



Effect of Different Level of Potassium and Sulfur Fertilizers on Growth and Yield of Onion (*Allium cepa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MdMHM and MdAR designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MdIH and MdRKJ managed the analyses of the study. Author KS wrote the final draft and did all the editing after submitting the paper. Author AAK, MdSR and SNA managed the literature searches. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:

<https://prh.ikpress.org/review-history/12194>

Original Research Article

Received: 18/04/2024

Accepted: 21/06/2024

Published: 25/06/2024

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Cite as: Manik, M. M. H., Razzaque, M. A., Haque, M. I., Joha, M. R. K., Syfullah, K., Khanam, A. A., Reza, M. S., & Afrose, S. N. (2024). Effect of Different Level of Potassium and Sulfur Fertilizers on Growth and Yield of Onion (*Allium cepa* L.). *Asian Journal of Agriculture and Allied Sciences*, 7(1), 33–40. Retrieved from <https://journalagriculture.com/index.php/AJAAS/article/view/40>

ABSTRACT

An experiment was undertaken at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October, 2020 to June 2021 to observe the influence of different levels (100, 120, 140 and 160 kg K/ha) of potash and sulfur (5, 15, 25, and 35 kg S/ha) on growth, yield of BARI Piaz-6 in Randomized Complete Block Design having two factors with three replications. There is significant difference was observed in the leaf number, leaf length, bulb diameter, bulb height, individual bulb weight, bulb yield due to different doses of S. In case the effect of different doses of potassium showed significant variation in the above all parameters, where the highest and lowest results were obtained at 140 and 100 kg/ha potassium doses. The interaction effects of different doses of S and K significantly influenced on all growth and yield data. The highest plant height, leaf number, leaf length, bulb diameter, bulb height, individual bulb weight, bulb yield was observed at 140 kg/ha potassium with 35 kg/ha dose of sulfur and the lowest values of these parameter were found at the lowest doses of S (5 kg S/ha) and K (100 kg K/ha) combination.

Keywords: Potassium; sulfur; leaf; bulb; yield; Onion.

1. INTRODUCTION

Onion (*Allium cepa* L.) is a spice crop from the family Alliaceae, has the chromosome number $2n=16$ [1]. It has entered into farmers field 5000 years ago and there is no wild species of it. It is on the FAO's 15 vegetable and spice crops list [2]. In 2022, the global area cultivated with onion was about 5.96 million ha, which produced 110 million Mg, with a calculated average yield of 18 Mg ha⁻¹ [3]. Among all the spices crops onion has the significance for its diversified use. It is known as the kitchen queen. It is one of the main spice elements for curry, pilaf, biryani etc. The high nutritional value (vitamins, proteins, iron and calcium) and using versatility make it one of the most important vegetables as well as spice crops within the world [4]. The anti-oxidant and anti-cancer element quercetin is found in onion [5]. During growth period onions need a great amount of different nutrients. Throughout the whole life cycle, among the major nutrients, potassium is highly needed. Many physiological activities, like protein formation, respiration, photosynthesis, ion absorption and transferring, resisting the pollutant and diseases, as well as, increasing the yield and vegetative growth, all are interconnected with potassium [6-10]. Sulfur plays as a constituent of secondary compounds for alline, cycloalline and thio propanol, which are responsible for taste, pungency, resistance against pest and diseases with some medicinal properties. It is required not only for plant growth and yield, but also for bulb yield [2]. The objective of the study was effects of different doses of sulfur and potassium on plant height, leaf number, leaf length, bulb diameter, bulb height, individual bulb weight, bulb yield of onion (BARI Piaz-6).

2. MATERIALS AND METHODS

The experiment was undertaken in October, 2020 to June 2021 at the farm of Sher-e-Bangla Agricultural University (SAU), Dhaka and in the Department of Agricultural Chemistry, SAU, Dhaka, Bangladesh.

2.1 Plant Materials

The high yielding cultivar of Onion BARI Piaz-6 was used as experimental planting material. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

2.2 Treatments

The experiment was set in Randomized Complete Block Design (RCBD) having two factors with three replications.

The two factors are given below:

Factor A: Four doses of sulfur	Factor B: Four doses of Potassium
1.S1 = 5 kg S/ha	K1= 100 Kg K ha-1
2.S2 = 15 kg S/ha	K2= 120 Kg K ha-1
3.S3 = 25 kg S/ha	K3= 140 Kg K ha-1
4.S4 = 35 kg S/ha	K4= 160 Kg K ha-1

Treatment combination: Sixteen treatment combinations

S1K1, S1K2, S1K3, S1K4, S2K1, S2K2, S2K3, S2K4, S3K1, S3K2, S3K3, S3K4, S4K1, S4K2, S4K3, S4K4

2.3 Experimental Design and Layout

The experiment was set in Randomized Complete Block Design (RCBD) having two factors with three replications.

Factor 1: Four doses of sulfur ($S_1= 5$ kg S/ha, $S_2 = 15$ kg S/ha, $S_3 = 25$ kg S/ha and $S_4 = 35$ kg S/ha)

Factor 2: Four doses of Potassium ($K_1= 100$ kg K/ha, $K_2= 120$ kg K/ha, $K_3= 140$ kg K/ha and $K_4 = 160$ kg K/ha)

Replication: 3

The four doses of sulfur in combination with four doses of Potassium ($4 \times 4=16$) were randomly assigned to 48 (16×3) experimental plots. Each plot was $1\text{m} \times 1\text{m}$ (1m^2) in size. The distance maintained between two plots was 0.50 m and between blocks was 0.75m.

2.4 Agricultural Practice

Onion was sown in a nursery early in September 2020, transplanted on 14 November, and harvested as bulbs on 24 May 2021. Irrigation was practiced when necessary and all the other agricultural practices were carried out on time. According to FRG, (2012) (Fertilizer Recommendation Guide, BARC 2012) the recommended doses of urea as a source of Nitrogen (120 kg N/ha), Triple super phosphate (TSP) as a source of phosphorus (60 kg P/ha), were added to the soil of main experimental plots. According to sulfur and potassium treatments, the required amounts of S and K from gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and muriate of potash (KCL), respectively were applied at the unit plots. The whole amounts of P, S and K fertilizers were applied at the time of final plot preparation as per treatment of the experiment. The urea fertilizer was applied by 3 splits application during land preparation and at 25 & 45 days after seedlings transplantation.

2.5 Data Collection and Recording

Data were recorded on the following parameters from the sample plants during the course of experimentation.

1. Plant height
2. Leaf number
3. Leaf length
4. Bulb Diameter
5. Bulb height
6. Individual bulb weight
7. Bulb yield

2.6 Statistical Analysis

The collected data were analyzed statistically following RCBD design by MSTAT-C computer package programs developed by [11]. The treatment means were compared by Duncan's

Multiple Range Test (DMRT) and regression analysis were performed as and where necessary.

3. RESULTS

3.1 Plant Height

For sulfur, the tallest plant was 40.44 cm for 35kg/ha. The height was 42.83 cm for 140kg/ha potassium doze. During the interaction effect of S and K, the height (43.19 and 43.13 cm) was higher than individual doze of S and K. The combination of K and S dozes were 140kg K/ ha, 35 and 15 kg S/ha.

For sulfur, the shortest plant was 39.72 cm for 5kg/ha. The height was 36.38 cm for 100kg/ha potash doze. During the interaction effect of S and K, the height (35.25 cm) was lower than individual doze of S and K. The combination of K and S dozes were 100kg K/ ha and 5 kg S/ha.

3.2 Leaf Number

The maximum leaf number (5.29) was produced at the highest dose of S (35 kg S/ha), which was statistically similar with 25 and 15 kg S/ha doses. For potassium, 140 kg K/ha gave the maximum leaf number (5.60). For interaction effect, the maximum number of leaf (5.80) was found in 140 kg K/ha with 35 kg S/ha, which was statistically similar with 140 kg K/ha at 5 and 15 kg S/ha.

The minimum leaf number (4.83) was found at the lowest dose of S (5 kg S/ha).whereas the lowest dose of potassium (100 kg K/ha) produced the minimum number of leaf (4.40). The minimum number of leaf (3.87) was found at the lowest dose of S and K combination (5 kg S/ha with 100 kg K/ha).

3.3 Length of Leaf

The highest leaf length (36.39 cm) was produced at S dose of 35 kg/ha, which was gradually decreased until the lowest dose of S. The maximum length of leaf (38.36 cm) was produced by 140 kg K/ha dose of potassium, which was statistically similar with 160 kg K/ha dose potassium. The interaction effect of different doses of S and K significantly influenced leaf length of BARI Piaz-6. The maximum length of leaf (39.03 cm) was found in 35 kg S/ha with 140 kg K/ha, which was statistically similar with 160 kg K/ha in same dose S and also 140 kg K/ha with 15 and 25 kg S/ha.

The lowest dose of potassium (100 kg K/ha) produced the minimum length of leaf (30.34 cm). The lowest values of leaf length (28.19 and 29.44 cm) were found at 100 kg K/ha with 5 and 15 kg/ha sulfur doses, respectively.

3.4 Bulb Diameter

For the 35 and 25 kg/ha sulfur application, the maximum bulb diameter was 30.52 mm. whereas there was the maximum bulb diameter was 31.41 mm for 140 kg/ha of potassium. During the combined application of both fertilizers, the maximum bulb diameter was 32.19 mm finding at 35 kg S/ha with 140 kg K/ha, which was statistically similar with 120 kg K/ha at same doze Sulfur.

The minimum bulb diameter was 29.56 mm for 5 and 15 kg kg/ha dose of S. It was 28.65 mm for 100 kg/ha of potassium. The lowest values of bulb diameter (28.33 and 28.36 mm) were found at 100 kg K/ha with 5 and 15 kg/ha sulfur doses, respectively.

3.5 Bulb Height

For 35 kg/ha and 25kg/ ha sulfur application, there was the highest bulb height (28.41 mm). It was 28.95 mm for 140 kg/ha potassium application. For 35 kg S/ha with 140 kg K/ha, which was statistically similar with 160 kg K/ha at same dose S, the height was 29.75 mm. S

For 5 and 15 kg S/ ha application, the minimum bulb height was 27.16 mm. The minimum bulb height was 26.64 mm for 100 kg K/ha. The lowest values of bulb height (26.13, 26.33 and 26.43 mm) were found at 100 kg K/ha with 5, 25 and 35 kg/ha sulfur doses, respectively; which were statistically similar with 120 kg/ha K dose at 25 kg/ha S dose.

3.6 Individual Bulb Weight

The highest individual bulb weight (29.11 g) was found at 35 kg/ha S dose. The highest individual bulb weight (30.01 g) was recorded at 140 kg/ha K dose. The highest individual bulb weight (33.40 g) was found at 35 kg S/ha with 140 kg K/ha dose.

The lowest individual bulb weight (25.38 g) was recorded at 5 kg/ha S dose, which was statistically similar with 15 kg/ha S dose. It was lowest (24.21 g) at 100 kg/ha K dose, which was

statistically similar with 120 kg/ha K dose. The lowest values of individual bulb weight (22.40 and 22.93 g) were found at 5 kg S/ha with 100 and 120 kg/ha K doses, respectively.

3.7 Bulb Yield

The highest bulb yield (10.48 t/ha) was found at 35 kg/ha S dose. The highest bulb yield (10.80 t/ha) was recorded at 140 kg/ha K dose. The maximum bulb yield (12.02 t/ha) was found at 35 kg S/ha with 140 kg K/ha dose.

The lowest bulb yield (9.14 t/ha) was recorded at 5 kg/ha S dose, which was statistically similar with 15 kg/ha S dose. It was lowest (8.72 t/ha) at 100 kg/ha K dose, which was statistically similar with 120 kg/ha K dose. The lowest value of bulb yield (8.06 t/ha) was found at 5 kg S/ha with 100 kg K/ha and it was statistically similar at 5 kg S/ha with 120 kg/ha K dose.

4. DISCUSSION

For the 35 kg/ha sulfur, there was the tallest plant (40.44cm), maximum leaf numbers (5.29), highest leaf length (36.39 cm), maximum bulb diameter (30.32 mm), highest bulb height (28.41 mm), highest individual bulb weight (29.11 g) and highest bulb yield (10.48 t/ha). In some cases, another amount of sulfur gave the highest result, like 25 and 15 kg S/ha doses gave maximum leaf number, and 25 kg s/ha gave maximum bulb diameter and height. Reducing the doses of sulfur fertilizer declines the parameters. At 5 kg/ ha application, we got the minimum result. Tilahun [12] conducted a field experiment to evaluate the effect of nitrogen and sulfur fertilizers on the growth, yield, quality and nutrient uptake of onion. The interaction effect of nitrogen and sulfur significantly increased plant height. Bappy [13] conducted a field experiment to determine the growth and yield of onion as influenced by Sulphur and Boron with mulch materials. In the case of Sulphur and Boron treatments at 60 days after transplanting (DAT), the highest plant height was 53.38 cm, maximum leaf number of 10.48 was found at S60 kg B3 kg/ha. Nahar [14] carried out a field experiment to evaluate the effects of boron and Sulphur on the growth and yield of summer onion. Results of the experiment revealed that the highest plant height (26.84 cm at 75 DAT) was obtained when S was applied at the rate of 30 kg/ha.

Table 1. Effects of different doses of sulfur and potassium on plant height (cm), leaf number plant-1, Leaf length (cm) Bulb diameter, Bulb height, individual Bulb weight and Bulb yield of BARI Piaz-6

Treatment	Plant height (cm)	Leaf number Plant ⁻¹	Leaf length (cm)	Bulb diameter (mm)	Bulb height (mm)	Individual bulb weight (g)	Bulb yield (t ha ⁻¹)
S doses (kg/ha)							
5	39.72	4.78 b	34.48 c	29.56 b	27.16 b	25.38 c	9.14 c
15	40.43	5.08 a	35.30 bc	29.92 b	27.22 b	25.44 c	9.16 c
25	39.67	5.11 a	35.88 ab	30.51 a	28.23 a	27.13 b	9.77 b
35	40.44	5.29 a	36.39 a	30.52 a	28.41 a	29.11 a	10.48 a
Signi. Level	NS	**	**	**	**	**	**
LSD _{0.05}	-	0.23	0.91	0.41	0.49	0.80	0.29
CV (%)	4.09	5.34	3.08	1.63	2.10	3.58	3.55
K doses (kg/ha)							
100	36.38 d	4.40 d	30.34 c	28.65 c	26.64 d	24.21 c	8.72 c
120	39.76 c	5.00 c	35.61 b	30.32 b	27.28 c	24.66 c	8.89 c
140	42.83 a	5.60 a	38.36 a	31.41 a	28.95 a	30.01 a	10.80 a
160	41.28 b	5.27 b	37.74 a	30.13 b	28.14 b	28.17 b	10.14 b
Signi. Level	**	**	**	**	**	**	**
LSD _{0.05}	1.36	0.23	0.91	0.41	0.49	0.80	0.29
CV (%)	4.09	5.34	3.08	1.63	2.10	3.58	3.55

Table 2. Interaction effects of different doses of sulfur and potassium on plant height, leaf number, leaf length, Bulb diameter (mm),Bulb height (mm),Individual bulb weight (g) ,Bulb yield ,(t ha-1) of BARI Piaz-6

Treatment		Plant height (cm)	Leaf number Plant ⁻¹	Leaf length (cm)	Bulb diameter (mm)	Bulb height (mm)	Individual bulb weight (g)	Bulb yield (t ha-1)
S doses (kg/ha)	K doses (kg/ha)							
5	100	35.25 f	3.87 g	28.33 f	26.13 f	22.40 i	28.19 e	8.06 i
	120	39.17 cde	4.80 def	29.22 ef	26.78 ef	22.93 i	34.42 c	8.26 i
	140	42.70 ab	5.60 ab	31.28 b	28.16 bcd	28.75 cd	37.85 ab	10.35cd
	160	41.74 abc	4.87 def	30.23 cd	27.61 de	27.67 de	37.45 ab	9.96 de
15	100	36.25 ef	4.40 f	28.36 f	27.67 de	25.17 gh	29.44 e	9.09 fgh
	120	40.95 abc	4.87 def	30.72 bc	27.97 cd	26.06 efg	35.95 bc	9.38 ef
	140	43.13 a	5.60 ab	31.28 b	29.06 ab	30.27 bc	38.30 a	10.90 bc
	160	41.39 abc	5.47 abc	31.12 b	28.22 bcd	27.00 ef	37.51 ab	9.72 ef
25	100	36.38 ef	4.77 def	28.94 ef	26.33 f	23.78 hi	31.71 d	8.56 hi
	120	39.27 cde	5.07 cde	29.17 ef	26.44 f	23.91 hi	35.93 bc	8.63 ghi
	140	42.30 abc	5.40 abc	30.89 bc	28.83 abc	27.63 de	38.26 a	9.94 de
	160	40.72 abc	5.20 bcd	29.83 de	27.22 def	26.21 efg	37.60 ab	9.44 ef
35	100	37.66 def	4.57 ef	28.94 ef	26.43 f	25.51 fgh	32.01 d	9.18 fg
	120	39.65 bcd	5.27 bcd	32.18 a	27.94 cd	25.74 fg	36.12 bc	9.27 f
	140	43.19 a	5.80 a	32.19 a	29.75 a	33.40 a	39.03 a	12.02 a
	160	41.25 abc	5.53 abc	29.33 e	29.51 a	31.79 b	38.39 a	11.44 b
Signi. Level		*	*	*	**	**	**	**
LSD _{0.05}		2.73	0.45	1.83	0.82	0.97	1.60	0.57
CV(%)		4.09	5.34	3.08	1.63	2.10	3.58	3.55

** 1 % level of Significance; * 5 % level of Significance; NS Non-significant

For 140 kg/ha potassium, we got the maximum plant height (42.83 cm), maximum leaf number (5.60), the maximum leaf length (38.36 cm), maximum bulb diameter (31.41 mm), highest bulb height (28.95mm), highest individual bulb weight (30.01 g) and highest bulb yield (10.80 t/ha). Reducing the doses of potassium fertilizer declines the parameters. At 100 kg/ ha application, we got the minimum result. The above result indicates that onion yield and quality depended on a considerable K supply Behairy, DíazPérez, Garg, Bekele [15,16,17,18] stated that potassium fertilizer application at different levels significantly affected growth, yield and quality parameters, i.e. plant height, leaf length, leaf number, sheath length, bulb weight, bulb length, bulb diameter and bulb shape index. Fatematuzzohora [19] experimented to assess the effect of potassium fertilizer on improving summer onion production. In the case of different doses of potassium, the highest leaf number per plant (13.93) was recorded from 120 kg K ha⁻¹. In this experiment, we got a threshold level of potassium 140 kg/ha. We have maximum growth here. The amount higher or lower than it did not give the maximum growth. Bekele [18] stated that there was a statistically highly significant ($p < 0.001$) difference encountered in mean bulb weight due to the application of K at different levels.

During the combination of sulfur and potassium, the dose S 140 kg/ha and potassium 35 kg/ha gave the maximum height (43.19 cm), maximum leaf number (5.80), maximum leaf length (39.03 cm), maximum bulb diameter (32.19 mm), highest bulb height(29.75mm), highest individual bulb weight (33.40 g) and highest bulb yield (12.02 t/ha). The sulfur potassium combined application showed the highest result than the individual fertilizer application. The dose of the combination may vary. According to Ozkan C. F [20] under a similar K application rate (270 kg K₂O ha⁻¹), additional S supply brought about significant yield increases of 10-20%, depending on fertilizer type. The increase in mean bulb weight with the supply of K and S nutrients could be due to more luxuriant growth, foliage and leaf area and a higher supply of photosynthates, which help produce more giant bulbs, resulting in higher yields. Similar results are reported in a significantly higher yield of bulb (24.7ton ha⁻¹) and fresh weight of bulbs (49.53 g) with application of 150 kg of K₂O ha⁻¹ over other potassium levels [21].

5. CONCLUSION

In conclusion, the findings of the present study speak of the significance of K and S supply in obtaining high onion growth and yield. Interactions between K, and S, when adequately supplied, further increase onion yields. High rates of K and S application did not make any positive relation with growth and high yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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