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Effect of sulphur on yield and quality of onion (*Allium cepa* L.) as influenced by applied sulphur levels and sources in inceptisols of Western Maharashtra

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Abstract

A field experiment was conducted on onion at All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri during *rabi* season of 2010-11. The effect of sources and levels of sulphur application in onion on its growth, yield and quality was studied. The treatments consist of two sources (gypsum and elemental sulphur 95) and six levels of sulphur from each sources i.e. 0, 15, 30, 45, 60 and 75 kg S ha^{-1}). The experiment was conducted in factorial randomized block design with three replications. The observations on growth yield and quality character was recorded and data was analyzed. The results indicated that there was substantial increase in all the characters studied. The polar and equatorial diameter and average weight of bulb was influenced by sources and levels of sulphur application. The efficacy of gypsum and elemental sulphur in increasing total bulb yield was found to be at par. Response to fertilizer sulphur applied at 15 kg S ha^{-1} is substantial. By studying the sulphur use efficiency and apparent sulphur recovery percentage, the maximum yield obtained at 45 kg S ha^{-1}. The pyuvic acid, sulphur content in bulb and S uptake was increase with increasing levels of sulphur. The total storage loss was also improved by increasing levels of sulphur. The sulphur application was beneficial for increasing the yield and quality of onion cv. N-2-4-1 in *rabi* season on inceptisols under Western Maharashtra conditions.

Keywords : Onion, Sulphur, SUE, % ASR, Storage

Introduction

Onion is an important vegetable crop grown worldwide. It is popularly used both in immature and mature bulb stages as a vegetable and as spice. It is used in soups, sauces and for seasoning of foods. It is one of the important basic vegetable of mass consumption in India. Maharashtra, Gujarat, Karnataka and Andra Pradesh produce onions in three seasons viz., rainy, winter and summer. One of the key reasons for average yield of onion is inadequate and unbalanced fertilizer appplication. The balanced use of all the nutrients along with sulphur is necessary for good yields and quality in onion. Sulphur has long been known as inessential major nutrient required for growth and development of plants. Sulphur is essential for synthesis of proteins, oils and vitamins in plant body. It is the constituent of essential amino acids viz., methionione and cysteine, vital for protein production. Volatile S-compounds mainly sulphides are the source of pungency in onions. Sulphur is associated with the production of crops of superior nutritional and market quality. Beneficial effect of sulphur on growth, yield and storage quality of onion has been reported by Mishra and Prasad (1966). Maharashtra is one of the largest onions growing State in India, but it continues to have rather skeletal interest in sulphur nutrition of onion. On the whole, sulphur research on onion in Maharashtra needs to be stepped up in the right earnest. It is necessary to estimate onion response to sulphur fertilization on sulphur deficient soils of Maharashtra. It is also necessary to identify the cheaper source and appropriate levels of sulphur as a fertilizer to onion crop. Keeping in view, the situation of sulphur nutrition of onion in Maharashtra, the present investigation was undertaken to study the effect of sulphur on yields, S uptake, puruvic acid, storage losses and sulphur use efficiency by onion grown under Western Maharashtra conditions on inceptisols.

Materials and Methods

An field experiment was conducted at All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri on onion cv. N-2-4-1 during *rabi*-summer season of 2010-11 in a factorial randomized block design with three replications. The treatment consisted of two sources of S (Gypsum-S1 and Elemental Sulphur 95-S2) and five S levels (15,

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30, 45, 60, 75 kg ha^{-1}) including control i.e. no. sulphur application in each source. The treatment symbolized as T_1-S_1L_1 - 0 kg Sha^{-1}, T_2-S_1L_1 - 15 kg S ha^{-1}, T_3-S_1L_2 - 30 kg S ha^{-1}, T_4-S_1L_3 - 45 kg S ha^{-1}, T_5-S_1L_4 - 60 kg S ha^{-1}, T_6-S_1L_6 - 75 kg S ha^{-1}, T_7-S_2L_1 - 0 kg S ha^{-1}, T_8-S_2L_2 - 15 kg S ha^{-1}, T_9-S_2L_3 - 30 kg S ha^{-1}, T_{10}-S_2L_4 - 45 kg S ha^{-1}, T_{11}-S_2L_5 - 60 kg S ha^{-1} and T_{12}-S_2L_6 - 75 kg S ha^{-1}. Basal application of phosphogypsum and elemental sulphur 95 was made and mixed uniformly in soil before the transplanting time. Recommended dose of 100 kg N, 50 kg P_2O_5, 50 kg K_2O and 20 ton FYM per hectare were applied and mixed with soil for each treatment. Soil of the experimental plot consist of course sand (2.20%), fine sand (44.4%), silt (26.3%), clay (22.5%), bulk density (1.10 mg m^{-3}) with loam texture in class. The PH of the soil was 7.8, EC (0.25 dSm^{-1}) organic carbon (0.60%), available nitrogen (188 kg ha^{-1}), available phosphorus (13.70 kg ha^{-1}), available potassium (330 kg ha^{-1}) and available sulphur (7.3 mg ha^{-1}). Nitrogen, phosphorus and potassium were applied through S-free fertilizers viz., Urea, Single super phosphate and muriate of potash, respectively. All the agronomic practices were adopted to raise good and healthy crop. The samples of onion were dried in oven at 58°C, their weights were taken as dry matter weight of bulbs and tops and these samples were grind, processed and use for nutrients analysis i.e. sulphur content and uptake of sulphur by AOAC (1989). The 10 kg bulbs for each treatment were kept for storage studies of total storage losses after 180 days. The pyruvic acid content was determined by method as suggested by Schwimmer and Weston (1991). The S use efficiency (SUE) and apparent S recovery (ASR) were calculated as,

$$\text{SUE (kg bulb kg-1 applied sulphur)} = \frac{\text{Bulb yield with sulphur} - \text{Bulb yield without sulphur}}{\text{Amount of sulphur applied}} \times 100$$

$$\% \text{ ASR} = \frac{\text{S uptake by crop in S treated plot} - \text{S uptake by crop in control plot}}{\text{Amount of S applied}} \times 100$$

The observations on yield and yield contributing characters and storage studies was recorded and statistically analyzed by using methods given by Panse and Sukhatme (1989).

Results and Discussion

Effect of S application through gypsum and elemental sulphur 95 on bulb growth and yields of onion is presented in Table 1. The growth characters such as plant height, number of leaves and neck thickness was not much influenced by sources and levels of sulphur application. In source, gypsum, the plant height was 76.13 cm (72.67 to 78.53 cm) and for elemental sulphur it was 75.57 cm (70.67 to 81.00 cm). Similar trend was for number of leaves and neck thickness. There was increase in growth parameters due to sulphur levels was also reported by Mishra and Prasad (1966) and

Table 1 : Effect of sources and levels of sulphur on yield of onion.

Treatments	Plant height (cm)	No. of Leaves	Neck thickness (cm)	Average weight of bulb (g)	Polar diameter (cm)	Equatorial diameter (cm)	Premature bolting (%)	Total yield (t/ha)
T1 – S1L1 Gypsum -0 kg S /ha	77.00	12.00	0.83	63.00	4.15	4.89	1.49	42.00
T2 – S1L2 Gypsum -15 kg S /ha	73.93	12.20	0.95	83.33	4.32	5.21	1.25	55.66
T3 – S1L3 Gypsum -30 kg S /ha	72.67	13.13	0.97	83.33	4.39	5.29	1.04	55.59
T4 – S1L4 Gypsum -45 kg S /ha	78.07	12.73	0.97	83.67	4.67	5.29	1.40	55.81
T5 – S1L5 Gypsum -60 kg S /ha	78.53	13.93	1.00	83.67	4.41	5.69	1.13	55.82
T6 – S1L6 Gypsum -75 kg S /ha	76.60	13.87	1.00	83.67	4.72	5.61	1.31	55.98
Mean	76.13	12.64	0.96	80.11	4.44	5.33	1.27	53.48
T7 – S2L1 Elemental Sulphur 95 -0 kg S /ha	70.67	12.60	0.80	63.00	4.48	5.45	1.43	42.03
T8 – S2L2 Elemental Sulphur 95-15 kg S /ha	74.33	13.20	0.81	82.67	4.54	5.57	1.34	55.23
T9 – S2L3 Elemental Sulphur 95-30 kg S /ha	76.27	12.40	0.83	83.67	4.48	5.49	1.19	55.82
T10 – S2L4 Elemental Sulphur 95-45 kg S /ha	74.00	12.93	1.01	83.33	4.43	5.74	1.13	55.61
T11 – S2L5 Elemental Sulphur 95-60 kg S /ha	77.13	12.73	1.00	84.00	4.75	5.54	1.41	55.75
T12 – S2L6 Elemental Sulphur 95-75 kg S /ha	81.00	13.73	1.07	85.00	4.54	5.72	1.39	55.99
Mean	75.57	12.93	0.92	80.28	4.54	5.59	1.32	53.41
S.E. ±								
Source	0.94	0.21	0.03	1.30	0.06	0.07	0.66	8.71
Levels	1.64	0.38	0.06	2.25	0.11	0.13	0.10	15.08
S x L	2.32	0.53	0.09	3.18	0.16	0.19	0.15	21.33
C.D. at 5%								
Source	NS	NS	NS	NS	NS	0.22	NS	NS
Levels	NS	NS	NS	6.60	NS	NS	NS	44.25
S x L	NS	NS	NS	NS	NS	NS	NS	NS

Jaggi and Dixit (1999). Mean average weight of bulb at maturity was influenced by levels of sulphur but there was no much response beyond 15 kg S ha^{-1}. This indicates that the need of sulphur for increasing the weight of bulb even though there was balanced nutrition of NPK to all treatments. However, the response was limited up to 15 kg S ha^{-1}. This indicates synergistic effect of sulphur with other nutrient increasing bulb weight. Similar results were also reported by Shamin *et.al.* (2003). Polar and equatorial diameter was not much differential because of sources and levels of sulphur. Uniform balanced nutrition is resulted in non significant differences in both the diameters. There was substantial increase in diameters due to increased levels of sulphur as compared to control. Increased bulb diameter due to sulphur has been reported by Channagouda *et al.,* (2009). The premature bolting was also reported as non-significant due to sources and levels of sulphur in onion. It is seen from the Table 1, that as sulphur level increased the premature bolting was reduced substantially, but the results was non-significant. The total bulb yield was responding to levels of sulphur significantly but the sources have not very much effect for increasing the yield. The yield is increased with every increase in input of sulphur from 15-75 kg ha^{-1}, but the increase was found to be nonsignificant. This indicates that sulphur has a synergistic effect along with other nutrients like nitrogen in increasing bulb weight, but their effect was seen up to 15 kg S ha^{-1} only and maximum up to 45 kg S ha^{-1}. Increased bulb yield due to sulphur has been also reported by Mishra and Prasad (1966), Shamin *et.al.,* (2003), Qureshi and Lawande (2006) and Channagouda *et.al.,* (2009). The yield was optimum up to 45 kg S ha^{-1} in both sources of sulphur. The bulb yields were not much increased at higher levels of applied S (75 kg S ha^{-1}). Application of 45 kg S ha^{-1} produced an yield of 55.81 t/ha in gypsum source and 55.61 t/ha in elemental sulphur 95 source. The apparent sulphur recovery for 45 kg S ha^{-1} was also maximum i.e. 58.66 % and 59.70% for both sources, respectively. The sulphur use efficiency (SUE) was maximum at 15 kg S ha^{-1} in both sources and gradually decreases with increase in sulphur level applied to onion. Similar results were also reported in cowpea and French bean by Singh *et al.,* (2011).

Data on S uptake and apparent S recovery are presented in Table 2. Sulphur uptake by onion was significantly influenced by the levels of sulphur applied. It was minimum in control (S_1L_1) 68.33 kg/ha and maximum in S_1L_6 (111.47) for gypsum and minimum in control kg/ha 68.30 (S_2L_1) and maximum in S_2L_6 (112.17) for elemental sulphur sources respectively. The apparent S recovery of added S ranged from 45.77 to 58.66 % in gypsum and 50.22 to 59.70 % in elemental sulphur. The greater recovery of S with smaller rates of added S was obtained. However, apparent S recovery with 45 kg S ha^{-1} was higher as compare to other levels of sulphur applied. The higher S uptake by crop may be attributed to the increased availability of the micronized SO_4-S particles in the soil solution through added sulphur 95 and gypsum source and consequently better utilization by plant roots. Similar findings were also reported by Singh *et al.,* (2011).

The TSS%, pyruvic acid, sulphur content in bulbs and storage losses is presented in Table 2. The TSS% has not much influenced by sources and levels of sulphur in onion. It was ranged from 12.93 to 13.57% for various treatments. The pyruvic acid was ranged form 3.20 to 5.63 µmol g-1 in both sources and it was increased with increase in level of sulphur applied. Sulphur fertilization has been effective in increasing pungency of onion due to pyruvic acid. Significant increase in sulphur amino acid concentration in onion bulbs on S fertilization was observed by Jaggi and Dixit (1999) and Quareshi and Lawande (2006). Sulphur application has been found to increase S content (0.35 to 0.51%) in onion bulbs on dry weight basis in present investigation. Qureshi and Lawande (2006) concluded that S content in onion bulbs is increased due to S fertilization. These findings are in close agreement with present investigation also. The total storage losses has been reduced (16.63%) in sulphur applied treatments as compare to control (19.83%) after six months of storage. The L_1 level for both sources has not received any sulphur application and it recorded the maximum storage losses after six months. The remaining levels have received sulphur and recorded minimum losses as compared to control. This indicates that the sulphur has role in reducing storage losses in onion bulbs. Beneficial effect of sulphur on storage quality of onion bulbs has been reported by Mishra and Prasad (1966) and Quareshi and Lawande (2006).

For increasing the yields in *rabi* onion cv. N-2-4-1, there was substantial increase in yield and yield attributing parameters by application of 45 kg S ha^{-1} either in the form of gypsum or elemental sulphur. The other parameter such as pyruvic acid, sulphur content in bulb and S uptake increase with increasing the sulphur levels. The SUE decreases with S levels increases and maximum apparent sulphur recovery was found for 45 kg S ha^{-1}. From the above findings it can be concluded that for obtaining higher yields in onion, the application of sulphur @ 45 kg ha^{-1} from gypsum or elemental sulphur along with recommended dose (100:50:50 NPK kg/ha + 20 t FYM ha^{-1}) of fertilizers. The applied sulphur

Table 2 : Effect of sulphur sources and levels on quality, characters and S uptake by onion.

Treatments	TSS (%)	Pyruvic acid (μ mol g-1)	Sulphur content in bulb (%)	Total storage losses after 180 days (%)	Uptake of sulphur (kg/ha)	SUE (kg bulb kg-1 S)	Apparent sulphur recovery (%)
T1 – S1L1 Gypsum -0 kg S /ha	13.07	3.20	0.35	19.83	68.33	-	-
T2 – S1L2 Gypsum -15 kg S /ha	12.93	4.03	0.40	18.87	75.20	91.00	45.77
T3 – S1L3 Gypsum -30 kg S /ha	12.95	4.50	0.45	19.07	85.03	45.00	55.66
T4 – S1L4 Gypsum -45 kg S /ha	13.21	4.98	0.50	16.40	94.73	31.00	58.66
T5 – S1L5 Gypsum -60 kg S /ha	13.42	5.51	0.51	16.07	102.27	23.00	56.55
T6 – S1L6 Gypsum -75 kg S /ha	13.38	5.63	0.51	16.63	111.47	19.00	57.60
Mean	13.16	4.64	0.45	16.98	89.51	-	-
T7 – S2L1 Elemental Sulphur 95 -0 kg S /ha	13.05	3.20	0.36	19.37	68.30	-	-
T8 – S2L2 Elemental Sulphur 95-15 kg S /ha	13.29	4.03	0.41	19.13	75.83	88.00	50.22
T9 – S2L3 Elemental Sulphur 95-30 kg S /ha	13.34	4.50	0.46	17.37	85.40	46.00	57.00
T10 – S2L4 Elemental Sulphur 95-45 kg S /ha	13.30	4.92	0.47	18.77	95.17	30.00	59.70
T11 – S2L5 Elemental Sulphur 95-60 kg S /ha	13.27	5.51	0.51	16.93	101.73	23.00	55.72
T12 – S2L6 Elemental Sulphur 95-75 kg S /ha	13.57	5.63	0.51	16.87	112.17	19.00	58.49
Mean	13.30	4.63	0.45	18.07	89.77	-	-
S.E. ±							
Source	0.07	0.02	0.004	0.66	0.16	0.04	0.72
Levels	0.12	0.04	0.007	1.15	0.28	0.08	1.25
S x L	0.18	0.06	0.010	1.63	0.40	0.12	1.77
C.D. at 5%							
Source	NS	NS	NS	NS	NS	NS	NS
Levels	NS	0.12	0.022	3.39	0.84	0.25	3.67
S x L	NS	NS	NS	NS	NS	NS	NS

is beneficial for increasing the yield, reducing storage losses and better for obtaining the best quality parameters in onion crop.

सारांश

प्याज के विकास, उपज व गुणवक्ता के प्रति अध्ययन करने हेतु अखिल भारतीय समन्वित अनुसंधान परियोजना, महात्मा फूले कृषि विद्यापिठ, राहुरी में वर्ष 2010–11 में रबी मौसम में किया गया। शोधित घटक में दो स्रोत (जिप्सम व तत्व सल्फर 95) तथा प्रत्येक स्रोत से सल्फर के 6 स्तर यानी 0, 15, 30, 45, 60 तथा 75 किलोग्राम सल्फर/हे.) प्रयोग किया गया। प्रयोग हेतु फैक्टोरिएल रैण्डोमाइजड ब्लाक डिजाइन का प्रयोग कर स्रोत को 3 बार प्रतिकृति किया गया। विकास उपज व गुणवत्ता गुणों को अंकित कर आकड़ों का विश्लेषण किया गया। परिणाम से पता चला कि अध्ययन में प्रयुक्त सभी गुणों में वास्तविक वृद्वि हुई। धुवीय व भूमध्य रेखीय व्यास व औसत कन्द भार सल्फर के स्रोत व स्तर दोनों में प्रभावित हुए। जिप्सम की क्षमता व तत्व सल्फर की प्रभाविता दोनों प्याज के कंद उपज हेतु लगभग समान थे। उर्वरक के रूप में प्रयुक्त सल्फर 15 किलोग्राम/हे. वास्तवितक है। सल्फर प्रयोग क्षमता तथा स्पष्ट सल्फर प्राप्ति प्रतिशत के अध्ययन में सबसे अधिक उपज 45 किलोग्राम/हे. सल्फर देने से प्राप्त हुई। कंदों में पायरूविक सल्फर की मात्रा व सल्फर के ग्रहण की क्षमता सल्फर के स्तर को बढ़ाने से बढ़ गया। कुल भण्डारण नुकसान में कमी भी सल्फर के प्रयोग बढ़ गया। प्याज की प्रजाति एम.–2–4–1 में सल्फर का प्रयोग उपज व गुणवत्ता में वृद्धि पश्चिम महाराष्ट्र की मृदा में रबी मौसम में उपयोगी है।

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