Effect of Zinc and Boron Application on Growth and Yield Parameters of Multiplier Onion (*Allium cepa* L. *var aggregatum* Don.) var. CO (On)5

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ABSTRACT

Field experiment was carried out in the College orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during 2013 - 2014 to study the effect of zinc and boron application on seeding transplanting multiplier onion CO(On)5 at different levels of both foliar and basal application. The treatment consist of soil application of zinc sulphate (5 kg ha^{-1} and 10 kg ha^{-1}), Borax (5 kg ha^{-1} and 10 kg ha^{-1}), foliar application of zinc sulphate (0.5% foliar) and Borax (0.25% foliar), zinc sulphate (5 kg soil + 0.5% foliar), zinc sulphate (10 kg ha^{-1} soil + 0.5% foliar), borax (5 kg ha^{-1} soil + 0.25% foliar), borax (10 ha^{-1} kg soil + 0.25% foliar) and control without micronutrient, replicated thrice in a randomized block design. The foliar spray was given 30 and 45 days after transplanting for both zinc sulphate and borax. N, P, K, and S were applied at 90-60-60-20 kg ha^{-1} respectively as basal dose. Results were found to be significant in most of the yield contributing parameters of multiplier onion. The plant height (50.30 cm), number of leaves per plant (51.3), leaf girth (8.1 mm), fresh leaf weight (22.7 g), fresh bulb weight (85.4 g), total dry matter production (5.31 t ha^{-1}), bulb yield per plot (10.1 kg) and bulb yield per hectare (16.9 t ha^{-1}) were highest in zinc sulphate 0.5% foliar spray. While 10 kg ha^{-1} borax soil application showed highest polar (26.0 mm) and equatorial diameter (27.2 mm) and borax (5 kg ha^{-1} soil + 0.25% foliar), highest number of bulblets per clump (8.8) in borax (10 kg ha^{-1} soil).

Key words:

Multiplier onion; micronutrient; seedling transplanting; onion growth; yield

Introduction

Onion (*Alliumcepa* L.) is one of the most important commercial vegetable crops being grown all over the country. It is very useful for human beings because it has several nutritional and medicinal value commands extensive markets and is rate as an important and indispensible item of every kitchen. It has diuretic properties, relieves heat sensation, hysterical faintness, insect bites and is also heart stimulation. Multiplier onion (*Alliumcepa* L. var. *aggregatum* Don.) is one the very important type of onion grown extensively in Southern states of India and mainly famous for its pungency used in *Sambar* preparation, important dish in South Indian

kitchen. Application of micronutrients to soil deficient in them has shown remarkable increase in yield of several crops. Micronutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzymes activity, nitrogen fixation etc. [1]. In India, it is grown in 11.10 lakh hectare with production of 159.30 lakh tons and productivity of 14.5 t ha^{-1}. India ranks first in area and second to China in production but 102nd in terms of productivity [2].

In India, analysis of 2.52 lakhs surface soil samples collected from different parts of the country revealed the predominance of zinc deficiency in divergent soils. The magnitude of zinc deficiency varied widely among soil types and within the various states. Coarse textured, calcareous, alkaline or sodic soils having sandy texture, high pH and low in organic matter are generally low in available zinc. Calcareous soils of Bihar, Vertisols and Inceptisols of Andhra Pradesh, Tamil Nadu and Madhya Pradesh and Aridisols of Haryana showed extensive deficiency of zinc resulting low crop yields. Zinc is a crucial component of the package of the practices recommended sodic soils reclamation. Deficiency of boron occurs widely in highly calcareous soils of Bihar, parts of Gujarat and Tamil Nadu. Indian soils are exposed to multi-micronutrient deficiencies that closely associated with the yield and quality of crops. Particularly, zinc deficiency is widely prevalent and it has been estimated that 60 % of Indian soil and more than 70 % of Tamil Nadu soils are found to be by many scientists at different types of soils. This multiplier onion variety CO(On)5 is only seedling transplanting as multiplier onion is shy flowering in nature. Although some study on micronutrient application on the bulb transplanting multiplier very less study has been undergone. The purpose of this experiment was to study the effect of micronutrients deficient and therefore, micronutrient fertilizer is almost essential in order to achieve the yield of crops [3].

Producing of good quality onion bulbs is an important target by onion growers whom have an inadequate Knowledge about beneficial role of micronutrients in increasing yield and quality of onion for local and foreign markets. Hence, its cultivation has been expanded in the newly reclaimed areas which characterized with low fertility, high pH value and low organic matter content, consequently low available of micronutrients in the soil. These problems are well known in newly reclaimed areas in Egypt where sandy and calcareous soils are exist. Foliar application of micronutrients during crop growth was successfully used for correcting their deficits and improving the mineral status of plants as well as increasing the crop yield and quality [4]. The foliar application of micronutrients had a significant effect on plant growth, yield and quality [5]; [6];[7]; [8]; [9]. In the same respect, spraying onion plants cv. Pusa Red with Fe or Zn at 60 and 70 days after transplanting date lead to significant increase of plant vegetative growth as well as bulb yield and quality [10]. The onion, like any other crops not only needs macronutrients but also micronutrients in adequate and balanced amounts. These can be applied singly or mixed with other nutrient too. The use of micronutrients should be made with great caution because of their small amounts needed and interactions with other nutrients. Improvement in onion growth and yield has been reported through micronutrient especially zinc and boron on growth and yield of multiplier onion variety CO(On)5 under Coimbatore condition.

Materials and Methods:

The experiment was carried out at College orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil

Nadu during *Kharif* season the year 2013-14. The experiment was laid out in a Randomized Block Design which was replicate thrice. Coimbatore is situated at 11° N latitude and 77° E longitude and at an elevation of 426.6 m above mean sea level. Coimbatore is cocooned between the Western Ghats in the north and western side, the Nilgiri Biosphere Reserve, Annamalai range, Munnar range and the western pass Palghat. As such, this location gives Coimbatore a peculiar rainfall pattern. It receives an average rainfall of 61.22 cms annually, spreading over an average of 44.5 days in a year. The south-west monsoon contributes rain in the months from June to August. A humid September is followed by an October-November rain by the retreating North-eastern monsoon. The experimental soil is reddish brown calcareous clay soil with alkaline pH 8.12, low in organic carbon (0.42%), non-saline, electrical conductivity (0.85 dS m^{-1}),available nitrogen (216 kg ha^{-1}), available phosphorus (18 kg ha^{-1}), available potassium (1501 kg ha^{-1}), available Zn (0.31 ppm) and available boron (0.48 ppm). The soil is deficient in available zinc and boron. Hence the soil application and foliar application (two times 30 and 45 days after transplanting) of micronutrient source, zinc sulphate for zinc and borax for boron was used as experimental material and its effect on the yield and quality of onion. The treatments consist of T_1 (zinc sulphate soil application @ 5 kg ha^{-1}), T_2 (zinc sulphate soil application @ 10 kg ha^{-1}), T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT), T_4 (zinc sulphate soil application @ 5 kg ha^{-1}+ zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT), T_5 (zinc sulphate soil application @ 10 kg ha^{-1}+ zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT), T_6 (borax soil application @ 5 kg ha^{-1}), T_7 (borax soil application @ 10 kg ha^{-1}), T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT), T_9 (borax soil application @ 5 kg ha^{-1}+ boric acid foliar spray 0.25% @ 30 and 45 DAT), T_{10} (borax soil application @ 10 kg ha^{-1} + boric acid foliar spray 0.25% @ 30 and 45 DAT) and T_{11} (control without micronutrients) replicated thrice in a randomized block design. Growth and yield parameters such as plant height, number of leaves per plant, leaf girth, fresh leaf weight, fresh bulb weight, total dry matter production, number of bulblets per clump, equatorial diameter, polar diameter, bulb yield per plot and hectare were under study.The results recorded in various experiments were statistically analysed for drawing out definite conclusions [11].

Results

1. Growth Parameters

Plant Height

The application of zinc and boron on plant height of multiplier onion was found significant. At harvesting stage, the tallest plant height (59.1 cm) was observed in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) which was on par with T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) with height of 58.0 cm whereas the shortest plant height was recorded by T_{10} (borax soil application @ 10 kg ha^{-1} + boric acid foliar spray 0.25% @ 30 and 45 DAT) which was 41.3 cm.

Number of leaves

There was significant effect of zinc and boron application on number of leaves which ranges from 37.8 to 51.3. The highest number of leaves per plant was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (51.3) followed by T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) (47.7) at harvest. The lowest number of leaves per plant was observed in T_5 (zinc sulphate soil application @ 10 kg ha^{-1} + zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) which was noted as 37.3.

Leaf girth

The highest leaf girth was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (8.1 mm) which was on par with T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) (7.2 mm). The lowest leaf girth was observed in T_{10} (borax soil application

@ 10 kg ha^{-1} + boric acid foliar spray 0.25% @ 30 and 45 DAT) (5.6 mm) at harvest.

Fresh leaf weight

The fresh leaf weight range from 10.5 g to 22.7 g and significant response was observed among treatments. The highest fresh leaf weight was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (22.7 g) followed by T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) (17.9 g) which was on par with T_8(boric acid foliar spray 0.25% @ 30 and 45 DAT) (17.3 g). The lowest fresh leaf weight per plant was recorded in T_{11} (Control without micronutrients) which was recorded as 10.5 g.

Fresh bulb weight

The highest fresh bulb weight was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (85.4 g) which was on par with T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) (85.3 g). The lowest fresh bulb weight per plant was recorded in T_{11} (Control without micronutrients) (40.1 g).

Total dry matter production

At harvest, total dry matter production was separately calculated as total dry matter production of tops (leaves) and bulb. At harvesting stage, the highest total dry matter production of tops (leaves) was observed in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (1.45 t ha^{-1}) which was on par with T_2 (zinc Sulphate soil application @ 10 kg ha^{-1}) (1.28 t ha^{-1}) followed by T_8(boric acid foliar spray 0.25% @ 30 and 45 DAT) (1.15 t ha^{-1}). The lowest total dry matter production of leaves was recorded T_{11} (Control without micronutrients) (0.59 t ha^{-1}) at harvesting stage. The highest total dry matter production of bulb was observed in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (5.31 t ha^{-1}) which was on par with T_2 (zinc sulphate soil application @ 10 kg ha^{-1}) (5.09 t ha^{-1}) and T_8(boric acid foliar spray 0.25% @ 30 and 45 DAT) (4.85 t ha^{-1}) respectively. The lowest total dry matter production of leaves was observed in T_{11} (Control without micronutrients) (2.41 t ha^{-1}) at harvesting stage.

Table 1: Effect of zinc and boron application on growth parameters of multiplier onion var. CO(On)5

Treatment	Plant Height (cm	Number of leaves	leaf girth (mm)	Fresh leaf weight per plant (g)	Fresh bulb weight per plant (g)	Dry matter production (t ha^{-1})	
						Tops	Bulbs
T_1	50.2	41.3	6.7	15.7	54.3	0.83	3.29
T_2	58.0	47.7	7.2	17.9	85.3	1.28	5.09
T_3	59.1	51.3	8.1	22.7	85.4	1.45	5.31
T_4	50.3	42.3	6.9	16.8	73.4	1.12	4.63
T_5	45.9	35.3	5.9	15.3	63.9	1.11	3.95
T_6	48.9	39.4	6.2	12.6	46.7	0.79	2.89
T_7	52.3	43.3	6.8	16.5	63.8	1.08	4.40
T_8	54.6	45.4	7.0	17.3	73.9	1.15	4.85
T_9	50.2	41.3	6.7	16.1	61.7	1.04	3.70
T_{10}	41.3	37.8	5.6	15.8	58.5	0.99	3.26
T_{11}	47.7	39.0	6.0	10.5	40.1	0.59	2.41
Mean	50.8	42.2	6.7	16.1	64.3	1.04	3.98
SEd	1.53	1.39	0.21	1.33	5.58	0.097	0.367
CD (0.05)	3.19	2.89	0.44	2.77	11.64	0.202	0.766

2. Yield and Yield Parameters

Polar diameter

The application of zinc and boron shows significant effect in the bulb polar diameter of aggregatum onion. The highest bulb polar diameter was recorded in T_7(borax soil application @ 10 kg ha^{-1}) (26.0 mm) which was on par with T_8(boric Acid foliar spray 0.25% @ 30 and 45 DAT) (25.8 mm), T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (25.5 mm) and T_4 (zinc sulphate soil application @ 5 kg ha^{-1} + zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (25.1 mm). The lowest bulb polar diameter was observed in T_{11} (Control without micronutrients) (18.3 mm).

Equatorial diameter

The application of zinc and boron shows significant effect in the bulb equatorial diameter of multiplier onion. The highest bulb equatorial diameter was recorded by T_7 (borax soil application @ 10 kg ha^{-1}) (27.2 mm) which was on par with T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT) (26.3 mm). The lowest bulb equatorial diameter was observed in T_{11} (Control without micronutrients) (16.0 mm) which was on par with T_5 (zinc sulphate soil application @ 10 kg ha^{-1} + zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (17.1 mm).

Bulblets per clump

There was significant effect of zinc and boron application on the number of bulblets per clump. The highest number of bulblets per clump was noted in T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT) (8.8) which was on par with T_9(borax soil application @ 5 kg ha^{-1} + boric acid foliar spray 0.25% @ 30 and 45 DAT) (8.3) respectively. The lowest number of bulblets per clump was recorded in T_{11} (Control without micronutrients) (4.2).

Bulb yield per plot

The response of aggregatum onion under different level of zinc and boron was found significant for the bulb yield per plot (kg). The highest bulb yield per plot was noted in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (9.6 kg) which was on par with T_8 (boric acid foliar spray 0.25% @ 30 and45 DAT) (9.5 kg) and T_4 (zinc sulphate soil application @ 5 kg ha^{-1} + zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (9.2 kg) respectively. The lowest bulb yield per plot was recorded in T_{11} (control without micronutrient) (6.0 kg).

Bulb yield per hectare

The application of zinc and boron was found to have significant effect on the bulb yield per hectare of aggregatum onion. The highest bulb yield per hectare was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) with bulb yield of 16.0 t ha^{-1} followed by T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT) (15.9 t ha^{-1}) and T_4 (zinc sulphate soil application @ 5 kg ha^{-1} + zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) (15.3 t ha^{-1}). The lowest bulb yield was observed in T_{11} (control without micronutrients) (10.0 t ha^{-1}).

Table 2: Effect of zinc and boron application on yield and yield parameters of multiplier onion var. CO(On)5

Treatment	polar diameter (mm)	Equatorial diameter (mm)	No. of bulblets per clump (nos)	Yield per plot (kg)	Yield per hectare (t ha^{-1})
T_1	21.4	19.0	4.7	7.7	12.9
T_2	22.8	19.9	7.0	9.1	15.2
T_3	25.5	23.5	8.2	9.6	16.0
T_4	25.1	20.9	6.2	9.2	15.3
T_5	21.3	17.1	5.3	7.4	12.4
T_6	22.1	21.3	5.2	8.2	13.9

T_7	26.0	27.2	7.1	9.3	15.5
T_8	25.8	26.3	8.8	9.5	15.9
T_9	22.8	21.0	8.3	8.6	14.3
T_{10}	20.5	19.5	5.9	7.2	12.0
T_{11}	18.3	16.0	4.2	6.0	10.0
Mean	22.9	21.1	6.4	8.4	13.9
SEd	0.75	1.05	0.85	0.59	0.99
CD (0.05)	1.57	2.19	1.78	1.22	2.06

Discussion

1. Growth parameters

The highest plant height, number of leaves per plant and leaf girth was observed in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) followed by T_2 (zinc sulphate soil application @ 10 kg ha^{-1}). Other treatments like T_4 (zinc sulphate soil application @ 5 kg ha^{-1}+ zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT), T_5 (zinc sulphate soil application @ 10 kg ha^{-1}+ zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT), T_9 (borax soil application @ 5 kg ha^{-1}+ boric acid foliar spray 0.25% @ 30 and 45 DAT) and T_{10} (borax soil application @ 10 kg ha^{-1} + boric acid foliar spray 0.25% @ 30 and 45 DAT). Application of zinc and boron through soil or foliar or in combination had a beneficial effect on the growth of onion. This may be due to initial soil application and one foliar application of zinc sulphate. Zinc is essential for tryptophan synthesis, which is a prerequisite for auxin formation, therefore amount of auxin decreases by zinc deficiency [12]; [13]; [14]. Zinc deficiency decreases plant growth by increasing the concentration of boron in the young leaves and tips of the branches. The favorable effect of zinc on plant growth may be due to its role in many physiological process and cellular function within plants. In addition, zinc and boron play an essential role in improving plant growth, through the biosynthesis of endogenous hormones which is responsible for promotion of plant growth [15]; [16]. Increase in number of leaves per plant may be attributed to the role of micronutrients (Zn, B) in cell division, meristematic activity of plant tissue and expansion of cells [17]. Application of zinc and boron through soil or foliar or in combination had a beneficial effect on the growth of onion regardless of stages. It is quite obvious that the experimental soil is deficient in zinc and boron and external application will favorably enhance the growth of onion. The same trends were also recorded by many authors in onion [18]; [5]; [6]; [7]; [19]; [8]; [9];[20]; [1]; [21]; [22].

2. Yield and yield parameters

The yield parameters under study were number of bulblets per clump, polar diameter, equatorial diameterand yield per plot and hectare. The number of bulblets per clump was significantly higher in T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT) followed by T_7 (borax soil application @ 10 kg ha^{-1}) and T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT). This may be due to the improved growth characters as a result of foliar application of micronutrient which would have enhanced photosynthesis and other metabolic activities, which lead to increase in cell division and elongation [23]. This result is in agreement with [24]; [25]; [26]; [21] in onion.

The polar diameter, equatorial diameter influence the yield of onion and consumer preference. The polar and equatorial diameter was higher in T_7 (borax soil application @ 10 kg ha^{-1}) followed T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT). This may be due to the micronutrient application especially boron which enhances the enzyme activity which in turn trigger the physiological processes like protein and carbohydrate

metabolism in plants. Similar results were reported by [24]; [25]; [27]; [26]; [9]; [21].

The response of application of zinc and boron either in soil or foliar had a favorable influence in the bulb yield of onion in a slightly sodic soil with the zinc and boron deficient soil than critical level. The highest bulb yield per plot and hectare was recorded in T_3 (zinc sulphate foliar spray 0.5 % @ 30 and 45 DAT) followed by T_8 (boric acid foliar spray 0.25% @ 30 and 45 DAT). This may be due to zinc, which is one of the most important elements in the carbohydrates metabolism, most enzymes that play a role in carbohydrates metabolism are activated by zinc. In addition Carbonic anhydrase, Fructose-1, 6-bisphosphate and Aldolase enzymes are activated by zinc. These enzymes are active in the chloroplasts and cytoplasm, six-carbon sugar molecule are separated between chloroplasts and cytoplasm by Fructose-1,6-bisphosphate and three-carbon sugars molecule in photosynthesis are transported from cytoplasm to chloroplasts by Aldolase. The activity of these enzymes decreased in zinc deficiency condition, in resulting carbohydrate accumulation in plant leaves [13]; [28]. Similar finding were reported by [24]; [25]; [18]; [29]; [5]; [6]; [7]; [26]; [8]; [9]; [20]; [1]; [21]; [22] in onion.

Conclusion:

The application of zinc and boron shows positive effect towards the growth, yield and yield parameters of aggregatum onion. Growth parameters such as plant height, number of leaves and leaf girth and dry matter production were highly responsive to foliar spray and soil application of zinc sulphate and borax. Yield parameters highly responded to boron as well as zinc, so judicial application of zinc and boron may provide highest yield.

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