Indian Journal of Agricultural Sciences **83** (10): 1086–9, October 2013/Article

Effect of sulphur nutrition on pungency and storage life of short day onion (*Allium cepa*)

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Received: 30 May 2011; Revised accepted: 2 September 2013

ABSTRACT

A field experiment was carried out to evaluate the effect of sulphur nutrition at 0, 7.5, 10, 20, 30, 40 and 50 kg S/ha on pyruvic acid and storage life of onion bulbs in *Vertic Haplustepts*. Besides that, the effect of sulphur nutrition on soil available sulphur level, marketable bulb yield and sulphur uptake were also assessed. The results of this study revealed that sulphur application increased marketable bulb yield, sulphur uptake and pungency level over no sulphur treatment. Moreover the increase in bulb yield and sulphur uptake was less with increasing the sulphur level beyond 20 kg/ ha. The pyruvic acid content had significant and positive correlation with sulphur application (r^2=0.735**). Sulphur application did not influence the storage life of onion bulbs significantly and showed no significant correlation with total storage losses of onion bulbs (r^2= -0.0828). Soil sulphur level after harvest was increased over the initial values with application of sulphur @ 30, 40 and 50 kg S/ha while application of 7.5 kg S/ha and control without sulphur reduced soil available sulphur content. From this study, we conclude that sulfur nutrition is essential for increasing the onion yield and pungency level in soils having sufficient sulphur. However, excess sulphur application did not influence the yield and pungency level significantly. The storage life of onion bulbs were not influenced significantly by sulphur nutrition and application of either low or higher sulphur is detrimental to soil health.

Key words: Bulb yield, Soil health, Soil sulphur level, Sulphur uptake

Onion (*Allium cepa* L.) is an important spicy vegetable crop grown since ancient times by the farmers. The bulbs and leaves of onion are used for flavoring the dishes all over the world. Pungent flavour of onion is derived from number of volatile sulphur compounds. These compounds are produced when the onion cell is mechanically disrupted, bringing the enzyme allinase into contact with flavor precursors such as S- alk(en)yl-L-cysteine sulfoxides (ACSOs). Besides the volatile sulphur compounds, the enzymatic break down of ACSOs also produces ammonia, pyruvic acids and lachrymator factor. The amount of pyruvic acid generated has been shown to be correlated with onion pungency. This enzymatically produced pyruvic acid is commonly accepted measure of pungency. Several studies have been conducted to determine the influence of sulphur level on onion pungency (McCallum *et al.* 2005) who indicated increased pungency level with higher sulphur nutrition in the soil while Lee *et al.* (2009) did not observe any significant increase in pungency with sulphur application to soil having high sulphur content.

Sulphur nutrition has also been shown to affect the bulb firmness and dry weight of onion bulbs. Lancaster *et al.* (2001) showed low sulphur supply reduced the sulphur in cell walls and also decreased the bulb hardness and the storage life of onion bulbs. Qureshi and Lawande (2006) also reported that the storage losses were decreased with application of sulphur. However, the information about the influence of sulphur nutrition on pungency level and storage life of onion is unclear. Hence the present study was carried out to evaluate the effect of different levels of sulphur nutrition on pungency level and storage life of onion bulbs.

MATERIALS AND METHODS

A field experiment was conducted at Directorate of onion and Garlic Research, Pune, Maharashtra during *rabi* season during 2008-09 and 2009-10 with onion cv. N-2-4-1. The soil was clay loam in texture and had pH (1:2.5) 7.92, electrical conductivity 0.24 dS/m, organic carbon 6.45 g/kg soil, available N 200 kg/ha, P 23.0 kg/ha, K 578 kg/ha and S 14 ppm. The irrigation water contained 17 ppm of sulphur. Six levels of sulphur (0, 7.5, 10, 20, 30, 40 and 50 kg/ha)

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Table 1 Effect of sulphur application on marketable bulb yield of onion crop

Sulphur levels (kg S/ha)	Marketable bulb yield (tones/ha)		Pyruvic acid content (μmols/ gfresh weight)		TSS (%)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
0	50.91 a	41.30 c	3.74 e	3.20 b	11.50 a	12.97 a
7.5	51.83 a	44.77 b	3.68 e	3.35 b	12.97 a	13.14 a
10	55.50 a	44.37 b	4.12 d	3.52 b	11.60 a	13.63 a
20	55.83 a	45.70 ab	4.32 c	4.40 a	11.26 a	13.30 a
30	54.08 a	47.57 a	4.34 bc	4.47 a	12.07 a	13.23 a
40	53.75 a	44.93 b	4.51 ab	4.80 a	12.27 a	13.42 a
50	56.25 a	45.70 ab	4.58 a	4.79 a	11.60 a	13.30 a

Means with the same letter are not significantly different

were applied through elemental sulphur (90% water soluble powder form). The trial comprised 7 treatments: T_1- NPK alone; T_2- T_1 +7.5 kg S; T_3-T_1+10 kg S; T_4-T_1+20 kg S; T_5-T_1+30 kg S, T_6-T_1+ 40 kg S and T_7-T_1+ 50 kg S. The experiment was laid out in randomized block design with 3 replications. Nitrogen, phosphorus and potassium were applied as per recommended dose of fertilizer, ie 150:50:80 kg NPK/ha, respectively. Half of nitrogen, whole of P, K and S were applied at the time of transplanting during the December. Remaining nitrogen was applied in two equal splits, at 30 and 45 days after transplanting. Standard package of practices were followed to grow onion crop. The crop was harvested after attaining maturity during last week of April. Bulbs were covered by its top and left in the field for curing for 3-4 days. After neck cutting, the bulb yield was recorded. Representative bulb samples were collected for the biochemical and nutritional analysis. Chopped bulb samples were dried in oven at 60º C till the constant weight was attained. The soil samples from 0-15 cm were collected randomly using auger after harvest for analyzing the available sulphur content in soil. The available sulphur in soil was extracted using 0.15 % $CaCl_2$. While the plant samples were digested using nitric acid and perchloric acid mixture. The plant digests and soil extractant were used for estimating the sulphur content using turbidimetric method (Chesnin and Yien 1950). The total soluble solid (TSS) of onion bulbs were estimated using hand refractometer and the percent TSS was noted down. Pyruvic acid content was estimated using dinitro phenyl hydrazine (DNPH) reagent method. Two opposite quarters of onion bulbs were selected and made into pieces after removing the neck, basal plate and skins. The onion tissues were crushed in a home mixer grinder without adding water. Bulb tissues were blended with equal volumes of water for 10 minutes. The homogenate was filtered through Whatman No. 4 filter paper and the filtrate was used for pyruvic acid analysis (Schwimmer and Weston 1961).

The onion bulbs @ 20 kg from each treatment in three replications were stored in perforated plastic crates under top and bottom ventilated storage structure under ambient conditions. Storage losses were recorded every month while sorting samples up to 150 days from the date of harvest. Cumulative storage losses were calculated (sum of physiological loss of weight, sprouting loss and rotting loss) and expressed in per cent. Analytical values obtained were subjected to statistical analysis using Statistical Analytical System (SAS) software.

RESULTS AND DISCUSSION

Available sulphur content in soil

Soil sulphur content ranged from 12 - 17 ppm among the

Table 2 Influence of sulphur addition on sulphur uptake (kg/ha) by onion

Sulfur levels (kg S /ha)	Uptake by leaves		Uptake by bulbs		Total uptake		Available sulphur status (ppm)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
0	1.11 abc	0.83 bc	16.00 c	12.42 c	17.11 d	13.25 d	13.50 bc	14.39 a
7.5	0.82 c	0.66 c	18.76 bc	14.67 c	19.58 cd	15.33 c	12.87 c	13.81 a
10	1.04 bc	0.97 bc	20.60 bc	15.76 c	21.57 bc	16.73 bc	15.17 abc	15.31 a
20	0.99 bc	0.91 bc	21.64 ab	16.46 bc	22.55 abc	17.37 b	14.33 bc	15.84 a
30	0.94 bc	0.99 bc	21.93 ab	17.61 ab	22.87 ab	18.60 ab	15.50 abc	16.08 a
40	1.26 ab	1.23 ab	22.30 ab	19.33 a	23.56 ab	20.55 a	15.78 ab	15.53 a
50	1.62 a	1.46 a	23.20 a	18.65 a	24.72 a	20.12 a	17.22 a	17.17 a

Means with the same letter are not significantly different treatments (Table 2). Application of sulphur beyond 20 kg/ ha to onion successively for two years increased the soil available sulphur levels slightly over the initial sulphur level. Besides external sulphur application, irrigation water has also contributed for soil sulphur (17 ppm). Lowest soil sulphur level after onion harvest was recorded in control plot and those receiving 7.5 kg S/ha. The decrease in sulphur content could be due to the removal of sulphur by onion crops. Yoo *et al*. (2006) showed that soil sulphur content of 18 ppm was sufficient for normal onion production.

Marketable bulb yield

Marketable bulb yield was significantly increased with higher application of compared to control. (Table 1). However, no significant difference was observed between sulphur treatments. Marketable bulb yield increased up to 20 kg S application beyond which it was not significant. The results of the studies by Qureshi and Lawande (2006) revealed that onion yield increased with increasing sulphur nutrition level up to 75 kg/ha in low sulphur soils (<10 ppm S) while no increase was recorded in soils having high sulphur levels (Yoo *et al.* 2006). Critical limit of $CaCl_2$ (0.15 %) extractable sulphur in soil is 10 ppm below which the soil are deficient in sulphur (Pasricha and Sarkar 2002). S levels low enough to reduce onion yield and pungency likely range between 5 and 10 ppm (Yoo *et al*. 2006). Whereas, the soil available sulphur content of the experimental fields of present study was ranged from 12-17 ppm which was in sufficiency level. This could be the reason for decrease in response by onion crop to the additional sulphur beyond 20 kg S. Similar results were also recorded by Jaggi and Raina (2008) who found that application of sulphur @ 30 kg/ ha recorded significantly higher bulb yield and further increasing the level to 45 kg/ha decreased the bulb yield in soils having sufficient sulphur (13 ppm) at Palampur.

Total soluble solids and pyruvic acid

In the present study, application of sulphur enhanced the pyruvic acid content of onion bulbs (Table 1). TSS was not significantly influenced by sulphur application. Low pyruvic acid content of 3.20 μ moles/g fresh weight was registered in control where no sulphur was added. Pyruvic acid content increased with increasing the sulphur level up to 50 kg/ha in both the years. The previous studies indicated that the pungency level significantly increased with increasing the sulphur level in low sulphur soils (Qureshi and Lawande 2006). However, increasing the sulphur level to 30, 40 and 50 kg sulphur/ha increased the pyruvic acid content slightly. The present study showed that rate of increase in pyruvic acid content declined with increasing sulphur level.

Sulphur uptake

Sulphur uptake in leaves and bulbs were increased significantly with increasing the sulphur levels up to 50 kg/ ha (Table 2). Among the different levels of sulphur, application of 7.5 kg S/ha registered lower total sulphur uptake whereas maximum was recorded with application of 50 kg sulphur/ ha. Increase in sulphur uptake decreased with increasing sulphur administration. Lee *et al.* (2009) observed that the increase in sulphur content in bulbs was restricted to addition of sulphur up to 13 kg/ha. The decrease in response to additional sulphur supply could be due to the supply of sulphur partly through the native soil sulphur and irrigation water.

Storage loss

The results of storage loss revealed that sulphur application to onion crops did not show significant effect on storage life (Fig 1). The storage losses of onion bulbs after five months ranged from 30-42%. Among the treatments, control plots recorded comparatively lower storage losses as

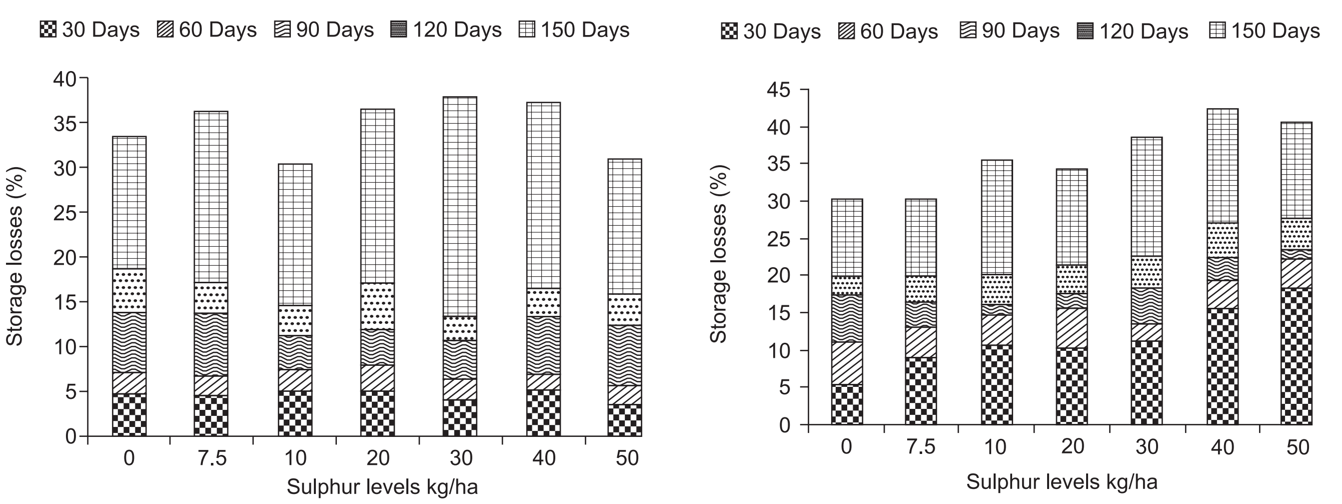

Fig 1 Influence of sulphur application on cumulative storage losses (%) of onion

compared to sulphur treatments. The storage losses up to 120 days were about 15-20 % and 22-27 % during 2008-09 and 2009-10 respectively. The storage losses were almost doubled and maximum loss was recorded during 120-150 days. The increase in loss was mainly due to rooting of onion bulbs. The rooting of bulbs was mainly due to the increase of atmospheric relative humidity. This clearly showed that the storage loss was mainly influenced by the genetic and environmental factors. The sulphur application did not have significant correlation with storage losses (r^2= -0.0828) and found to be contrary to the findings of Lancaster *et al*. (2001) and Qureshi and Lawande (2006) in which application of sulphur enhanced the storage quality of onion bulbs and in conformity with Forney *et al*. (2010) who reported that sulphur applications did not affect sprouting, root formation, decay or the development of surface discoloration or mold during storage.

The present study revealed that the soils with sufficient sulphur level responded slightly to the sulphur nutrition. Besides sulphur nutrition, irrigation water (17 ppm) also contributed sulphur to onion crop. Addition of 20 kg sulphur/ ha to onion crops was sufficient to increase the marketable bulb yield and pungency levels significantly. Irrespective of the sulphur level, higher storage losses of onion bulbs were noticed after five months of storage period. This indicated that application of sulphur had no significant influence on storage life of onion bulbs. It is clear from the study that application of 20 kg S/ha is adequate for attaining higher yield in soils having sufficient sulphur. Further, addition of extra sulphur increases the soil sulphur level. Hence, site specific nutrient application as per crop requirement is most important to maintain soil health, save the costly fertilizer inputs and sustain crop production.

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