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Effect of Zinc and Boron on Growth and Yield of Onion under Temperate Conditions

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A B S T R A C T

An investigation was performed at the experimental field of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K) during Rabi 2015-16 and Rabi 2016-17 to find out the effect of different levels of zinc and boron on growth, yield and quality of onion. The experiment was laid out in Randomized completely block design with three replications comprising of two factors with four levels of each viz., Zinc (Z), Z_0 (control or no zinc), Z_1 (2.500 kg ha^{-1}), Z_2 (5.00 kg ha^{-1}) and Z_3 (7.500 kg ha^{-1}) and Boron (B), B_0 (control or no boron), B_1 (0.500 kg ha^{-1}), B_2 (1.000 kg ha^{-1}) and B_3 (1.500 kg ha^{-1}). The observations were recorded on growth, yield and quality from 10 randomly selected plants of each treatment. Pooled analysis revealed significantly maximum values for plant height (66.07 cm), number of leaves plant^{-1} (10.61) and leaf length (41.36cm) as compared to other levels including control. Similarly application of boron @ B_3 (1.500 kg ha^{-1}) recorded significantly maximum values for plant height (64.67 cm), No of leaves plant^{-1} (10.38) and leaf length (41.08 cm) while significantly lowest values for plant height (58.69 cm), No of leaves plant^{-1} (9.06) and leaf length (38.63 cm) were recorded in control. Pooled analysis revealed that zinc @ 7.500 kg ha^{-1} (Z_3) recorded maximum values for polar diameter (6.31 cm), equatorial diameter (6.32 cm), average bulb weight (82.64 g) and total bulb yield (275.50 q ha^{-1}) followed by Z_2 (5.000 kg ha^{-1}). Similarly application of boron @ 1.500 kg ha^{-1} (B_3) recorded significantly maximum values for polar diameter (5.95 cm), equatorial diameter (6.14 cm), average bulb weight (81.15 g) and total bulb yield (270.29 q ha^{-1}).

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India. Onion is the most widely cultivated species of the genus *Allium*. It belongs to family Alliaceae. The edible bulb can grow up to 10 cm in diameter; it is composed of several overlapping layers on a central core. The edible portions of the bulb are the enlarged leaf bases and compact stem. Green onions also called scallions are eaten for their immature bulb and green foliage.

Onion is a cool season vegetable crop but is among the most widely adapted vegetable crops. They can be grown from the tropics to subarctic regions. This adaptation is primarily due to differing response to day length. Unlike most other species, day length influences bulbing in onions as opposed to flowering. Onion bulbs are placed into three groups based on their response to hours of day length. The short-day bulb varieties with day lengths of 11-12 hours while intermediate bulb varieties with day lengths of 13-14 hours and are found in the mid-temperate regions of this country; finally, the long-day varieties are adapted to the most northern climates with day lengths of 16 hours or greater.

Onion (*Allium cepa* L.), the "Queen of Kitchen" is one of the most important commercial crop not only in India but also in the world. Onion is cultivated under an area of 3991.51 ('000 ha) with a production of 76377.21 ('000 Mt) in the world (Anonymous, 2015). India ranks first in area and is the second largest producer of onion in the world, next to China, accounting for 22.18 per cent of the world area and 18.78 per cent of the world production. In India, onion is being grown in an area of 1274 ('000ha) with production of 21717.70 ('000 Mt) and the productivity is 17.04 t ha^{-1} which is low (Anonymous, 2015). Productivity of onion were higher in the case of Turkey (34.3 Mt ha^{-1}) followed by Brazil (26.1 Mt ha^{-1}). In Kashmir it is grown under an area of 950 ha and produces 24250 (Mt) with a productivity of 25.4 (T ha^{-1}) (Anonymous, 2015). Due to lower yields, though India has the highest area under onion, it stands second in the production of onion in the world. Hence, there is a lot of potential for increasing the production of onion by improving the yields. India is also the largest exporter of onion and hence, it is crucial to improve the yields for enhancing the export level, so that it helps in earning foreign exchange for the exchequer of the country. Productivity could be increased by use of suitable varieties, balanced nutrition, optimum water management as well as need based plant protection measures. Among the many constraints for low productivity in onion, imbalanced nutrition is the main limiting factor.

Fertilizers offer the best means of increasing yield, quality and maintaining soil fertility. Results of various fertilizers have revealed that essential elements are important viz., nitrogen, phosphorus, potassium, sulphur, etc. In addition to nitrogen, phosphorus, potassium and sulphur, zinc as a micronutrient have great role in the fertilization program to achieve higher and sustainable bulb yields (Singh and Tiwari, 1995). Zinc is a micronutrient which is required for plant growth and development relatively in small amount. Zinc is involved in the formation of Chlorophyll and carbohydrate and is also involved in a diverse range of enzyme system. The functional role of zinc includes auxin metabolism, influence on the activities of dehydrogenase and carbonic anhydrate enzymes, synthesis of cytochrome and stabilization of ribosomal fractions (Tisdale *et al.,* 1984). Zinc also plays very important role for grain formation and nutrition. Zinc deficiency is prevalent worldwide in temperate and tropical climates

(Fageria *et al.,* 2011). Zinc deficiency has been reported in soils of India and Kashmir (Mandal *et al.*, 2000 and Wani *et al.*, 2013). Application of zinc increased the growth and yield of onion (Phor *et al.*, 1995).

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 growth, root growth and health of fleshy roots, flower and fruit set and quality and flavor of vegetables (Vitosh *et al.*, 2001). Boron is one of the important micronutrient for onion production and is essential for cell division, nitrogen and carbohydrate metabolism, protein formation and water relation in plant growth (Brady, 1990). 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. High calcium and high nitrogen levels can reduce boron uptake. Boron deficiency has been observed in soils with high organic matter contents (Valk *et al.,* 1989). Soils of Jammu and Kashmir are mostly dominated by Lithic or Typic Udorthents (Sidhu *et al.*, 1999). These soils have already been reported to be deficient in boron (Mondal, 2002). The soils of Himalayas were found very low in boron (Khatri and Ghimire, 1992). Application of boron increases bulb size, weight per bulb and yield of onion (Smiriti *et al.*, 2002). Keeping In view of above facts, the present study was undertaken to investigate the "Response of onion cv. Yellow Globe to different levels of zinc and boron under temperate conditions".

Materials and Methods

The investigation entitled "Response of onion cv. Yellow Globe to different levels of Zinc and Boron under temperate conditions" in Kashmir valley was carried out during Rabi 2015-16 and Rabi 2016-17 at Vegetable Experiment Farm, Division of Vegetable Science, SKUAST-K, Shalimar. The experiment was laid out in randomized Complete Block Design (RCBD), the total number of treatments were sixteen with three replications. The sixteen treatment combinations, Z_0 B_0 (No Zinc + No boron), Z_0 B_1 (No Zinc + 0.500 kg boron ha^{-1}), Z_0 B_1 (No Zinc + 0.500 kg boron ha^{-1}), Z_0 B_2 (No Zinc + 1.000 kg boron ha^{-1}), Z_0 B_2 (No Zinc + 1.500 kg boron ha^{-1}), Z_1 B_0 (2.500 kg zinc ha^{-1}+ No boron), Z_1 B_1 (2.500 kg zinc ha^{-1} + 0.500 kg boron ha^{-1}), Z_1B_2 (2.500 kg zinc ha^{-1} + 1.000 kg boron ha^{-1}), Z_1 B_3 (2.500 kg zinc ha^{-1}+ 1.500 kg zinc ha^{-1}), Z_2 B_0 (5.000 kg zinc ha^{-1} + NO boron), Z_2 B_1 (5.000 kg zinc ha^{-1} + 0.500 kg boron ha^{-1}), Z_2B_2 (5.000 kg zinc ha^{-1} + 1.000 kg boron ha^{-1}), Z_2 B_3 (5.000 kg zinc ha^{-1} + 1.500 kg zinc ha^{-1}), Z_3 B_0 (7.500 kg zinc ha^{-1} + NO boron), Z_3 B_1 (7.500 kg zinc ha^{-1} + 0.500 kg boron ha^{-1}), Z_3B_2 (7.500 kg zinc ha^{-1} + 1.000 kg boron ha^{-1}), Z_3 B_3 (7.500 kg zinc ha^{-1}+ 1.500 kg zinc ha^{-1}).

The entire dose of FYM was applied as basal dose and thoroughly incorporated in the soil. The recommended dose of fertilizer for onion i.e., 120: 80: 60: 45 NPKS kg ha^{-1}, whole of phosphorus and potassium along with half dose of Nitrogen was applied at the time of sowing to plots in which recommended dose of fertilizer was to be applied. Moreover, zinc and boron were also applied to soil as per the treatments at the time of planting.

The remaining half dose of nitrogen was given as top dose after 128 days. Urea (46 % N), Di-ammonium phosphate (18 % N, 46 % P_2O_5), Muriate of potash (60 % KCL) and Gypsum (18%), zinc sulphate (35 % Zn) and solubor (20.5 % B) were applied as sources of nitrogen, phosphorus, potassium, sulphur, zinc and solubor respectively.

Results and Discussion

Pooled analysis of data over the years 2015-16 and 2016-17 revealed that plant height significantly increased with increasing levels of zinc. Significantly maximum plant height (66.07), number of leaves plant^{-1} (10.61) and leaf length (41.36 cm) was recorded with treatment Z_3 (7.500 kg Zn ha^{-1}) as compared to other treatments whereas control recorded significantly lower values for plant height (56.52 cm) number of leaves plant^{-1} (9.06), number of leaves per plant (9.06) and leaf length (38.63 cm) (Table 1). The increase in growth parameters with the application of zinc might be due to their role in the cell division and other physiological processes like photosynthesis, nitrogen metabolism etc. It helps in the biosynthesis of cytochrome and maintains plasma membrane integrity. Zinc modifies and/or regulates the activity of cabonic anhydrase, an enzyme that regulates the conversion of carbon dioxide to reactive bicarbonate species for fixation to carbohydrates in these plants. Zinc is also a part of several other enzymes such as superoxide dismutase and catalase, which prevents oxidative stress in plant cells. In addition to above zinc plays an important role in production of tryptophan which in turn is precursor of auxin, an essential growth hormone for plant growth. The results are in conformity with Lal and Maurya (1981); Jitendra *et al.,* (1989); Gamili *et al.,* (2000); Thakare *et al.,* (2007); and Verma *et al.,* (2014) in onion; Tiwari *et al.,* (2003) in garlic and Mahesh and Sen in okra (2005).

Perusal of Table 1 reflected that pooled data over two different years 2015-16 and 2016-17 showed significant increase in polar diameter, equatorial diameter, average bulb weight and total bulb yield with increase in zinc level. Significantly maximum values for polar diameter (6.31 cm), equatorial diameter (6.32 cm), average bulb weight (82.64 g) and total bulb yield (275.50 q ha^{-1}) was registered with application of zinc at the rate of 7.500 kg ha^{-1} as compared to lower levels of zinc including control treatment. The increase in bulb yield related parameters and total bulb yield of onion with the application of higher levels of zinc might be due to enhanced synthesis and translocation of photosynthates to the bulbs. Further the improvement of bulb yield was due to better vegetative growth as observed in the present study. This result corroborates the findings of Singh and Tiwari (1996) who reported that a high yield was a reflect of vigorous vegetative growth and healthy plants. Similar findings have also been reported in onion by Jawaharlal *et al.,* (1986), Pena *et al.,* (1999), Gamili *et al.,* (2000), Kumar *et al.,* (2000), Khan *et al.,* (2007), Thakare *et al.,* (2007), and Kurtz and Ernani (2010). The onion cv. Yellow Globe was significantly influenced with respect to growth parameters like plant height, leaf number and leaf length by boron levels. Application of boron (B_3) at the rate of 1.500 kg ha^{-1} registered maximum plant height (64.67 cm), leaf number (9.06) and leaf length (38.63 cm) which was statistically higher as compared to rest of treatments including control B_0 (Table 2). The increase in growth parameters of onion with progressive increase in the application of boron might be due to their role in cell division, meristematic activity of plant tissue and expansion of cell (Patil *et al.,* 2009). The favourable effect of boron on plant growth might also be due to its role in physiological processes such as carbohydrate and protein metabolism and cellular function within the plant. Since boron is mainly involved in the hormone development and stimulation or inhibition of specific metabolism pathways (Waqar *et al.,* 2009). Boron may affect metabolic pathways by binding apoplastic proteins to cis-hydroxyl groups of cell walls and membranes, and by interfering with manganese-dependent enzymatic reactions (Dale and Krystyna, 1998).

Table.1 Effect of different levels of zinc on growth and yield parameters of onion

Zinc	Plant height (cm)	Leaf number	Leaf length (cm)	Polar diameter (cm)	Equatorial diameter (cm)	Average bulb weight (g)	Total bulb yield (q ha^{-1})
Z_0	58.69	9.06	38.63	4.92	5.13	74.34	247.54
Z_1	62.41	9.48	40.25	5.45	5.55	75.35	252.77
Z_2	63.06	9.90	41.08	5.82	5.87	80.51	268.58
Z_3	66.07	10.61	41.36	6.31	6.32	82.64	275.50
C.D($p \leq 0.05$)	0.65	0.17	0.17	0.09	0.15	0.67	1.86
S.E (m)	0.22	0.06	0.06	0.03	0.05	0.22	0.64

Table.2 Effect of different levels of boron on growth and yield parameters of onion

Boron	Plant height (cm)	Leaf number	Leaf length (cm)	Polar diameter (cm)	Equatorial diameter (cm)	Average bulb weight (g)	Total bulb yield (q ha^{-1})
B_0	60.71	9.18	39.59	5.16	5.18	75.24	250.83
B_1	61.89	9.58	40.06	5.82	5.62	77.39	257.98
B_2	62.96	9.92	40.58	5.85	5.92	79.62	265.29
B_3	64.67	10.38	41.08	5.95	6.14	81.15	270.29
C.D($p \leq 0.05$)	0.65	0.17	0.17	0.09	0.15	0.67	1.86
S.E (m)	0.22	0.06	0.06	0.03	0.05	0.22	0.64

Boron is functionally important in forming a pectic network in cell wall which is responsible for the extensibility of cell wall and consequently regulates cell growth (Yang and Yiqin, 1999). Further boron regulates the activity of ascorabate and dehydroascorbate which losses cell wall and thus giving more space to grow and increase the elongation and meristematic regions in onion (Naqib and Jahan, 2017). Similar findings were also reported by Maurya and Lal (1975), Abou El-Magd *et al.,* (1989), Smriti *et al.,* (2002), Salam *et al.,* (2004), Rashid *et al.,* (2007) in onion; Howlader *et al.,* (2010) and Chanchan *et al.,* (2013) in garlic; Singh and Verma (1991) in tomato; Sharma (2002) in cauliflower. Interaction effect of zinc and boron was found significant in increasing plant height.

Significantly highest values for polar diameter (5.95 cm), equatorial diameter (6.14 cm), average bulb weight (81.15g) and total bulb yield (270.29 q ha^{-1}) was obtained when boron were applied at the rate of 1.500 kg ha^{-1} in both 2015-16 and 2016-17, which was significantly superior to all the treatments including control and data is presented on Table 2. The increase in total bulb yield was 7.75 percent over control treatment (B_0).

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 were also reported by Mishra *et al.,* (1990), Singh and Verma (1991) and Chattopadhyay and Mukhopadhyay (2004) in onion.

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