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Effect of sulphur application in onion (A*llium cepa* L.)

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ABSTRACT

*An experiment was conducted to study the effect of sulphur application on growth, yield and quality of onion at Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan. The treatments consisted of six incremental doses of sulphur application (10, 20, 30, 40, 50 and 60 kg ha^{-1}) and no sulphur application (control, 0 kg S ha^{-1}). Treatments were arranged in Randomized Block Design with three replications. Yield, yield attributes and most of the other traits of onion (*Agrifound Dark Red) *response favourably to the sulphur application in a range of 40 to 60 kg ha^{-1}. Graded level of sulphur application linearly increased the yield up to 50 kg ha^{-1} with bulb yield of 35.5 tonnes. Maximum pyruvic acid content in onion bulbs was noticed with sulphur application at 40 and 50 kg ha^{-1}. However, application of sulphur did not affect number of scales and TSS content of onion bulb.*

***Key words** : Onion, pyruvic acid ,sulphur, yield, TSS*

Onion (*Allium cepa* L., 2n=16, Alliaceae), is an important bulb crop used as fresh vegetable, condiments and also processed. Members of the Alliaceae family contain sulphur compounds, which give them their distinctive smell and pungency. Sulfur plays critical roles in the catalytic or electrochemical functions of the bio-molecules in cells (Saito, 2004). Sulfur is useful for the formation of amino acids, oligopeptides, chlorophyll, certain enzymes, vitamins and cofactors, proteins and oils, and a variety of secondary products in *Allium* (Leustek, 2002; Stewart, 2010). Sulfur-containing secondary products are act as signaling molecules for fundamental cellular functions (Matsubayashi *et al.,* 2002) and believed to take part in defense mechanisms against pathogenic organisms (Bell, 1981). Sulphur has been found to increase the bulb yield of onion and also improves its quality, especially pungency and flavour (Jaggi and Dixit, 1999). Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of onion (Ajay and Singh, 1994). The original source of soil sulphur is metal sulphide minerals that when exposed to weathering, S^{-2} oxidizes to SO_4^{-2} and uptake of sulfur into roots from the soil is almost exclusively as sulfate uptake (Havlin *et al.,* 2005). Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields. Sub-soil fertility also needs due consideration to have better prediction of sulphur supply in growing plants (Singh, 2001). It is possible to provide sulphur to plants through artificial nutrition. Incidental sulphur returns to soil is possible through farmyard manure and the use of conventional sulphur containing fertilizers, such as Ammonium sulphate (24% S), Ammonium phosphate sulphate (14% S), Potassium sulphate (12% S), Gypsum (17% S) and Elemental sulphur (90-99% S). The liquid fertilizers containing sulphur are Ammonium thiosulphate (26% S), Ammonium polysulphide (40% S), Potassium polysulphide (22% S) and Potassium thiosulphate (17% S) (Messick, 2014). Red and Laterite soils of West Bengal found deficient in sulphur ranged from 13 to 73 per cent with an average of 45.2 per cent. Among them, as per SAI (Sulphur Availability Index) 87 per cent of the surface soil samples of Birbhum district fall under low sulphur range (Patra *et al.,* 2012). Local farmers often grow onion as a cash crop and also to meet up household demand in Red and Laterite zone of West Bengal. However, inclusion of sulphur in crop nutrition programme was found rare. It was strongly felt that enriching the soil with sulphur fertilizer would be beneficial for onion crop of this region. An investigation was, therefore, conducted to study the effect of sulphur application on growth, productivity and quality of onion.

MATERIALS AND METHODS

The experiment was conducted at Horticulture Farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan that represents sub-humid, sub-tropical, lateritic belt of West Bengal. Treatments consisted of six incremental doses of sulphur application (10, 20, 30, 40, 50 and 60 kg ha^{-1}) and no sulphur application (control, 0 kg S ha^{-1}). All the treatments were arranged in RBD with three replications. Individual plot size was kept 2 x 1.5m and

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plant spacing was 15 x 10cm. A general dose of FYM was applied @ 15 t ha^{-1} a fortnight before planting. Doses of NPK were followed as 125 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}. The sources of nitrogen, phosphorus and potassium were Urea, DAP, MOP respectively. The source of sulphur was Sulfex (elemental sulphur 80%; Excel Industries Ltd.). Full dose of phosphorous and potassium and 1/3rd of nitrogen was also applied before transplanting. The remaining 2/3rd of Nitrogen was applied in two equal splits at 30 and 60 days after transplanting. Onion cultivar Agrifound Dark Red was taken as study material. Transplanting of onion was done on 21st September 2015. Regular irrigation and weeding was done and plant protection measures were taken as needed. The crop was harvested at 120 days after transplanting on 20th January, 2016. The observations on various traits were recorded from five randomly selected competitive plants in each treatments and replication. Data on plant height, number of leaves, leaf length and diameter, neck length and diameter, bulb polar and equatorial diameter, average bulb weight, were taken in field. Bulb yield ha^{-1} was computed from the yield obtained $plot^{-1}$. Number of scale $bulb^{-1}$, total soluble solid (TSS) and pyruvic acid (Anthon and Barrett, 2003) was determined in the Departmental Laboratory of Department of Crop Improvement Horticulture and Agricultural Botany, Palli Sikhsa Bhavana. The data on all the growth, yield and post harvest studies were tabulated and subjected to statistical analysis. The total variation for different treatments was tested for significance by "F" test using analysis of variance technique.

RESULTS AND DISCUSSION

The analysis of variance of onion with respect to different traits for graded levels of sulphur application in onion revealed that considerable variation exists for all the studied traits, except number of scales and TSS.

The application of sulphur was effective to increase plant height over no sulphur application (Table 1). The plant height was noted maximum in a range of sulphur application between 20 to 50 kg ha^{-1}. However, plant height was noted decline significantly at higher rate of sulphur application (60 kg ha^{-1}). These results may be related to the benefits of adequate S supplies to the plants, because either low or excessive doses are detrimental to growth and development crops. Several researchers also noticed significant response of onion to sulphur application for this trait [Jana and Kabir (1990), Nagaich *et al.* (1999) and de Souza *et al.* (2015)]. The number leaves contributes the amount of nutrient available to plant through photosynthesis. It was found that sulphur application at the range of 40 to 50 kg ha^{-1} was most effective for this trait (Table 1). Increase in leaf number with the application of sulphur also reported by Nagaich *et al.* (1999), Jaggi (2005) and Tripathy *et al.* (2013). In the present experiment, no sulphur application, and application of sulphur at 10 kg and 60 kg ha^{-1} produced minimum number of leaves per plant. Sulphur application at 20 to 50 kg ha^{-1} resulted maximum leaf length and at 20 to 60 kg ha^{-1} resulted maximum leaf diameter in onion. Maximum neck length and diameter was noted with the sulphur application of 40 and 40 to 50 kg ha^{-1} respectively. On the other hand, no sulphur application or application of sulphur at 10 kg ha^{-1} recorded minimum neck length and diameter. Kumar *et al.* (1998) reported that sulphur application increased neck diameter in onion. On the contrary, Mishu *et al.* (2013) and Tripathy *et al.* (2013) reported that the neck diameter was not significantly affected by different doses of sulphur application.

Both polar and equatorial diameter play important role in determining the shape and size of onion bulb. More efficient S utilization resulted in greater increases in bulb diameter (Abbey *et al.* 2002). Significantly higher polar and equatorial diameter was observed with sulphur application at the range of 20 to 60 kg ha^{-1} (Table 2). Several workers reported that bulb diameter was influenced by sulphur application (Jana and Kabir, 1990; Nagaich *et al.* 1999 and Tripathy *et al.* 2013). No sulphur application or application of sulphur at 10 kg ha^{-1} recorded significantly less polar and equatorial diameter. Average bulb weight is an important yield contributing trait that directly influences the productivity of onion. Bulb weight of onion significantly increased with the application of sulphur over no application. Highest bulb weight was observed with the application of sulphur at the range of 30 to 60 kg ha^{-1}. Increase in bulb weight with increasing rates of sulphur was reported by a number of researchers (Jana and Jahangir, 1990; Nagaich *et al.* 1999; Jaggi, 2005 and Mishu *et al.* 2013). Yield is the main character of consideration nearly for all of the field experiment undertaken. In this experiment, it was noted that of onion yield was significantly increased with the application of sulphur over no application. de Souza *et al.* (2015) reported that onion productivity was 16% lower, when S was not applied. It was also noted that graded level of sulphur application linearly increased the yield of onion up to 50 kg ha^{-1} (bulb yield 35.5 tonnes). Then it started diminishing. Jaggi (2005) and Raina and Jaggi (2008) reported that addition of sulphur after a certain level brought down the yield to lower level. In this experiment sulphur application at 40 to 60 kg ha^{-1} result at par yield. Qureshi and Lawande (2006) reported that onion bulb yield responded significantly to 30 to 75 kg S ha^{-1}. Benefits of sulphur application in onion with respect to increase in yield was recorded by Mishu *et al.* (2013) and Tripathy *et al.* (2013)

The treatment effect on number of scales of onion bulb revealed that application of sulphur has no significant effect (Table 3). Total soluble solid is an important bio-chemical parameter that determines the quality of onion. Experimental data revealed that application of sulphur did not significantly affect TSS content of onion bulb. The quality of onion depends on its pungency. Highly pungent onions are preferred in India. The pyruvic acid content of onion bulbs is associated with its pungency. Onion pungency is primarily determined by the content of flavor precursor compounds and not by total S, total sugars or individual/ total free amino acids in short day bulbs (Lee *et al.* 2009). In this experiment maximum pyruvic acid content in onion bulbs was noticed in sulphur application at 40 and 50 kg ha^{-1}. Control and sulphur application at 10 to 30 kg ha^{-1} and 60 kg $ha^{-1}$was found statistically at par with each other. Thangasamy *et al.* (2013) also find that the pyruvic acid content had significant and positive correlation with sulphur application.

Findings of the present experiment revealed that most of the studied traits and yield of onion response favourably to the sulphur application in a range of 40 to 60 kg ha^{-1}. Thus, sulphur application @40 to 60 kg S ha^{-1} may be recommended to the farmers' for onion cultivation to get better growth, yield and bulb quality under Red and Laterite zone of West Bengal.

Table 1:Effect of sulphur on growth parameters of onion.

Treatment (S kg ha^{-1})	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf diameter (mm)	Neck length (cm)	Neck diameter (mm)
0	50.5 ^{c}	5.2 ^{d}	43.4 ^{c}	7.2 ^{c}	5.7 ^{e}	6.7 ^{c}
10	52.6 ^{bc}	5.6 ^{d}	44.3 ^{bc}	7.7 ^{b}	6.5 ^{d}	7.4 ^{c}
20	54.5 ^{ab}	6.7 ^{c}	46.5 ^{ab}	9.0 ^{ab}	7.0 ^{cd}	9.7 ^{b}
30	56.2 ^{a}	7.3 ^{b}	47.3 ^{a}	9.8 ^{a}	8.0 ^{bc}	9.9 ^{b}
40	56.7 ^{a}	8.5 ^{a}	47.6 ^{a}	10.0 ^{a}	8.8 ^{b}	11.5 ^{a}
50	56.9 ^{a}	8.7 ^{a}	48.2 ^{a}	10.2 ^{a}	10.0 ^{a}	11.8 ^{a}
60	51.5 ^{c}	6.4 ^{c}	43.3 ^{c}	10.1 ^{a}	8.0 ^{bc}	9.2 ^{b}
Mean	**54.13**	**6.9**	**45.8**	**9.2**	**7.7**	**9.4**
LSD (0.05)	**2.85**	**0.47**	**2.39**	**1.59**	**1.13**	**1.42**

Note: Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT

Table 2: Effect of sulphur on bulb diameter, bulb weight and yield of onion.

Treatment (S kg ha^{-1})	Polar diameter (mm)	Equatorial diameter (mm)	Bulb weight (g)	Yield ha^{-1} (t)
0	41.5 ^{b}	43.5 ^{c}	49.1 ^{d}	24.4 ^{d}
10	42.2 ^{b}	48.6 ^{b}	55.4 ^{c}	27.1 ^{c}
20	47.5 ^{a}	49.7 ^{ab}	58.2 ^{bc}	28.3 ^{c}
30	47.8 ^{a}	50.1 ^{ab}	61.1 ^{abc}	32.0 ^{b}
40	48.3 ^{a}	51.4 ^{ab}	63.0 ^{ab}	33.4 ^{ab}
50	50.5 ^{a}	52.6 ^{a}	65.8 ^{a}	35.5 ^{a}
60	48.8 ^{a}	49.7 ^{ab}	63.0 ^{ab}	33.5 ^{ab}
Mean	**46.7**	**49.4**	**59.4**	**30.6**
LSD (0.05)	**3.10**	**3.83**	**6.07**	**2.4**

Note: Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT

Table 3: Effect of sulphur on number of scales, TSS and pyruvic acid of onion.

Treatment (S kg ha^{-1})	Number of scales	TSS (^{0}Brix)	Pyruvic acid (μmol g^{-1})
0	11.0	13.1	5.94 ^{b}
10	11.8	13.4	6.18 ^{b}
20	11.5	13.9	6.29 ^{b}
30	11.8	13.8	6.31 ^{b}
40	12.0	14.0	7.41 ^{a}
50	12.7	14.6	7.77 ^{a}
60	12.3	14.5	6.79 ^{ab}
Mean	**11.9**	**13.9**	**6.7**
LSD (0.05)	**NS**	**NS**	**0.88**

Note: Within a column, means followed by the same letter are not significantly different at the 0.05 level of probability by DMRT

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