Original Research Article

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

ABSTRACT

The present investigation entitled "Response of onion (*Allium cepa* L.) to different sources and levels of sulphur on growth, yield and quality" was carried out in the Horticulture Research Farm, Sam Higginbottom University of Agriculture And Sciences, Prayagraj during the Rabi season of 2021-22 to find out the best treatment combination for better growth, yield and quality of onion. The experiment was laid out in Randomized Block Design comprising of 13 treatments. The treatments consisted of two sources (viz., Elemental Sulphur and Gypsum) and six levels of sulphur (10, 20, 30, 40, 50 and 60 kg ha^{-1}) along with control group. RDF was applied uniformly to all treatments. The parameters relating to growth, yield and quality were recorded to make a critical analysis of the crop as affected by the different treatments. The technique of representative sample was adopted for recording the observations on various morphological characters in onion. At every observation, five plants from each plot were randomly selected and tagged. The treatments in each replication were allotted randomly. The results revealed that the treatment T10 (40 kg/ha Gypsum + RDF at transplanting) was found to be the most suitable over all the other treatments in relation to growth, yield and quality of onion.

Keywords: growth, yield, quality, elemental sulphur, gypsum, RDF

1. INTRODUCTION

Onion (*Allium cepa* L.) 2n=2x=16, is one of the important bulb crops belonging to family Alliaceae and has gained the importance of a cash crop in recent years because of its very high export potential and grown throughout the world for its food and cuisinal value. Onion is characterized by its distinctive flavor and pungency, which is the due to *Allyl propyl-disulphide*, a sulphur containing compound found in the scales of the bulb. The red and yellow colour of outer skin of onion is due to presence of *Anthocyanin* and *Quercetin*, respectively. Anti-fungal activities in onion is due to a phenolic factor i.e., *Catechol* [1].

The onion plant has hollow leaves and shallow roots. It is a cool season crop, but, however it can adapt to a wide range of climatic conditions. The edible portion is a modified stem, which is known as bulb and develops underground. It is a unique vegetable that is used throughout the year in the form of salad or condiments or for cooking with another vegetable. Onion is also used in preparing various items like soups, sauces, curries, pickles and for flavouring or seasoning foods, onion bulbs have many medicinal properties. It is commonly recommended for people suffering from high cholesterol, weakness, lethargy and lack of vitality. It increases appetite and suppresses the formation of gases. It is used against sunstroke and is the best remedy during summer [2].

Onion is a sulphur loving plant and is required much for proper growth and yield of onion. Sulphur has been recognized as an important nutrient for higher yield and quality of onion bulbs. Sulphur is essential for building up sulphur containing amino acids and also for a good vegetative growth and bulb development in onion [3].

Generally, a heavy dose of fertilizer is recommended for onion cultivation. Onion is a sulphur loving crop and is required much for proper yield and growth of onion. It has been found not only to increase the bulb yields of onion but also improves its quality, especially pungency and flavours. It has also been reported sulphur containing secondary compounds was not only of importance for nutritive value and flavours, but also for resistance against pests and diseases [4].

The yield potential of onion has not been exploited fully as sulphur fertilizers are used in very low quantity in spite of its very high requirement. Sulphur is essential for building up sulphur containing amino acids in plant cells, particularly in the early stage of plant growth. In recent years, sulphur is receiving more attention throughout the world. Non-application of sulphur in sulphur deficient soils has often resulted in low yield of onion. Sulphur deficient plants also had poor utilization of macro and micronutrients and significantly lower total solids in onion bulbs at maturity. Sulphur is also required for synthesis of three important essential amino acids such as cysteine (27% S), cysteine (26% S) and methionine (21% S) besides increasing allyl propyl disulphide alkaloid (43% S) and the capsaicin, the principle alkaloids responsible for pungency in onion and chilli, respectively [5].

The magnitude of response to sulphur application varies with crop to crop, variety soil type, soil sulphur status rate and source of fertilizer. Sulphur could be supplied from a variety of sources such as gypsum, elemental sulphur, ammonium sulphate etc. and these differ in effect, solubility and availability to crop plants. So, in order to incur higher benefits, these different forms of sulphur should be used efficiently and judiciously. Hence, sources of sulphur also play a key role in achieving high fertilizer use efficiency and net return.

2. MATERIAL AND METHODS

A field experiment was carried out during the Rabi season 2021-2022 at the Horticulture Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, 211007 (U.P.) which is situated on the bank of Yamuna river. The experimental site is located in the sub–tropical region, 98 meters above mean sea level. Prayagraj is situated in the south-eastern part of Uttar Pradesh, India. Transplanting of seedlings took place on December 5, 2020.

N-53 variety of onion was selected for the study. The experiment consisted of thirteen treatments replicated thrice. Treatments involved were T0 – Control, T1 – 10 kg/ha Elemental Sulphur + RDF at transplanting, T2 – 20 kg/ha Elemental Sulphur + RDF at transplanting, T3 – 30 kg/ha Elemental Sulphur + RDF at transplanting, T4 – 40 kg/ha Elemental Sulphur + RDF at transplanting, T5 – 50 kg/ha Elemental Sulphur + RDF at transplanting, T6 – 60 kg/ha Elemental Sulphur + RDF at transplanting, T7 – 10 kg/ha Gypsum + RDF at transplanting, T8 - 20 kg/ha Gypsum + RDF at transplanting, T9 - 30 kg/ha Gypsum + RDF at transplanting, T10 - 40 kg/ha Gypsum + RDF at transplanting, T11 -

50 kg/ha Gypsum + RDF at transplanting, T12 - 60 kg/ha Gypsum + RDF at transplanting. The land was ploughed and brought to a fine tilth through ploughing and tillage.

NPK was applied at the rate of 120:60:100 in all treatments. The experiment was conducted in randomized block design (RBD). The plot size was 1m x 1m with 15 cm row to row spacing and 10 cm plant to plant spacing.

Note: 50% of N was applied at the time of transplanting and the remaining amount at 30 days after transplanting.

3. RESULTS AND DISCUSSION

The application of (T10) 40 kg/ha Gypsum + RDF at transplanting was found beneficial in terms of plant height (cm), number of leaves per plant, leaf length (cm), neck diameter (mm), fresh weight of bulbs per plant (g), bulb diameter (cm), bulb yield (q/ha), number of scales, total soluble solid (^{o}Brix) and ascorbic acid (mg/100g).

Application of sulphur at different levels through the different sources were proved significantly different as compared to control in increasing growth, yield and quality of onion (Tables 1, 2 and 3).

3.1 Growth Parameters

The statistical data on growth parameters in different treatments were recorded (Table 1). In this experiment the results revealed that maximum plant height was recorded in T10 (40kg/ha Gypsum + RDF at transplanting) with 39.33 cm, 50.09 cm and 72.11 cm at 30, 60 and 90 DAT respectively whereas the minimum plant height at these stages of growth was found in T0 (Control) which was 28.23 cm, 33.50 cm and 49.39 cm. Maximum number of leaves at 30, 60 and 90 DAT was recorded in T10 (40 kg/ha Gypsum + RDF at transplanting) with 6.71, 8.08, and 11.96 leaves per plant while the minimum number of leaves per plant was recorded in T0 (Control) with 5.24, 6.54 and 8.11 leaves per plant. Maximum leaf length at 30, 60 and 90 DAT was found in T10 (40 kg/ha Gypsum + RDF at transplanting) with 33.33 cm, 44.41 cm and 63.34 cm respectively whereas the minimum leaf length was found in T0 (Control) with 22.07 cm, 27.77 cm and 48.40 cm. Largest neck diameter was recorded in T10 (40 kg/ha Gypsum + RDF at transplanting) with 15.68 mm while the smallest diameter, 11.21 mm was found in T0 (Control).

Sulphur being one of the most important elements in plants influences different growth functions such as nitrogen metabolism, enzyme activity, protein and oil synthesis etc. The increased plant height, leaf length and number of leaves per plant is likely due to the role of sulphur in the synthesis of chlorophyll as well as the fact that sulphur application helps in reducing soil pH, improving soil particle dispersion, thereby improving soil structure and increasing the availability of certain plant nutrients in the soil [6], which are utilized in building of new cells. Increased plant height, leaf length and number of leaves in onion with the application of gypsum as a source of sulphur was recorded by Jaggi [7] and Tripathy *et al.* [8].

The increased neck diameter may be due to the application of gypsum as a source of sulphur, which owing to presence of free calcium in the soil solution reduces its quick solubility as a result of common ion effect and makes gypsum sparingly soluble and prevents the possibility of leaching losses, So, a steadier supply of gypsum is available for longer periods as compared to other soluble sulphate - sulphur sources [9]. This longer sulphur supply helps in higher production of metabolites and increase in meristematic activity. The present results are in conformity with the findings of Wani and Chatoo [10] who also recorded enhanced growth parameters with the application of gypsum as a source of sulphur.

3.2 Yield Parameters

Statistical data on yield parameters was recorded (Table 2). The data reveals that T10 (40 kg/ha Gypsum + RDF at transplanting) recorded the largest polar and equatorial bulb diameter with 69.63 mm and 69.33 mm respectively while the smallest was recorded in T0 (Control) at 53.71 and 53.06 mm. Maximum fresh weight of bulbs per plant was recorded in T10 (40 kg/ha Gypsum + RDF at transplanting) with 132.42 g while the minimum weight was recorded in T0 (Control) with 97.28 g. Highest bulb yield per plot as well as per hectare was recorded in T10 (40 kg/ha Gypsum + RDF at transplanting) at 4.67 kg and 312.46 q respectively, while the lowest yield was obtained from T0 (Control) with 3.44 kg per plot and 229.18 q per hectare. Maximum number of scales per bulb was found in T10 (40 kg/ha Gypsum + RDF at transplanting) with 12.89 scales per bulb. Meanwhile minimum number of scales per bulb was recorded in T0 (Control) with 10.28 scales per bulb.

The enhanced yield attributes might be due to availability of sulphur for a longer period, which helped in better growth and development. Increasing sulphur availability has been associated with enlargement of bulb and increasing bulb weight [11]. Jaggi [12] also recorded similar improved attributes with the application of sulphur in the form of gypsum.

Higher bulb yield response of onion with the application of gypsum along with the recommended dose of fertilizers is likely also linked to the longer availability of sulphur and supply of extra calcium resulting in the development of efficient photosynthetic systems as a result of activation of many enzymes which might have increased the growth rate through increased phosphorylation process in photosynthesis [13]. Enhanced growth rate due to this phenomena is likely further responsible for better partitioning of photosynthetates and their accumulation in the bulbs and the storage organs of the onion, which may have led to increased uptake of N, P, K and S by the crop resulting in improvement of number of scales per bulb and also contributed to improvement in various other yield attributes. Shakila and Sriramachandrasekharan [14] found similar results radish; Jaggi and Raina [15] and Shinde *et al*. [16] have also documented significantly higher bulb yield of onion with application of sulphur through gypsum.

3.3 Quality Parameters

Quality parameters (TSS and ascorbic acid) were recorded (Table 3) and statistical analysis was done. Highest TSS was recorded in T10 (40 kg/ha Gypsum + RDF at transplanting) with 11.5 °Brix whereas minimum TSS was found in T0 (Control) with 9.8 °Brix. The highest ascorbic acid content was found in T10 (40 kg/ha Gypsum + RDF at transplanting) with 11.5 mg/100g while the lowest ascorbic acid content was recorded in T0 (Control) with 9.8 mg/100g.

The increase in TSS with application of gypsum is possibly due to the increased synthesis of primary flavor compounds with sulphur containing amino acids [17].Similar results where

Table 1: Growth parameters of onion as influenced by different sources and levels of sulphur

Treatments	Plant height (cm)			Leaf Length (cm)			Number of Leaves			Neck Diameter (mm)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	
T0-Control	28.23	33.5	49.39	22.07	27.77	48.4	5.24	6.54	8.11	11.21
T1-10 kg/ha Elemental Sulphur + RDF at transplanting	33.19	37	59.77	26.97	31.97	54.04	5.26	6.56	8.37	11.87
T2-20 kg/ha Elemental Sulphur + RDF at transplanting	34.39	37.93	60.36	27.23	33.36	54.4	5.22	6.73	8.37	12.25
T3-30 kg/ha Elemental Sulphur + RDF at transplanting	35.47	43.65	60.52	27.74	38.05	55.92	5.61	7.15	8.39	13.46
T4-40 kg/ha Elemental Sulphur + RDF at transplanting	36.11	46.85	64	30.3	41.41	58.22	6.52	7.83	9.67	14.35
T5-50 kg/ha Elemental Sulphur + RDF at transplanting	36	45.32	63.07	29.66	40.02	57.87	6.23	7.32	9.38	14.31
T6-60 kg/ha Elemental Sulphur + RDF at transplanting	35.59	44.73	62.21	29.84	38.98	56.74	6.22	7.29	9.04	14.14
T7-10 kg/ha Gypsum + RDF at transplanting	33.6	43.52	61.07	27.89	38.06	54.33	5.62	7.18	8.59	13.51
T8-20 kg/ha Gypsum + RDF at transplanting	34.68	44.15	61.81	29.17	38.98	56.41	5.85	7.32	8.63	13.69
T9-30 kg/ha Gypsum + RDF at transplanting	35.47	45.12	62.17	29.36	39.96	56.64	6.04	7.37	8.91	13.85
T10-40 kg/ha Gypsum + RDF at transplanting	39.33	50.09	72.11	33.33	44.41	63.34	6.71	8.08	11.96	15.69
T11-50 kg/ha Gypsum + RDF at transplanting	38.41	47.6	68.92	32.28	42.07	63.03	6.64	7.73	10.48	14.78

Treatments	Plant height (cm)			Leaf Length (cm)			Number of Leaves			Neck Diameter (mm)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	
T12-60 kg/ha Gypsum + RDF at transplanting	36.57	46.87	64.07	30.49	41.85	58.47	6.45	7.66	10.33	14.66
SEd (±)	0.65	0.33	0.36	0.36	0.23	1.21	0.12	0.16	0.23	0.24
CD at 5%	1.35	0.69	0.75	0.74	0.47	3.52	0.25	0.32	0.48	0.5

Table 2: Yield parameters of onion as influenced by different sources and levels of sulphur

Treatments	Bulb Diameter (mm)		Fresh weight of bulbs per plant (g)	Bulb Yield		No. of scales per bulb
	Polar Diameter (mm)	Equatorial Diameter (mm)		Yield/plot (kg)	Yield (q/ha)	
T0 Control	53.71	53.06	143.24	3.44	229.18	10.28
T1 10 kg/ha Elemental Sulphur + RDF at transplanting	56.11	55.11	152.69	3.66	244.3	10.4
T2 20 kg/ha Elemental Sulphur + RDF at transplanting	57.39	56.44	160.14	3.84	256.22	11.38
T3 30 kg/ha Elemental Sulphur + RDF at transplanting	58.56	57.56	168.24	4.04	269.18	11.92
T4 40 kg/ha Elemental Sulphur + RDF at transplanting	65.94	66.28	185.76	4.46	297.22	12.53
T5 50 kg/ha Elemental Sulphur + RDF at transplanting	64.94	64.83	183.46	4.4	293.54	12.48

Treatments	Bulb Diameter (mm)		Fresh weight of bulbs per plant (g)	Bulb Yield		No. of scales per bulb
	Polar Diameter (mm)	Equatorial Diameter (mm)		Yield/plot (kg)	Yield (q/ha)	
T6 60 kg/ha Elemental Sulphur + RDF at transplanting	63.56	63.56	183.18	4.39	293.09	11.88
T7 10 kg/ha Gypsum + RDF at transplanting	59.89	59.17	170.44	4.09	272.7	10.78
T8 20 kg/ha Gypsum + RDF at transplanting	61.14	61.33	175.67	4.22	281.07	11.54
T9 30 kg/ha Gypsum + RDF at transplanting	62.61	62.28	182.23	4.37	291.57	12.32
T10 40 kg/ha Gypsum + RDF at transplanting	69.63	69.33	195.29	4.67	312.46	12.89
T11 50 kg/ha Gypsum + RDF at transplanting	68	67.67	192.63	4.62	308.21	12.64
T12 60 kg/ha Gypsum + RDF at transplanting	67	67	190.45	4.57	304.72	12.61
SEd (±)	0.95	0.78	1.56	0.05	1.76	0.07
CD at 5%	1.97	1.61	3.21	0.11	3.63	0.13

Table 3: Quality parameters of onion as influenced by different sources and levels of sulphur

Treatments	TSS (°Brix)	Ascorbic Acid (mg/100g)	Cost of Cultivation (Rs.)	Gross return (Rs/ha)	Net Return (Rs/ha)	Benefit Cost Ratio
T0-Control	9.8	10.2	128136	343800	215664	1.68
T1-10 kg/ha Elemental Sulphur + RDF at transplanting	10.1	10.88	133636	366450	232814	1.74
T2-20 kg/ha Elemental Sulphur + RDF at transplanting	10.27	11.31	139136	384300	245164	1.76
T3-30 kg/ha Elemental Sulphur + RDF at transplanting	10.4	11.41	144636	403800	259164	1.79
T4-40 kg/ha Elemental Sulphur + RDF at transplanting	11.27	13.01	150136	445800	295664	1.96
T5-50 kg/ha Elemental Sulphur + RDF at transplanting	11.03	12.66	155636	440250	284614	1.83
T6-60 kg/ha Elemental Sulphur + RDF at transplanting	10.87	12.16	161136	439650	278514	1.73
T7-10 kg/ha Gypsum + RDF at transplanting	10.67	11.53	131536	409050	277514	2.1
T8-20 kg/ha Gypsum + RDF at transplanting	10.53	11.83	134936	421650	286714	2.12
T9-30 kg/ha Gypsum + RDF at transplanting	10.73	12.28	138336	437400	299064	2.16
T10-40 kg/ha Gypsum + RDF at transplanting	11.5	13.62	141736	468750	327014	2.31
T11-50 kg/ha Gypsum + RDF at transplanting	11.4	13.21	145136	462300	317164	2.18
T12-60 kg/ha Gypsum + RDF at transplanting	11.27	13.13	148536	457050	308514	2.07
SEd (±)	0.32	0.07				
CD at 5%	0.65	0.14				

application of gypsum as a source of sulphur resulted in increase in total soluble solids was also investigated by Tripathy *et al*. [18]. The combined effects of different fertilizers, especially between sulphur and nitrogen which work synergistically, is most likely responsible for the increase in ascorbic acid content. Similar results where increase in ascorbic acid content of onion bulbs with application of sulphur through gypsum were obtained by Vivek and Backiyavathy [19].

3.4 Economics

In terms of economics, the maximum benefit cost ratio, 2.31, was observed in T10 (40 kg/ha Gypsum + RDF at transplanting) while the minimum benefit cost ratio was observed in T0 (Control) which was 1.68.

4. CONCLUSION

It is concluded from the present experiment findings that T10 (40 kg/ha Gypsum + RDF at transplanting) produced the best results in all parameters recorded i.e., leaf length, plant height, number of leaves, neck diameter, bulb diameter, fresh weight of bulbs per plant, bulb yield, number of scales, total soluble solids and ascorbic acid content. Regarding economics of various treatments, maximum gross return (Rs. 468750) and net return (Rs. 327014) along with the benefit cost ratio (2.31) was also obtained in T10 (40 kg/ha Gypsum + RDF at transplanting).

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