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Original Article

Effects of boron and sulphur application on growth and yield of summer onion

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A B S T R A C T

A field experiment was carried out at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh to evaluate the effects of boron and sulphur on growth and yield of summer onion during the period from February to June, 2017. The experiment consisted of two-factors, Factor A: four levels of boron *viz.*, (i) B_0 = 0 kg B ha^{-1}, (ii) B_1 = 0.5 kg B ha^{-1}, (iii) B_2 = 1.0 kg B ha^{-1}, (iv) B_3 = 1.5 kg B ha^{-1}; and Factor B: four levels of sulphur, *viz.*, (i) S_0 = 0 kg S ha^{-1}, (ii) S_1 = 15 kg S ha^{-1}, (iii) S_2 = 30 kg S ha^{-1}, (iv) S_3 = 45 kg S ha^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. BARI Piaz-3, a summer onion variety was used as planting material for this experiment. Results of the experiment revealed that B and S alone or in combination significantly influenced all the parameters studied. The highest plant height (28.74 cm at 75 DAT), bulb diameter (2.87 cm), individual weight of bulb (23.06 g), per cent dry matter (8.64) and yield of bulb (11.54 ton ha^{-1}) were obtained when B applied at the rate of 1 kg ha^{-1} and the lowest for these parameters were obtained from the control treatment i.e. 0 kg B ha^{-1}. On the other hand, the highest plant height (26.84 cm at 75 DAT), bulb diameter (2.84 cm), individual weight of bulb (21.73 g), per cent dry matter (8.28) and yield of bulb (10.88 ton ha^{-1}) were obtained when S applied at the rate of 30 kg/ha and the lowest for these parameters were recorded from 0 kg S/ha. Among the treatment combinations, 1.0 kg B ha^{-1} and 30 kg S ha^{-1} produced the maximum values for plant height (29.74 cm at 75 DAT), bulb diameter (3.06 cm), individual weight of bulb (25.83 g), per cent dry matter (9.03) and yield of bulb (12.93 ton ha^{-1}) while the lowest for these parameters were obtained from the control treatment i.e. without boron and sulphur fertilizers.

Introduction

Onion (*Allium cepa* L.) belonging to the family Alliaceae and genus *Allium*, is one of the most important vegetable and spice crops in the world as well as in Bangladesh. It is used to prepare almost every food item by all classes of people. It relieves head sensation and insect bites due to its medicinal properties. Onion contains vitamin B, vitamin C and also iron, calcium and volatile oil. Onion is used for treating digestion problems, heart and blood vessel problems and for preventing hardening of the arteries.

In Bangladesh, it is usually grown in winter season and commercially cultivated in the greater districts of Dhaka, Faridpur, Rajshahi, Rangpur, Kustia, Khulna, Barisal and Pabna (BBS, 2018). Annual production of onion in Bangladesh is 1700 thousand tons and the annual demand is about 2400 thousand tons (BBS, 2018). Therefore, the prevailing shortage of onion is about 700 thousand tons per year. To meet up this demand, Bangladesh has to import onion every year (Hossain and Islam, 2011) at the expense of hard earning foreign currency. Moreover, the demand of onion is increasing day by day with the increasing population. This acute situation could be improved by many ways such as bringing more land under cultivation, increasing yield through introducing improved varieties, adopting improved production technologies, off-season production of onion i.e. during summer, etc.

It is worth mentioning that the land is extremely limited in Bangladesh. Therefore, the horizontal expansion of onion cultivation is very difficult in Bangladesh. At the same time, introduction of high yielding varieties from the temperate regions of the world does not seem to be sound because their climatic requirements cannot be fulfilled under Bangladesh condition. Therefore, growing onion during summer is the only possibility to expand onion production in Bangladesh.

Recently, Bangladesh Agricultural Research Institute (BARI) has developed and released three onion varieties, namely BARI Piaj 2, 3 and 5 which are suitable to grow in summer season, but their productivity and improved production technology has not yet been established. Thus, adopting new and improved production technologies would be a major way to increase onion production in this country.

Application of nutrients with proper dose is important for the production of onion. Micronutrients especially boron is essential for normal growth and production of sound and healthy vegetables. Boron has been linked with initiation and development of growing points, movement of sugars and starches to developing parts, movement of nutrient elements within the plant, formation of plant hormones affecting vegetative growth, root growth and health of fleshy roots, flower and fruit set, quality and flavor of vegetables (Hossain *et al*., 2008; Jahiruddin, 2011; Jahiruddin and Islam, 2014). Boron is one of the most important micronutrient for onion production and is essential for cell division, nitrogen and carbohydrate metabolism, protein formation and water relation in plant growth (Tariq *et. al*., 2018). Although it is quickly taken up from the soil, it is relatively immobile in the plant. It is important to maintain the correct balance of calcium, nitrogen and boron in the soil.

Among the plant nutrients, boron and sulphur have vital role in plant growth and development. Onion is a sulphur loving plant and is required much for proper growth and yield of onion (Kumar and Singh, 1995; Rashid, 2010). Sulphur has been found not only to increase the bulb yield of onion but also improves its quality, especially pungency and flavors (Jaggi and Dixit, 1999; Mishu *et. al*., 2013). Bell (1981) also reported sulphur containing secondary compounds was not only of importance for nutritive value and flavors, but also for resistance against pests and diseases. The yield potential of onion has not been exploited fully as the sulphur fertilizer is used in very low quantity instead of its very high requirement. However, the effects of boron on growth and yield of onion especially on summer onion has not been yet established in Bangladesh. Considering the above facts, the current study has been undertaken to investigate the role of sulphur and boron on growth and yield of summer onion.

Materials and Methods

The experiment was carried out at the Horticultural Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from February 2017 to June 2017. The seeds of onion variety BARI piaj-3 were collected from Spices Research Sub-center, Bangladesh Agricultural Research Institute (BARI), Lalmonirhat.

Two-factor experiment consisted of four levels of boron (B) i.e., B_0: 0, B_1: 0.5, B_2: 1.0 and B_3: 1.5 kg B ha^{-1}, respectively; and four levels of sulphur (S) fertilizer viz., S_0: 0, S_1: 40, S_2: 80 kg and S_3: 120 kg K ha^{-1}, respectively. Borax (11% boron in borax) and gypsum (18% S in gypsum) were used as the sources of boron and sulphur according to the treatments. The experiment was laid out in a randomized complete block design with three replications. In addition to boron and sulphur fertilizers, other manures and fertilizers such as, cowdung 10 ton ha^{-1}, urea 200 kg ha^{-1}, triple super phosphate (TSP) 175 kg ha^{-1} and zinc 3 kg ha^{-1} (FRG, 2012) were applied for normal growth and development of summer onion plant. The entire amount of cowdung, TSP, gypsum, zinc sulphate (source of zinc), 1/3rd of muriate of potash were applied during final land preparation. Rest 2/3rd muriate of potash and entire amount of urea were top dressed in three equal installments at 15, 30 and 45 days after transplanting. Seedlings were raised in seedbed and 45-day-old healthy seedlings were transplanted in 1 m x 1 m plot maintaining a distance of 20 cm x 15 cm keeping plot to plot and block to block distance 50 cm and 100 cm, respectively. Data were collected from five randomly selected plants from each plot and were statistically analyzed to find out the statistical significance of the experimental results. The means for all the treatments were calculated and the analyses of variance for all the characters were performed by F test. The significance of difference between the pairs of means was separated by LSD test at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Main effects of boron on the plant height were found to be significant ($P \leq 0.05$) at different days after transplanting (DAT). Application of boron @ 1.0 kg ha^{-1} produced the tallest (28.74 cm) plants and the shortest (23.02 cm) was found in control treatment (B_0) at 75 DAT (Table 1). Main effect of different levels of sulphur was also found to be significant on the plant height at different days after transplanting (Table 1). Maximum plant height (26.84 cm) was obtained from S_2 and the minimum plant height (25.66 cm) was recorded in control treatment (S_0) at 75 DAT (Table 2). The combined effects of boron and sulphur was also significant in respect of plant height. However, the maximum plant height was obtained with treatment combination B_2S_2 and the minimum with B_0S_0. At 60 DAT, the maximum plant height was obtained with same (B_2S_2) treatment combination, while the minimum from B_0S_0. In contrast, at 75 DAT, the tallest (29.74 cm) plant was observed with the treatment combination of B_2S_2 and the shortest (22.34 cm) with B_0S_0 (Table 3). Result of present study was in agreement with the findings of Smriti *et al.* (2002) who reported that the application of both boron and sulphur increased the plant height. Fatematuzzohora *et. al*. (2020) also found that application of higher doses of potassium fertilizer increased the plant height of summer onion cultivated during *Kharif* 2 season.

Number of leaves per plant

An increased number of leaves indicates better growth and development of onion crop and is directly related to the yield of bulb. The more leaves, the more photosynthetic area and thereby higher yield. Seedling age gave significant variation in respect of leaf number per plant at different DAT at ($P \leq 0.05$). The highest number of leaves per plant (7.85) was obtained when the plants were fertilized with boron @ 1.0 kg^{-1} and the lowest number of leaves per plant (6.39) produced from the control treatment (B_0) (Table 1). Sulphur had significant influence on number of leaves per plant. Effect of different doses of sulphur on the number of leaves per plant increased with the increase in sulphur level. At 75 DAT the highest number of leaves (7.48) was obtained from 30 kg S ha^{-1} whereas the control treatment (S_0) produced the lowest number of leaves per plant (6.94). Probably, the application of sulphur increased with the increased height of plants and ultimately the leaf number was increased due to the influence of this nutrient (Table 2). Number of leaves per plant was significantly influenced by the combined effect of boron and sulphur. The number of leaves per plant was recorded to be the highest (8.33) from 1.0 kg B ha^{-1} with 30 kg S ha^{-1} followed by 1.5 kg Bha^{-1} with 30 kg S ha^{-1}

treatment (7.87) whereas the lowest number (6.23) was found from control treatment (Table 3). Result of present study is supported with the findings of Manna and Maity (2016) who reported that the application of both boron and sulphur increased the number of leaves per plant in onion.

Table 1. Effects of seedling age on growth, yield and yield contributing characters of summer onion

Doses of boron	Plant height at 75 DAT	No. of leaves at 75 DAT	No. of roots per plant at harvest	Length of bulb (cm)	Diameter of bulb (cm)	Individual bulb weight (g)	Bulb dry matter content (%)	Bulb yield (ton ha^{-1})
B_0	23.02	6.39	7.45	2.82	2.44	15.25	6.87	7.65
B_1	24.54	6.95	8.91	3.33	2.62	17.08	7.75	8.54
B_2	28.74	7.85	10.12	3.89	2.87	23.06	8.64	11.54
B_3	28.24	7.67	9.59	3.73	2.72	20.46	8.33	10.24
LSD $_{(0.05)}$	0.22	0.08	0.07	0.05	0.05	0.13	0.09	0.16
Level of significance	*	*	*	*	*	*	*	*

B_0, B_1 and B_2 indicate 0, 0.5, 1.0 and 1.5 kg boron ha-^{1}, respectively; * indicate significant at 5% level of probability.

Number of roots per plant

Analysis of variance revealed that the effects of boron and sulphur significantly influenced the number of root per plant (P≤0.05). Application of different levels of boron showed significant variation on number of root per plant (Table 1). Maximum numbers of roots per plant (10.12) was obtained from B_2 treatment and that of the minimum (7.45) was from B_0 treatment (Table 1). Main effects of different levels sulphur on number of roots per plant were also significant. The Maximum number of roots per plant (9.42) was obtained from S_2 treatment while minimum number of roots per plant (8.69) was recorded from S_0 treatment (Table 2). The combined effects of boron and sulphur showed significant variation on number of roots per plant. Maximum number of roots (10.53) was produced in B_2S_2 treatment and that of the minimum (7.14) in B_0S_0 treatment (Table 3). The result is in agreement with Bohni (2015) who reported that boron application at 0.5% increased number of roots in onion.

Length of bulb

The variation in respect of bulb length due to the effects of different levels of boron and sulphur were found to be statistically significant (P≤0.05). The maximum length of bulb (3.89 cm) was observed from the B_2 treatment, while the control treatment produced the minimum length (2.82 cm) of bulb (Table1). On the other hand, the maximum bulb length (3.62 cm) was obtained with the treatment S_2 and that of the minimum (3.18 cm) from S_0 treatment (Table 2). Combined effects of boron and sulphur showed significant variations in respect of bulb length of onion. The highest bulb length (4.16 cm) was obtained from the treatment combination B_2S_2, while the minimum length (2.55 cm) was obtained from B_0S_0 treatment combination (Table 3). Result of present study was in agreement with the findings of Manna *et al*. (2014) and they observed that the application of both boron and sulphur increase bulb length of onion.

Table 2. Effects of different doses of potassium fertilizer on growth, yield and yield contributing characters of summer onion

Doses of potassium	Plant height at 75 DAT	No. of leaves at 75 DAT	No. of roots per plant at harvest	Length of bulb (cm)	Diameter of bulb (cm)	Individual bulb weight (g)	Bulb dry matter content (%)	Bulb yield (ton ha^{-1})
S_0	25.66	6.94	8.69	3.18	2.53	16.50	7.42	8.27
S_1	25.82	7.15	8.89	3.46	2.62	17.86	7.87	8.94
S_2	26.84	7.48	9.42	3.62	2.84	21.73	8.28	10.88
S_3	26.22	7.29	9.08	3.52	2.66	19.76	8.03	9.88
LSD (0.05)	0.22	0.08	0.07	0.05	0.05	0.13	0.09	0.16
Level of significance	*	*	*	*	*	*	*	*

S_0, S_1, S_2 and S_3 indicate 0, 15, 30 and 45 kg ha-^{1} sulphur, respectively; * indicate significant at 5% level of probability.

Diameter of bulb

Results revealed that the effects of boron and sulphur were highly signification in respect of the diameter of bulb (P≤0.05). Bulb diameter of onion was influenced by the single effects of boron and sulphur. The highest bulb diameter (2.87 cm) was obtained from B_2 treatment while the lowest bulb diameter (2.44cm) was obtained from B_0 treatment (Table 3). On the other hand, the maximum bulb diameter (2.84 cm) was obtained with the treatment of S2 and the minimum bulb diameter (2.53 cm) observed with S_0 treatment (Table 2). Combined effects of boron and sulphur showed significant variation among different treatment combinations. The treatment combination B_2S_2 produced the highest bulb diameter (3.06 cm) and that of B_0S_0 produced the lowest (2.28 cm) where no boron and sulphur were used (Table 3). Result of present study was in agreement with the findings of Abedin *et al*. (2012) and observed that the application of both boron and sulphur increase bulb length of onion.

Weight of individual bulb

The effects of boron and sulphur were significant in respect of individual weight of bulb per plant (P≤0.05). Significant variation was observed on individual bulb weight when different levels of boron were applied. The highest individual bulb weight (23.06 g) was recorded in the treatment B_2, while the lowest weight of individual bulb (15.25 g) was recorded in B_0 treatment (Table 1). On the other hand, main effects of sulphur on individual bulb weight showed significant variation. Maximum bulb weight (21.73 g) was obtained from S_2 and minimum (16.50 g) was obtained from S_0 (Table 2). The combined effects of boron and sulphur on individual bulb weight showed significant variation among different treatment combinations. The treatment combination B_2S_2 produced the maximum bulb weight (25.83 g) while control treatment (B_0S_0) produced the minimum bulb weight (13.13 g) (Table 3). This might be due to beneficial effect of boron on growth parameters which has increased yield and yield related parameters of onion. There may be favourable effects of boron on root development, formation of carbohydrates, regulation of water and translocation of photosynthates to bulbs from leaves. The higher photosynthesis accumulation in the bulbs would ensure higher individual bulb weight and large bulb diameter which collectively increases the bulb yield of onion. Similar finding was also reported by Mishra *et al.,* (1990), Singh and Verma (1991) and Chattopadhyay and Mukhopadhyay (2004) in onion.

Dry matter content of bulb

Dry matter content of bulb, expressed in percentage, was significantly influenced by the different levels of sulphur and boron ($P \leq 0.05$). Main effects of different levels of boron on dry matter content of bulb had been shown in (Table 1). It was observed that the maximum dry matter (8.64%) was obtained from B_2 treatment, whereas the minimum dry matter (6.87%) was obtained from control treatment (B_0). The main effects of different levels of boron and sulphur were also differed among the treatment combinations in respect of dry matter content of bulb (Table 2). The maximum dry matter (9.03%) of bulb was produced from the treatment combination of B_2S_2, while the combination of B_0S_0 gave the minimum dry matter (6.19%) (Table 3). The dry matter of bulb increased when doses of boron and sulphur were increased. These results corroborated with studies of Fatematuzzohora *et al*. (2020), Nasreen *et al*. (2007) and Smriti *et al*. (2002).

Table 3. Combined effects of seedling age and different doses of potassium fertilizer on growth, yield and yield contributing characters of summer onion

Treatment combination	Plant height at 75 DAT	No. of leaves at 75 DAT	No. of roots per plant at harvest	Length of bulb (cm)	Diameter of bulb (cm)	Individual bulb weight (g)	Bulb dry matter content (%)	Bulb yield (ton ha^{-1})
B_0S_0	22.34	6.23	7.14	2.55	2.28	13.13	6.19	6.60
B_0S_1	22.50	6.33	7.26	2.82	2.47	14.65	6.93	7.37
B_0S_2	23.98	6.53	7.76	3.04	2.50	17.34	7.28	8.70
B_0S_3	23.25	6.47	7.64	2.89	2.49	15.90	7.10	7.93
B_1S_0	24.20	6.67	8.82	3.13	2.48	14.84	7.57	7.43
B_1S_1	24.32	6.80	8.91	3.33	2.59	16.03	7.69	8.00
B_1S_2	24.88	7.17	9.02	3.44	2.76	19.25	7.96	9.63
B_1S_3	24.76	7.17	8.91	3.42	2.65	18.20	7.79	9.10
B_2S_0	28.13	7.47	9.65	3.58	2.75	20.39	8.27	10.20
B_2S_1	28.46	7.80	9.98	3.92	2.82	22.45	8.62	11.23
B_2S_2	29.74	8.33	10.53	4.16	3.06	25.83	9.03	12.93
B_2S_3	28.64	7.80	10.32	3.92	2.83	23.58	8.64	11.80
B_3S_0	27.95	7.40	9.14	3.47	2.59	17.65	7.65	8.83
B_3S_1	28.01	7.67	9.41	3.78	2.60	18.32	8.24	9.17
B_3S_2	28.76	7.87	10.36	3.84	3.03	24.51	8.85	12.27
B_3S_3	28.24	7.73	9.46	3.83	2.66	21.35	8.59	10.70
$LSD_{0.05}$	0.45	0.16	0.14	0.09	0.11	0.27	0.18	0.32
Level of significance	*	*	*	*	*	*	*	*

B_0, B_1 and B_2 indicate 0, 0.5, 1.0 and 1.5 kg boron ha-^{1}, respectively; S_0, S_1, S_2 and S_3 indicate 0, 15, 30 and 45 kg ha-^{1} sulphur, respectively; * indicate significant at 5% level of probability.

Yield of bulb

Yield of onion bulb was influenced by different doses of boron. The highest yield of bulb (11.54 ton ha^{-1}) was recorded with the treatment of B_2, while the lowest yield of bulb (7.65 ton ha^{-1}) was obtained from B_2 treatment (Table 1). The yield of bulb also increased significantly by the application of different levels of sulphur. The highest bulb yield (10.88 ton ha^{-1}) was obtained from S_2 treatment while the lowest bulb yield (8.27 ton ha^{-1}) was recorded in S_0 treatment (Table 2). The combined effects of different levels of boron and sulphur on the yield of bulb of onion were significant. It was observed that same treatment combinations of boron and sulphur produced higher yield than boron and sulphur alone. Maximum yield (12.93 ton ha^{-1}) was produced at B_2S_2 treatment combination while minimum yield (6.60 ton ha^{-1}) was obtained from the treatment combination of B_0S_0 (Table 3).

The application of boron might enhanced photosynthesis accumulation in the bulbs would ensure higher individual bulb weight and large bulb diameter which collectively increases the bulb yield of onion. Similar finding were also reported by Mishra *et al.*, (1990), Singh and Verma (1991) and Chattopadhyay and Mukhopadhyay (2004) in onion. In this study, it was noted that 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 tons). Then it started diminishing. Raina and Jaggi (2008) reported that addition of sulphur after a certain level brought down the yield to lower level. 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).

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References

Abedin MJ, Alam MN, Hossain MJ, Ara NA, Haque KMF (2012). Effect of micronutrients on growth and yield of onion under calcareous soil environment. International Journal of Biosciences 2(8): 95-101.

BBS (2018). Bangladesh Bureau of Statistics, Ministry of Planning, Government of People's Republic of Bangladesh. pp 58.

Bohni, NF (2015) Effect of potassium and sulphur on growth and yield of summer onion, MS Thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh. pp. 18.

Bose TK, Som MG (1990). Vegetable crops in India. Nayaprokash, Calcutta 6, pp. 545-582.

Chattopadhyay A, Mukhopadhyay R (2004). Response of onion to boron as foliar feeding. Indian Journal Ornamental Horticulture 11: 21-27.

Chroboczek E (1936). Study of some problems connected with growing and storage of onion. Annals of Horticulture Science 3: 57-137.

de Souza LFG, Filho ABC, de Túlio, FA Nowaki RHD (2015). Effect of sulphur dose on the productivity and quality of onions. Australian Journal of Crop Science 9: 728-33.

Fatematuzzohora, Sultana S, Karim MR (2020). Effects of seedling age and potassium fertilizer on growth and yield of summer onion. Asian Journal of Crop, Soil Science and Plant Nutrition 4(1): 134-140.

FRG (2012). Fertilizer Recommendation Guide-2005. Bangladesh Agricultural Research Council, Farmgate, New Airport Road, Dhaka. pp. 117.

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research. (2nd Ed.). John Wiley and Sons, New York. pp. 28-192.

Hossain AKMA, Islam J (2011). Status of *Allium* production in Bangladesh. Acta Horticulturae 358: 33-36.

Hossain MA, Jahiruddin M, Islam MR, Mian MH (2008). The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbean-rice system. Plant and Soil 306: 13-22.

Jaggi RC (2005). Sulphur levels and sources affecting yield and yield attributes in onion (*Allium cepa*). Indian Journal of Agricultural Science 75: 154-56.

Jaggi RC, Dixit SP (1999). Onion (*Allium cepa* L.) responses to sulphur in representative vegetable growing soils of Kangra Valley of Himachal Pardesh. Indian Journal of Agricultural Science 69: 289-291.

Jahiruddin M (2011). Screening, selection and molecular characterization of boron efficient wheat genotypes. Project Completion Report, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Jahiruddin M, Islam MR (2014). Project Report (2011-2014). Requirement of Micronutrients for Crops and Cropping Patterns. PIU-BARC (NATP Phase-I) project. Project ID No. 339.

Kumar A, Singh O (1995). Effect of sulphur deficiency on plant growth and yield of onion. Indian Journal of Agricultural Research 29: 127-130.

Manna D, Maity TK (2016). Growth, yield and bulb quality of onion (*Allium cepa* L.) in response to foliar application of boron and zinc. Journal of Plant Nutrition 39(3): 438-441.

Manna D, Maity TK, Ghosal A (2014). Influence of foliar application of boron and zinc on growth, yield and bulb quality of onion (*Allium cepa* L.). Journal of Crop and Weed 10(1): 53-55.

Mishra HP, Singh KP, Yadow JP (1990). Influence of zinc, iron, boron and manganese and their uptake on onion (*Allium cepa* L.) growth in calcareous soil. Haryana Journal of Horticulture Science 19: 153- 159.

Mishu HM, Ahmed, F, Rafii MY, Faruq G. Latif MA (2013). Effect of sulphur on growth, yield and yield attributes in onion (*Allium cepa* L.). Australian Journal of Crop Science **7**: 1416-22.

Nasreen S, Haq SMI, Hossain MA (2003) Sulphur effects on growth responses and yield of onion. Asian Journal of Plant Science 2: 897-902.

Nasreen S, Haque M, Hossain M, Farid A (2007) Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. Bangladesh Journal of Agricultural Research 32: 413-420

Qureshi AA, Lawande KE (2006). Response of onion to sulfur application for yield, quality and its storability in S-deficient soils. Indian Journal of Agricultural Science 76: 535-37.

Raina SK, Jaggi RC (2008). Effects of sulphur in presence and absence of farmyard manure on onion (*Allium cepa*) under onion-maize (*Zea mays*) cropping sequence. Indian Journal of Agricultural Science 78: 659-62.

Rashid, M.H.A. 2010. Effect of sulphur and GA_3 on the growth and yield of onion. Progressive Agriculture 21 (1&2): 57-63.

Singh SH, Verma SK (1991). Influence of potassium, zinc and boron on growth and yield of tomato (*Lycopersicon esculentum* Mill.). Vegetable Science 18:122-129.

Smriti S, Kumar R, Singh SK (2002). Effect of sulphur and boron nutrition on growth, yield and quality of onion. Journal of Applied Biology 12: 40-46.

Tariq AB, Chatto MA, Mustaq F, Akhter F, Mir SA, Zagar MY, Wani KP, Shah MD, Parry EA (2018). Effect of Zinc and Boron on Growth and Yield of Onion under Temperate Conditions. International Journal of Current Microbiology and Applied Sciences 7(4): 3776-3783.

Tripathy P, Sahoo BB, Priyadarshini A, Das SK, Dash DK (2013). Effect of sources and levels of sulphur on growth, yield and bulb quality in onion (*Allium cepa* L.). International Journal of Bio-resource and Stress Management 4: 641-44.