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Soil sulphur status and response of onion (*Allium cepa*) to sources and levels of sulphur

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ABSTRACT

Two hundred soil samples collected from Agra district were analysed for their physico-chemical properties and sulphur status. The total and available(0.15%$CaCl_2$ extractable)S ranged from 55.0 to156.0 mgkg^{-1}and 4.5 to 18.0 mgkg^{-1},respectively.Available S contributed to 10.2% of total S. Highly significant positive relationship was noted between these two fractions of S. About 58.0%of the investigated soils were found to be deficient in plant available S. Results of a field experiment conducted at R.B.S College Bichpuri Agra (u.p.) revealed that an improvement in yield, nutrients uptake and quality of onion was recorded with 40 kg S ha^{-1} through gypsum, elemental sulphur,SSP and pyrites as compared to control. An increase of 28.8% in bulb yield was recorded with the application of 40 kg S ha^{-1}. Further increase in the levels of S (60 kg ha^{-1}) had an adverse effect on yield of onion. Protein content and yield increased significantly with levels of Sand highest protein content in onion bulbs (6.8%) was obtained with 60kg S ha^{-1}. Such beneficial effect of S was also found in increasing nutrients (N, P and S) uptake of onion bulbs among the sources of S, gypsum being statistically at par with SSP, was superior to elemental S and pyrites in respect of yield, protein content and nutrient uptake by onion.

Key words: Sulphur status, sulphur sources, onion, uptake, protein content

INTRODUCTION

Sulphur (S), the nutrient required for increasing both the quantity and quality of the produce, is gaining importance of late owing to its increased deficiency in soils. The area speculated as sufficient in sulphur had started showing sulphur deficiency in Agra region (Singh, 2015). The importance of vegetables in the balanced diet of human beings as protective food and suppliers of adequate quantities of carbohydrate, fiber, minerals and vitamins is well known. Onion (*Allium cepa* L) is one of the most important bulbous vegetable crop commercially grown in India and used as raw as well cooked form. Onion is an export oriented crop earning valuable foreign exchange for the country. Fertilizers play an important role in increasing the production and improving the quality of vegetables and among them sulphur is prime because of its role in various physiological processes.Sulphur is essential for building up of sulphur containing amino acids, which are essential for protein synthesis. Sulphur not only increases the bulb yield but also improves its quality especially pungency and flavor, utilization of nitrogen, phosphorus and potassium and a significant reduction of catalase activities at all ages. Severe sulphur deficiency during bulb development has detriment effect on the yield and quality of onion (Uikey, 2015). Sulphur fertilizers are most commonly available as either soluble sulphate or elemental forms use of rich reserves of indigenous sulphur sources namely gypsum and pyrites could be a suitable alternative. Not much work has been done in Agra region of Uttar Pradesh on the effect of levels and sources of sulphur on onion. Hence, an experiment was conducted to assess the sulphur status and response of onion to sources and levels of sulphur in alluvial soils of Agra.

MATERIALS AND METHODS

Two hundred composite surface soil samples (0-15 cm) were collected from the cultivated fields of Agra district, Uttar Pradesh. These soil samples were analysed for EC,pH, organic carbon and free lime by adopting standard procedures (Jackson 1973). Extraction of total S was done through perchloric acid digestion of soil (Jackson 1973).Available S was extracted with 0.415% solution of calcium chloride. Sulphur in the extracts was determined

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by turbidimetric method (Chesnin and Yien, 1951). Field experiments were conducted for two consecutive years (2016-17 and 2017-18) at Panwari village of Agra district (U.P.). The experimental site is characterized by semi arid climate with extreme temperature during summer (45^o to 48^oC) and very low temperature during winter (as low as 2^oC). The average rainfall is about 650mm, most of which is received from June to September. The soil was alkaline in reaction and low in organic carbon (3.1 gkg^{-1}).Available N,P,K and S (0.15% $CaCl_2$ extractable) contents of the soil were 144,9.4, 105 and 17 kg ha^{-1}, respectively. The treatments comprised combinations of four sources of S (gypsum, elemental sulphur, pyrite and single superphosphate) applied in four rates (0, 20,40and 60 kg S ha^{-1}). A basal dose of 150kg N, 80 kg P_2O_5 and 80 kg K_2O along with S(through different sources at the desired rates) were applied at the time of planting. Nitrogen, P and K were applied through urea, diammonium phosphate and muriate of potash, respectively. Different levels of Ca supplied by gypsum were balanced by addition of $CaCl_{2.}$ All the treatments were replicated thrice in randomized block design. Onion (variety Nasik Red) was planted in second week of December during both the years of study. At maturity, bulb yield was recorded. The bulb sampleswere digested in di acid (HNO_4 and $HClO_3$) mixure and analysed for S by turbidimetric method (Chesnin and Yien, 1951) and phosphorus by molybdvanadate yello colour method. Nitrogen was determined by modified Kjeldahl method (Jackson, 1973) and protein content was obtained by multiplying with a factor 6.25. The uptake of nutrients by onion crop was worked out by multiplying their content values with corresponding yield data. The data obtained from consecutive two years were statistically analysed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Sulphur status

Some of the important physico-chemical properties of the soils are presented in Table 1. The soils of Agra district were alkaline in reaction, the variation in pH being from 7.4 to 8.8. The EC values of the soils were found to be within safe limits (0.10 to 2.2 dSm^{-1}). Organic carbon content in these soils was low to medium, ranging from 2.9 to 5.6 g kg^{-1} with an average of 4.2 g kg^{-1}. The low amount of organic carbon content may be due to high temperature prevailing in the area which is responsible for rapid decomposition of organic matter. The amount of free lime also varied widely (traces to 35 g kg^{-1}).The total S content in these soils varied from 55.0 to 156.0 mg kg^{-1} with a mean value of 94.5 $mgkg^{-1}$. The lower values of total sulphur in these soils might be associated with lower amount of organic carbon. Singh (2015) also reported similar results. Total sulphur content was positively and significantly correlated with organic carbon (r = 0.52) and negatively with pH (r = -0.22). The significant positive correlation of total S with organic carbon has also been reported by Das *et al.* (2012).Total S maintained a significant positive association with available sulphur (Singh, 2015) Available S in these soils ranged from 4.5 to 18.0 $mgkg^{-1}$ with an average of 9.7 $mgkg^{-1}$ (Table 1). This variation in available S may be attributed to the differences in soil properties, crop management practices and organic matter (Chandel *etal.* 2012). Taking 10 $mgkg^{-1}$ as the critical limit, about 58.0 % soil samples were found to be deficient in available S. Singh (2015) also reported similar results. Available S was positively and significantly correlated with organic carbon (r = 0.60) but negatively with soil pH (r= -0.30^0). The significant positive correlation of available S with organic carbon suggests that the S supplying power of these soils is largely dependent upon organic matter. These results are in accordance with those of Singh (2015).

Table 1: Physio-chemical properties and sulphur status in soils of Agra district

Characteristics	Range	Mean
pH	7.4 - 8.8	-
EC (dSm^{-1})	0.10 -2.2	1.1
$CaCO_3$ (g kg^{-1})	Tr - 35.0	16.5
Org. carbon (g kg^{-1})	2.9 -5.6	4.2
Sulphur status (mg kg^{-1})		
Total S	55.0 -156.0	94.5
Available S	4.5 -18.0	9.7

Tr, traces

Yield

The mean bulb yield of onion increased significantly with successive increase in level of

S application up to 40 kg ha^{-1} (Table 2). Further increase in S rate (60 kg ha^{-1}) depressed the onion yield. The bulb yield of onion increased by 28.8 % with 40 kg S ha^{-1} over no sulphur addition (control). Positive effect of sulphur doses on growth parameters might have ultimately resulted in higher bulb yield (Uikey*et al.* 2015). The effect of sulphur sources on the bulb yield was also significant and thehighest yield (37.40 t ha^{-1}) was recorded with the application of gypsum. Application of gypsum proved significantly superior to pyrites and elemental sulphur whereas it was at par with SSP in affecting bulb yield of onion. Superiority of gypsum to the other sources of S may be attributed to the fact that it improves the physical condition of the soil which ultimately results in better growth of the crop and thus increase in bulb yield. Similar observations were made by Kumar *etal.* (2014). Dry matter yield of onion bulb followed a similar trend as it was in case of onion bulb with sources and levels of sulphur. The interaction effect of sources and levels of sulphur was found to be significant (Table 3). The yield of onion bulbs was significant higher with 40 kg S ha^{-1} applied as gypsumas compared to the same dose of other sources of sulphur.

Table 2: Effect of sources and levels of sulphur on yield, quality and uptake of nutrients in onion (mean of 2 years)

Treatments	Yield (t ha^{-1})		Protein %	Protein yield (Kgha^{-1})	Uptake of nutrients (kgha^{-1})		
	Bulb	Dry Matter			N	P	S
Sources of S							
Gypsum	37.40	5.97	6.3	376.1	61.4	19.7	26.8
Elemental S	35.80	5.70	6.2	353.4	57.0	19.3	25.0
Pyrite	35.05	5.60	6.2	347.2	56.0	19.0	25.2
SSP	37.07	5.92	6.3	373.0	59.8	20.1	27.2
CD (P=0.05)	0.96	0.21	NS	11.5	2.3	NS	1.60
Sulphur levels (kg ha^{-1})							
0	31.05	4.97	5.9	293.2	47.2	14.9	19.9
20	34.80	5.56	6.1	339.1	55.0	18.3	23.9
40	40.00	6.40	6.3	403.2	65.2	22.4	29.4
60	39.24	6.26	6.8	425.6	67.0	23.1	31.9
CD (P=0.05)	0.96	0.21	0.24	11.5	2.3	0.83	1.60

Quality

Application of S to onion crop significantly increased the protein content in bulb from 5.9 to 6.8 % with 60 kg S ha^{-1} which may be attributed to role of sulphur in protein synthesis and nitrogen metabolism in the plants. Among the sources of S, the protein content was marginally higher with SSP and gypsum. The minimum amount of protein in bulb was recorded with pyrite. Application of SSP remained at par with gypsum which recorded higher protein yield of onion as compared to pyrite application. There was a consistent and significant increase in protein yield of onion bulbs with increasing levels of S and maximum value (425.6 kgha^{-1}) was recorded at 60 kg S ha^{-1}. Protein yield in onion bulbs ranged from 293.2 to 425.6 kgha^{-1}. This increase in protein yield due to sulphur levels may be attributed to increased bulb yield and protein content in bulb of the crop(Uikey*et al.*2015).

Uptake of nutrients

The nutrient uptake by onion bulbs was significantly affected by the sources and levels of S (Table 2). The highest uptake of N in bulb (67.0 kg ha^{-1}) was associated with 60 kg S ha^{-1}. Since, N uptake is the product of N concentration and yield so highest N uptake was observed with 60 kg S ha^{-1} followed by 40 kg S ha^{-1}. Sulphur is an essential constituent of enzymes involved in nitrogen metabolism; its application could lead to increase nitrogen assimilation (Uikey *et al.* 2015). Among the sources of S, gypsum proved significantly superior to other sources of S in enhancing the absorption of nitrogen from the soil by onion bulbs. Kumar *et al.*(2014) also reported greater nitrogen uptake by pea with S application through gypsum. Addition of S also resulted in increased P uptake by onion bulbs over control. The P uptake by onion bulb increased by 22.8, 50.3 and 55.0 % over control with 20, 40 and 60

Table 3: Interactive effect of sources and levels of S on bulb yield of onions (mean of 2 years)

Sources of Sulphur	Sulphur levels (kgha^{-1})			
	0	20	40	60
Gypsum	31.45	35.40	41.78	40.40
Elemental S	31.02	33.68	39.59	37.91
Pyrite	30.72	33.90	38.40	37.10
SSP	31.21	35.70	40.30	40.25
CD (P=0.05)		1.92		

kg S ha^{-1}, respectively.Sulphur improved growth of roots and shoot in S deficient soil so plant roots enhanced the uptake rate of P. Chandel *et al.* (2012) also reported that P uptake was stimulated in the presence of sulphur. In general SSP and gypsum brought about a greater uptake of P by onion bulbs over other sources of S. The lowest average value of P uptake (19.0 kg ha^{-1}) by onion bulb was recorded with pyrite.Irrespective of the variation in sources of S, sulphur uptake by the crop increased up to 60 kg S ha^{-1} (Table 2). Mean S uptake by bulbs increased from 19.9 to 31.9 kgha^{-1} with increasing S levels. This might be ascribed to better fertilization resulting in better growth and higher bulb yield under these treatments that activated the greater absorption of nutrients from the soil and resulted in higher S uptake. The minimum S uptake was recorded under control which was significantly lower than all the treatments. These results are similar to the findings of Chandel *etal.*(2012) reported in garlic. Differences in sulphur uptake by onion bulbs with different sources were significant. The highest uptake of S (27.2 kgha^{-1}) was recorded with SSP followed by gypsum, pyrites and elemental S.

From the results, it may be concluded that about 58% soil samples of Agra district were deficient in available S. A significant beneficial effect in onion bulbs could be achieved by the application of 40 kg S ha^{-1} in alluvial soil. Application of 40 kg S ha^{-1} as gypsum and SSP recorded substantial increase in yield, quality and uptake of nutrients in onion bulb.

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