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Effects of Different Application Methods of Zinc and Boron on Growth and Yield of Onion

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Abstract

Different application methods of nutrients were introduced to strengthen the judicial use of fertilizers. Zinc and boron are two vital micronutrients for cultivation, especially onion. Therefore, this study was designed to find the most suitable application methods of zinc and boron on growth and yield of onion. The single factor experiment was laid out following a randomized complete block design with three replications. The treatments were control (T_0), soil application of zinc (T_1), soil application of boron (T_2), foliar application of zinc (T_3), foliar application of boron (T_4), soil application of zinc and boron (T_5), soil application of zinc and foliar application of boron (T_6), foliar application of zinc and boron (T_7), soil application of boron and foliar application of zinc (T_8). The source of zinc and boron for the soil application were zinc sulfate and borax, respectively. And, the foliar applications were done with the solution of 1% chelated zinc and solubor, respectively. The foliar applications were applied from 40 days after transplanting three times with an interval of 15 days. The results of the experiment showed a significant effect of application methods of zinc and boron on growth and yield contributing characters of onion. The investigation revealed that soil application of zinc is more effective over that of foliar application, whereas foliar application is more effective in the case of boron.

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Introduction

Onion (*Allium cepa* L.) is one of the foremost important commercial vegetable crops and is widely grown in almost all over the world (Mishra *et al.*, 2013). In Bangladesh, onion is cultivated mainly as a spice crop. Usually, it's sown from October to November and harvested from March to April. The most suitable edible portion of onion is the bulb (modified-stem) consists of thickened scale leaves (Jones and Mann, 1963). Onion contains high medicinal values for having adequate vitamin B-complex, vitamin C, iron, and calcium (Thomson and Kelly, 1982). Although, the presence of allyl propyl disulphide made the onion pungency in taste (Malik, 1994). But in Bangladesh, for its special flavoring agent, onion is considered an integral part of the preparation of all curry food items (Hossain and Islam, 1994). The report shows the extract of onion is helpful for anticancer agents with the effects of antioxidants (Block, 1985). It also reduces glucose by 25 percent (Vohora *et al.*, 1974; Mossa, 1985; Yawalkar, 1985).

Onion is being cultivated all over the world. In Bangladesh, onion is grown as a winter crop (Satter and Haque, 1975). The leading onion growing country in the world is China (FAOSTAT, 2020). Onion is in the first position not just as a cultivated spice crop but also because of the produced spice crops in Bangladesh (BBS, 2020). In Pabna, the production of onion is ranked top among the districts of Bangladesh (BBS, 2020). But the yield in Bangladesh is 10.56 tons per hectare which are far below in comparison to the average yield of developed countries (BBS, 2020). As the demand for onion is increasing synchronously with the population. But it is not possible to increase the area of cultivation to increase production due to the limitation of land resources. Therefore, to increase the production of onion through management practices like fertilizer management especially micronutrients are very important. It has been reported that onion cultivation has significant effect on the application of zinc and boron (Lal and Maurya, 1991). And, micronutrients like boron, zinc plays a vital role as an essential function for cell division and the metabolism of carbohydrates.

It is well known that judicial management of nutrients is the best policy for the quantity and quality improvements of plants. Therefore, proper applications of micronutrients need to be followed. The basal and split applications are common now a days. And, also foliar application made the success for correcting the deficits and improvements of the status of nutrients for quality of crop and yield of production (Marschner, 1995). Hence, this research was focused to understand how the methods of application of zinc and boron can affect. So, the existing soil fertility status as well as the recommended rate of fertilizer will be a vital factor to advise a balanced fertilizer application method for a specific crop. Therefore, this study was designed to find out the most suitable application methods of zinc and boron on growth and yield of onion.

Materials and method

Site

The experiment was studied during the rabi season (October 2015 to March 2016) at the Horticulture Field Laboratory in Bangladesh Agricultural University. The geographical situation is 18m above sea level (Khan, 1997) and belongs to the sub-tropical climate. The soil containing 6.5 pH belonging Old Brahmaputra Flood Plain (UNDP, 1988).

Planting materials, treatments, and design

A cultivar of onion 'BARI Peaz-1' was used for the experiment. The seeds were collected from Spices Research Centre, Bogura. Total of nine treatments were arranged to conduct the study with RCBD (randomized complete block design) trial. The treatments were control (T_0), soil application of zinc (T_1), soil application of boron (T_2), foliar application of zinc (T_3), foliar application of boron (T_4), soil application of zinc and boron (T_5), soil application of zinc and foliar application of boron (T_6), foliar application of zinc and boron (T_7), soil application of boron and foliar application of zinc (T_8). The source of zinc and boron for the soil application were zinc sulfate and borax, respectively (Table 1). And, the

foliar applications were done with 1% solution of chelated zinc and solubor, respectively. All the nutrients were applied following the fertilizer recommendation guide (BARC, 2012).

Land preparation

The seedbed was raised about 20cm height with 3m × 1m in size for raising seedlings. The light textured and well-drained soil of the land was opened and left for drying for 10 days. Finally, by removing all the weeds, stubbles, and mixing well with decomposed cow-dung the soil was made loose, friable, and brought to fine tilth. The main field was prepared with a power tiller. The preparation was done one month before transplanting the seedlings. Final land preparation was done by removing weeds, stubbles and breaking all the clods with desired tilth by ploughing, cross ploughing and laddering. Each plot was raised about 15cm high from the soil surface with draining facilities.

Manure and fertilizer

Manures and fertilizers were applied with the prescribed doses of nutrients as showed in Table 1 (BARC, 2012). All the treatments were treated with prescribed doses of NPKS. All the manures and fertilizers with 1/3 portion of urea were applied on the day of final land preparation. The remaining urea was applied in two equal installments. The first installments were 30 days after transplanting (DAT) and the second installments were done at 50 DAT. The foliar applications of micronutrients were done 3 times at 15 days interval from 40 DAT.

Raising seedlings, transplanting and intercultural operations

After sowing the sprouted seeds at a depth of 0.5 cm, the raised seedbed was then covered with light soil and compacted carefully. Weeding, irrigation, and protective measures were taken as per the requirement of the seedlings. Following 15cm × 10cm spacing some healthy, disease-free and homozygous onion seedlings were transplanted. Thus, each plot contained 100 seedlings. The seedlings were collected followed by watering to keep minimum injury during uprooting. Immediate light irrigation was done just after the transplantation. This provide a better environment for seedlings to be established. The supplements of light irrigation were continued up to seven days. Border plants were kept to fill the gap. The moisture level was monitored regularly for irrigation to maintain the steady moisture level of the site. Weeding was followed by urea top dressing and also as per the requirement of the site to keep better soil aeration. The seedlings were attacked by cutworm (*Agrotisipsilon* R.) and field cricket (*Brachytrypes portentosus* L.) both in the seedbed and main field, were controlled mechanically. While, the purple blotch disease (*Alternaria porii*) was controlled by spraying of Supravit at 7 days' interval.

Harvesting and data collection

The maturity index was confirmed with the sign of drying leaves and true shape of the onion bulbs. Onions were harvested in the presence of 80% of mature crops (Bhonde *et al.*, 1983). To record the qualitative and quantitative characters of different stages of growth, ten sample plants were taken from every plot and tagged properly. The border plants were avoided to select sample plants. The data were collected from the sample plants for the parameters of plant height and leaves number at 15 days interval from 30 DAT. And, during harvesting data collected for the parameters of leaves length, bulb height, bulb diameter, pseudostem height, pseudostem weight, pseudostem diameter, bulb weight, and plant weight. The plant weight was sampled without the bulb portion and the bulb was sampled keeping 2-2.5cm of pseudostem. The weight of all the plants and bulb weight from plots were collected and converted as t ha^{-1} to construct the value of total plant weight and yield, respectively.

Percent dry matter in bulb

After harvesting, the sample bubs were chopped with a sharp knife and sun-dried. To attain constant weight the sun-dried sample was then kept at 70°C in an oven. The constant weight was then recorded in gram (g). Then the percent dry matter in the bulb (%DMB) was calculated following the formula:

$$\% \text{ DMB} = \frac{\text{Dry weight of the bulb}}{\text{Fresh weight of bulb}} \times 100$$

Analysis

The obtained data were statistically analyzed to understand the significance of different treatment combinations. The analysis was done by MSTAT program. The deviations among different treatments were evaluated through the least significant differences (LSD) at 5% level (Gomez and Gomez, 1984).

Results and discussion

Plant height, leaves number, and leaves length

The plant height (A) and leaves number (B) showed significant effects throughout the whole growing period from 45 DAT.

The records revealed that the maximum value was from T_6 and minimum value was from T_0 (Fig. 1).

Table 1. Nutrient rate and source for cultivation of onion.

Nutrients required for onion cultivation	Prescribed doses of nutrients (kg ha^{-1})	Sources of nutrients	Prescribed doses of fertilizers (kg ha^{-1})
N	100	Urea	218
P	35	TSP	175
K	100	MoP	200
S	15	Gypsum	84
Zn	3	$ZnSO_4$	8.5
B	2	Borax	19

The individual leaf length also showed variation for different treatment combinations (Table 2). In this case, the highest and the lowest value resulted from T_6 (application of soil zinc and foliar boron) and T_0, respectively (Table 2). This indicates, the application methods of zinc and boron either soil or foliar or both had an advantageous impact on the growth and development of onion. Throughout the growing period, the plant height and leaves number were statistically significant except on 30 DAT. This is maybe due to the beginning soil application and combination of soil and foliar application of zinc and boron. Besides, zinc and boron play an essential role to provide plant growth through the biosynthesis of endogenous hormones which ultimately promote plant growth (Bhatt *et al.,* 2004; Hansch and Mendel, 2009). Meristematic activities with cell expansion and division could be attributed as the role of zinc and boron (Patil *et al.*, 2009). As the application methods enhanced growth and development so there were lack of these micronutrients in soil. Sliman *et al.* (2009) reported that the growth of onion was severely favored with micronutrients application. Sindhu and Tiwari (1993) also mentioned the same.

Table 2. Effect of application methods of zinc and boron on leaf length, pseudostem height, pseudostem weight and pseudostem diameter of onion.

Treatment	Leaf length (cm)		Pseudostem height (cm)		Pseudostem weight (g)		Pseudostem diameter (cm)	
T_0	15.00	h	6.50	g	4.83	i	1.18	e
T_1	18.20	e	8.70	e	8.33	e	1.55	bc
T_2	17.67	ef	7.79	f	7.61	f	1.50	c
T_3	16.63	g	6.86	g	6.54	h	1.36	d
T_4	17.23	fg	7.55	f	7.31	g	1.38	d
T_5	23.93	b	10.51	b	10.15	b	1.85	a
T_6	25.60	a	12.50	a	11.20	a	1.86	a
T_7	19.57	d	9.10	d	9.00	d	1.56	b
T_8	20.60	c	9.90	c	9.37	c	1.84	a
$LSD_{0.05}$	0.75		0.37		0.29		2.16	
Level of significance	**		**		**		**	

** = Significant at 1% level of probability, df = Degrees of freedom, Means followed by the same letter (s) in a column are not significantly different at 5% level of significant.

The result from leaf length partially supports the finding by Ballabh and Rana (2012), where the conclusion was leaf length, leaf width was highest with the foliar application of zinc and boron.

Pseudostem height, pseudostem weight and pseudostem diameter

There was significant variation with the parameter of pseudostem height, pseudostem weight, and pseudostem diameter. The results (Table 2) revealed that the maximum length of pseudostem (12.50 cm), weight of pseudostem (11.20 g), and diameter of pseudostem (1.86 cm) with the treatment T_6 (application of soil zinc @ 3 kg ha^{-1} with foliar boron @ 1%). And, the minimum results were found with the treatment T_0 (control). Here, cell elongation and division induced with the enhanced metabolic activities as the result of photosynthesis increment due to the application methods of zinc and boron (Hatwar *et al.*, 2003). These results also support the findings of Schmidt (1964), Smriti *et al.* (2002), and Katare *et al.* (1971).

Table 3. Effect of application methods of zinc and boron on different quantitative characters of onion.

Treatment	Bulb height (cm)		Bulb diameter (cm)		Bulb weight (g)		Plant weight (g)		Total plant weight (t ha^{-1})		Yield (t ha^{-1})		Percent dry matter in bulb (%DMB)	
T_0	2.30	f	3.46	h	15.07	f	22.27	g	13.78	f	9.96	e	5.55	f
T_1	2.69	cd	3.91	e	18.57	de	30.80	cd	19.56	c	12.27	d	6.50	cde
T_2	2.66	d	3.79	f	18.53	de	28.60	de	18.56	cd	12.02	d	6.44	cde
T_3	2.36	e	3.66	g	17.20	ef	25.00	fg	16.33	de	11.33	de	6.22	e
T_4	2.37	e	3.70	g	17.90	e	26.53	ef	17.22	e	11.67	d	6.36	de
T_5	3.08	a	4.21	b	24.00	b	37.80	a	24.78	a	15.58	b	7.00	ab
T_6	3.11	a	4.71	a	28.53	a	38.87	a	25.11	a	17.78	a	7.14	a
T_7	2.73	c	4.03	d	20.80	cd	31.63	bc	20.11	bc	13.82	c	6.63	cd
T_8	2.85	b	4.10	c	22.97	bc	33.73	b	22.00	b	15.09	bc	6.72	bc
$LSD_{0.05}$	0.05		0.08		2.74		2.83		1.90		1.43		0.31	
Level of significance	**		**		**		**		**		**		**	

** = Significant at 1% level of probability, df = Degrees of freedom, Means followed by the same letter (s) in a column are not significantly different at 5% level of significant.

Bulb height, bulb diameter and bulb weight

Variations were found in respect of bulb height, bulb diameter and bulb weight due to the presence of application methods of zinc and boron (Table 3). The maximum data for these parameters were bulb height (3.11 cm), bulb diameter (4.71 cm) and bulb weight (28.53 g) found by the application of soil zinc @ 3 kg ha^{-1} with foliar boron @ 1% (T_6). Whereas, the minimum for these parameters were found in control (T_0). This is because the effect of different application methods results higher photosynthates accumulation in the bulbs. Therefore, the application of zinc on soils and boron in foliage has increased the bulb diameter. A similar result was also reported by Baghel and Sarnik (1988) and they showed that significant increment in bulb diameter was favored by the collective approach of zinc and boron application method. The same finding conformity also resulted in Khan *et al.* (2007).

Plant weight, total plant weight and yield

The present investigation showed variations in plant weight, total plant weight and yield (bulb) for different application methods of zinc and boron.

The highest plant weight, total plant weight and yield (bulb) was 38.87g, 25.11 t ha^{-1} and 17.78 t ha^{-1}, respectively (Table 3). And all these results were from the T_6 treatment combination followed by T_5 which was statistically similar to that of T_8. Whereas, the lowest results were from T_0 (Table 3).

The result showed bulb weight more induced by the application methods of soil zinc and foliar boron. This

could be a probable cause that, growth and yield attribute as a result of the positive influence of different application methods of zinc and boron. Maurya and Lal (1975) also reported that foliar application with boron responses in terms of leaf weight, plant weight, and bulb weight. Sabir *et al.* (1989) also found the same results as bulb weight significantly increased with zinc and boron. Therefore, it is clear that the favorable effect of micronutrients through hormonal biosynthesis plays a vital role in enhancing plant growth (Hansch and Mendel, 2009).

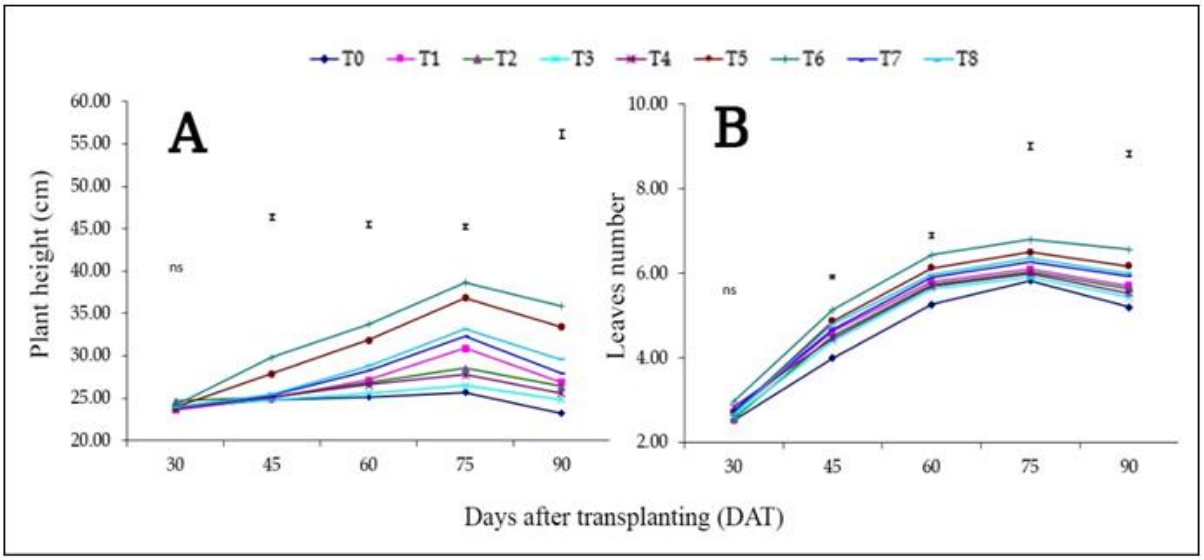

Fig. 1. Effect of application methods of zinc and boron for plant height (A) and leaves number (B) at different growth periods of onion cultivation.

The higher yield, therefore, attributed to the effect of zinc as the enzymes for metabolic activities are activated by it. Meena *et al.* (2017) also reported the same.

Percent dry matter in bulb

The different methods of application of zinc and boron caused remarkable variation in respect of dry matter content in bulb.

The maximum percent dry matter in bulb content was observed 7.14 g in the application of soil zinc @ 3 kg ha^{-1} with foliar boron @ 1% (T_6) and lowest mean dry matter of bulb was 5.55 cm in control (T_0) (Table 3).

This is maybe because of the application methods of zinc and boron, which enhance chlorophyll synthesis and the cell wall development and thus make higher dry weight. This result agrees with the findings of Meena and Singh (1998), as a prominent increment of percent dry matter occurs in bulb with the application of zinc.

Conclusion

Onion (*Allium cepa* L.) is considered as one of the significant flavor crops and positioned top of the rundown according to consumer's preference in Bangladesh.

In the production of onion, micronutrients play an important role. Where zinc and boron are the most important micronutrients concerning the yield contributing attributes. From the experiment, it is revealed that the application methods of zinc and boron have positive influences on different yield controlling attributes of onion. Specifically, zinc in soil and boron in foliage application always reveals higher results concerning different yield contributing characters of onion.

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