9 kg ha^{-1}) as gypsum. Similar report was made by Singh *et al.* (2001). Gypsum source was significantly influencing the sulphur uptake compared to elemental sulphur when integrated with RDF.

Overall application of sulphur along with RDF, irrespective of doses increases in uptake of N, P, K and S which might have influence the synthesis and translocation of stored materials. These results are in accordance with Dabhi *et al*. (2004), Jaggi (2005) and Sankaran *et al.* (2005). Again it may be concluded that application of gypsum @ 30-45 kg ha^{-1} as source of sulphur gives better result in nutrient uptake than elemental sulphur (Sankaran *et al.*, 2005; Channagoudra, 2004; Hariyappa, 2003).

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