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Effect of Sources and Levels of Sulphur on Growth, Yield and Quality of Onion (*Allium cepa L.*)

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A B S T R A C T

An experiment was conducted during rabi-2010-11, 2011-2012 and 2012-2013 at Faculty of Agriculture and Regional Research Station, wadura Sopore, SKUAST-Kashmir. The treatment consists two sources of sulphur (Gypsum and elemental sulphur) and four levels of sulphur (0,15,30,45 kg ha^{-1}). The experiment was laid in a randomised block design with three replications. It was observed that application of sulphur as gypsum recorded maximum growth, yield and quality parameters besides enhancing quality and storage life of bulbs as compared to elemental sulphur. Further it was proved that application of sulphur @45 kg ha^{-1} resulted in significant improvement in most of growth, yield and quality parameters besides enhancing nutrient uptake by crop as well as improving storage life of onion bulbs.

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. India ranks first in area, and next in production after china. In India, onion is being grown in an area of 1270.00 (000 ha) with a production of 21564.00(000 t) and the productivity is 17.30 t ha^{-1} (Annoymous, 2017). Although India has highest area under onion, still it stands second in the production of onion in the world. Hence there is a lot of potential for increasing the production by improving the yields.

In Kashmir onion is grown on an area of 950 ha with a annual production of 24250 t and the productivity is 25.52 t ha^{-1} (Annoymous, 2017). Since the India is the larger exporter of onion foreign exchange. Productivity could be increased by use of suitable varieties, balanced nutrition, need based agronomic practices. Among the many constraints for low production in onion, imbalanced nutrition is the main limiting factor. Sulphur has been recognised fourth major plant nutrient after nitrogen, phosphorus and potassium in crops. Sulphur deficiency is increasing in Indian soils at a faster rate and this has adversely affect the crop production even though crop is applied with recommended dose of N,P,K fertilisers 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 (Thippeswamy, 1993, Tripathy *et al*., 2013). Severe sulphur deficiency during bulb development has detrimental effect on an alkaloid allylpropyl disulphide, in which sulphur is the prime constituent. Sulphur application not only improves the bulb yield, pungency, flavours. Other quality parameters but also improves shelf life also, besides imparting resistance against pests and diseases, Jaggi and Dixit,1999 and Magray *et al*., 2017. Sulphur is essential for building up of sulphur containing amino acids, which are building blocks for essential proteins in plants. It is essential for vegetative growth and bulb development in onion (Anwar *et al.*, 2001). Sulphur deficiency in Indian soils becomes more prevalent due to extensive use of sulphur free fertilisers. 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 "Effect of Different Sources and Levels of sulphur on growth, yield and quality of onion cv. yellow onion was undertaken.

Materials and Methods

A field experiment was conducted during rabi-2010-11,2011-2012 and 2012-2013 at Faculty of Agriculture and Regional Research Station, wadura Sopore, SKUAST-Kashmir. Soil of the experimental plot was clay cloam, having PH of 7.21, Soil organic Carbon 0.60%, Electrical conductivity 0.160 dsm^{-1}, available N, P, K and S, 315, 18.09:156.30:19.49 kg ha^{-1} respectively. The treatment consists two sources of sulphur (Gypsum and elemental sulphur) and four levels of sulphur (0, 15, 30, 45 kg ha^{-1}). The experiment was laid in a randomised block design with three replications. The gypsum as a source of sulphur as per treatments as per treatments was applied at the time of transplanting, while elemental sulphur was applied before 15-20 days of transplanting. The recommended dose of phosphorus (50 kg ha^{-1}), potash (80 kg ha^{-1}), half dose of nitrogen (75 kg ha^{-1}) were applied as top dose on the onset of March. Farmyard manure of seven weeks old were tranplanted @20 t ha^{-1} at a spacing of 15×10 cms in plots of 6.0× 2.00 m size in the last week of November during 2010-13.Recommended package of practices was adopted to raise a healthy crop. The crop was harvested in last week of June in all the three years. The Observations on growth, yield, quality, storage life, nutrient uptake and availability were recorded, using standard procedures. The recorded data was subjected to stastiscal analysis as per the procedure suggested by Panse and Sukhatame (1978).

Results and Discussion

Effect on growth and yield attributing parameters are presented in table 1

Effect of sources of sulphur

Growth and yield parameters (Table 2)

The results on vegetative parameters as influenced by sources indicate a varied response. Number of leaves and plant height showed significant variations, gypsum recording maximum values of 72.57 cm and 12.11 for plant height and number of leaves $plant^{-1}$ respectively as compared to elemental sulphur (69.25 cm, l0.72 leaves $plant^{-1}$). Neck thickness and collar thickness exhibited a non-significant response to sulphur sources recording lower values of 10.22 and 1.80cm respectively with gypsum.

As per table 2 Yield and yield related attributes were significantly influenced by sulphur sources, gypsum proved superior to elemental sulphur. Gypsum recorded higher

values of 6.52 cm,6.13cm and 86.26 gram, 436.41 q ha^{-1} and 405.73 q ha^{-1} for equatorial diameter, polar diameter, average bulb weight, total bulb yield and marketable yield respectively and were significantly superior to the values recorded with elemental sulphur. Gypsum as a source of sulphur gave an additional bulb yield of 17.54 q ha^{-1} over elemental sulphur.

Quality parameters

Keeping quality, TSS and Pyruvicid acid content of onion bulbs was significantly influenced by sulphur sources, gypsum recorded a storage loss of 30.96 which was 3.19 % less, than that recorded with elemental sulphur (34.15) (Table 3).

Gypsum recorded significantly higher values of 11.01% and 6.75 µmolg^{-1} for TSS and pyruvic acid respectively as compared to elemental sulphur (10.51% and 6.54 µmolg^{-1}).

Nutrient uptake

Nutrient uptake depicted a significant response to sulphur applications. Gypsum recorded a uptake of 85.25, 20.51, 70.82 and 27.93 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur respectively and were found significantly superior to the values recorded with elemental sulphur.

Nutrient build up after harvest, resulted an improvement, nitrogen and potassium depicted a non significant build up, while in phosphorus and sulphur, the build up was significant.

Gypsum proved superior to elemental sulphur, recording a nutrient build up of 380.74, 29.20, 205.22 and 27.38 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur respectively (Table 2).

Effect of levels of sulphur

Growth and yield parameters

The data on growth, yield and yield attributes depicted influenced by different levels of sulphur indicate significant variations among different levels of sulphur. A marked increase in the values was observed with the increasing levels.

Application of sulphur@45 kg ha^{-1}(L_4) recorded significantly highest values of 76.40 cm for plant height as compared to all levels. L_4 (45 S kg ha^{-1}) recorded a leaf number of 12.88 cm, which was significantly superior to L_1 (10.09) and L_2 (10.82) but was statistically at par with T_3 (11.86). Neck Thickness and collar thickness recorded lower values of 0.18 cm and 1.54 cm, which were significantly lower to the values recorded with other levels, but exhibited at par results with T_3(30 kg S ha^{-1}) with respect to collar thickness (1.74 cm). Significant variations among sulphur levels were observed with respect to yield and yield related attributes of onion (Table 2).

Sulphur level L_4 (45 kg ha^{-1}) significantly registered higher values of 6.84cm,6.55 cm, 93.43g, 452.51 q ha^{-1} and 483.03 q ha^{-1} for equatorial diameter, polar diameter, average bulb weight, total bulb yield and marketable yield respectively as compared to other levels. Sulphur level 45 kg ha^{-1} (L_4) registered an increase in yield by 29.32%, 16.25% and 10.14% over L_1 (0 kg Sha^{-1}), L_2 (15 kg ha^{-1}) and L_3 (30 kg ha^{-1}) respectively. Similar findings have also been reported by Kumar and Singh (1994), Channagourda *et al.*, (2009) in onion and Magray *et al.,* (2017) in garlic.

Quality parameters (Table 3)

Significantly highest values of 11.54 %,7.06 µ mol g^{-1} were recorded with the application

of 45 kg S ha^{-1} for TSS and pyruvic acid content.L_4 (45 kg S ha^{-1}) recorded a storage loss of 26.18% which was 13.78 % less than that recorded with control (39.96%) (Table 3).

Nutrient uptake

Significant variations were observed for nutrient uptake among sulphur levels. Sulphur application L_4 (45 kg ha^{-1}) recorded an uptake of 94.44,23.89,78.65 and 32.54 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur were found significantly superior the values recorded with rest of the levels. Nutrient build up after harvest resulted an improvement in nitrogen availability depicted a non-significant build up, while phosphorus, potassium and sulphur resulted in a significant build up. L_4 (45 kg ha^{-1}) recorded higher nutrient build up of 386.23, 30.43, 189.34 and 30.04 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur respectively (Table 4).

All the interaction effects on growth, yield and quality parameters were found non-significant except PWL %.

Table.1 Initial status of experimental field with respect to available N, P, K, S, OC and soil pH

Character	Value	Method
Organic carbon (%)	0.60	Walkley and Blacks Method (1934) (Jackson, 1973)
Soil pH	7.21	1:2.5 soil water suspension with Beckman's Glass Electrode pH Meter (Jackson,1967)
Available N (kg ha^{-1})	315	Subbiah and Asija (1956) (Alkaline potassium permanganate method)
Available P (kg ha^{-1})	18.09	Olsens Method (1954) (Extraction with 0.5 M $NaHCO_3$)
Available K (kg ha^{-1})	156.30	Extraction with Neutral Normal Ammonium Acetate (Jackson, 1967)
Available S (kg ha^{-1})	19.49	Extraction by (Williamns and Steinberg, 1959) method and determination by turbidimetric (Chesnin and Yien, 1951) method

Table.2 Effect of various levels of sulphur on growth and yield contributing characteristics of onion (*Allium cepa L.)*

Treatment	Plant height (cms)	No. of leaves	Equator Dia (cms)	Polar Dia (cms)	Neck thickness (cms)	Collar Thickness (cm)	Average bulb weight (g)	Marketable Yield q ha^{-1}	Total Bulb Yield qha^{-1}
Sources									
S_1	72.57	**12.11**	**6.52**	**6.13**	**0.22**	**1.80**	**86.26**	**405.73**	**436.41**
S_2	69.33	10.72	6.23	5.80	0.23	1.86	80.98	372.09	418.87
C.D	1.75	0.76	0.16	0.16	NS	NS	2.06	9.51	11.23
Levels									
L_1 =0 kg ha^{-1}	63.94	10.09	5.83	5.36	0.28	2.15	74.49	330.40	373.50
L_2 =15kg ha^{-1}	69.86	10.82	6.31	5.82	0.23	1.89	80.89	370.58	415.48
L_3 =30 kg ha^{-1}	73.45	11.86	6.54	6.12	0.22	1.74	85.68	402.14	438.56
L_4 =45 kg ha^{-1}	76.40	12.88	6.84	6.55	0.18	1.54	93.43	452.51	483.03
C.D	2.47	1.07	0.23	0.23	0.03	0.23	2.92	13.45	15.88
SxL									
S_1L_1	64.53	10.41	5.99	5.50	0.27	2.12	75.97	339.48	377.11
S_1L_2	70.41	11.13	6.50	6.12	0.23	0.23	83.84	388.11	423.74
S_1L_3	76.00	12.94	6.62	6.20	0.20	0.20	88.49	419.70	447.60
S_1L_4	79.36	13.94	6.98	6.70	0.17	0.17	96.73	475.61	497.18
S_2L_1	63.36	9.77	5.67	5.23	0.28	0.28	73.00	321.32	369.89
S_2L_2	69.31	10.50	6.13	5.52	0.24	0.24	77.93	353.05	407.21
S_2L_3	70.90	10.78	6.45	6.05	0.23	0.23	82.88	384.58	429.52
S_2L_4	73.44	11.81	6.69	6.39	0.19	0.19	90.13	429.41	468.87
C.D @5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV	2.82	7.59	2.90	3.14	11.04	10.11	2.82	2.79	3.00

Table.3 Effect of various levels of sulphur on storage loss and bulb quality of onion

Treatments	PLW (%)	Sprouting (%)	Rotting (%)	Total Losses (%)	T.SS (%)	Pyruvic acid (µ mol g^{-1})
Sources						
S_1	17.79	9.73	3.44	30.96	11.01	6.78
S_2	19.67	10.70	3.78	34.15	10.51	6.54
C.D	0.90	0.99	0.28	-	0.36	0.22
Levels				39.96		
L_1 =0 kg ha^{-1}	22.54	12.88	4.54	31.83	10.06	6.34
L_2 =15kg ha^{-1}	19.58	10.97	3.76	24.61	10.56	6.59
L_3 =30 kg ha^{-1}	17.30	9.21	2.87	29.21	10.88	6.65
L_4 =45 kg ha^{-1}	15.50	7.81	78.65	32.54	11.54	7.06
C.D	0.90	0.99	0.40	0.94	0.52	0.32
SXL						
S_1L_1	22.50	12.40	4.56	39.46	10.15	6.35
S_1L_2	17.83	10.57	3.43	31.83	10.83	6.68
S_1L_3	16.04	8.71	3.16	27.91	11.17	6.75
S_1L_4	14.77	7.23	2.61	24.61	11.90	7.35
S_2L_1	22.57	13.36	4.52	40.45	9.98	6.33
S_2L_2	21.32	11.37	4.08	36.77	10.29	6.51
S_2L_3	18.56	9.70	3.39	31.65	10.58	6.56
S_2L_4	16.23	838	3.12	27.55	11.18	6.77
C.D (5%)	1.27	NS\	NS	---	NS	NS
C.V	3.88	7.80	8.94	---	3.87	3.82

Table.4 Effect of various levels of sulphur on nutrient uptake of onion (*Allium Cepa L.)*

Treatment	Nitrogen Uptake (Kg ha^{-1})	Phosphorus Uptake (Kg ha^{-1})	Potassium Uptake (Kg ha^{-1})	Sulphur Uptake (kg ha^{-1})
Sources				
S_1	85.25	20.51	70.82	27.93
S_2	81.71	18.74	68.18	25.63
C.D	2.68	0.57	1.78	0.66
Levels				
L_1 =0 kg ha^{-1}	71.85	14.88	60.75	20.77
L_2 =15kg ha^{-1}	81.25	18.15	67.24	24.61
L_3 =30 kg ha^{-1}	86.39	21.57	71.37	29.21
L_4 =45 kg ha^{-1}	94.44	23.89	78.65	32.54
C.D	3.78	0.81	2.52	0.94
SXL				
S_1L_1	73.71	15.25	61.03	21.39
S_1L_2	82.43	19.25	68.87	25.42
S_1L_3	87.97	22.45	72.76	30.76
S_1L_4	96.91	25.08	80.61	34.17
S_2L_1	69.99	14.51	60.46	20.15
S_2L_2	80.08	17.05	65.60	23.81
S_2L_3	84.81	20.69	69.97	27.65
S_2L_4	91.96	22.71	76.70	30.92
C.D (5%)	NS	NS	NS	NS
C.V	3.66	3.34	2.93	2.83

The increase in growth, yield and yield related attributes could be due to its role in balanced nutrition and performs in any physiological functions like synthesis of sulphur containing aminoacids, development of profused root system, resulting in increased nutrient uptake, ultimately increasing the photosynthesis, leading to improved growth, higher yield. Similar findings have also been reported by better quality, higher nutrient uptake and sustainable nutrient bulb up in the soil (Dudhat *et al*., 2011, Yaduvanshi and Yadav 2007, Jaggi, 2004, Tripathy *et al.*, 2013, Magray *et al.*, 2017, Nasrin *et al.*, 2007.

In conclusion, the results can be summarised as, the application of sulphur @45 kg ha^{-1} through gypsum is useful to promote better growth, yield, quality, storage life of onion and sustainable nutrient build up in the soil.

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