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RESEARCH ARTICLE

Effect of Zinc and Boron on Yield and Quality of Onion (*Allium cepa* L.) in Alfisols of Tamirabarni Tract

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ABSTRACT

A field experiment was conducted at Agriculture College and Research Institute, Killikulam, Tamil Nadu during *rabi* season of 2017-18 to determine the effect of zinc and boron along with soil test crop response (STCR) application of N, P and K for achieving better yield and quality of onion crop. The experiment was laid out in a randomized block design with three replications. The experiment consisted of eight treatments *viz.,* T_1 - Soil Test Crop Response (STCR) as 106:97:54 kg of NPK ha^{-1}, T_2 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1}, T_3 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 0.5% foliar spray, T_4 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% foliar spray, T_5 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 10 kg ha^{-1}, T_6 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 0.5% foliar spray, T_7 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 10 kg ha^{-1} + 0.5% foliar spray, T_8 – control. The results showed that yield parameters like bulb lets $clump^{-1}$ (6.4), polar diameter (3.35 cm), equatorial diameter (2.98 cm), weight of bulb (85.2g) and bulb yield (16.85 t ha^{-1}) and bulb qualities such as total soluble solids (15.7 °Brix), ascorbic acid content (13.95 mg $100g^{-1}$), protein (8.46%) and pyruvic acid content (4.82 µmol g^{-1}) was better in application of STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} with 0.5% foliar spray. This treatment recorded the highest net income (Rs.254243 ha^{-1}) and B:C ratio (4.07).

Keywords: *Onion, STCR, Zinc and Boron, Yield and bulb quality.*

INTRODUCTION

Onion (*Allium cepa* L.), 'Queen of Kitchen' is one of the major important bulb crops, belongs to the family Alliaceae. In Tamil, it is called as 'Venkayam'. It is cultivated for food, medicines, religious purpose, spices and condiments since early times. Onion is one of the oldest cultivated species and it has been in use as a food source for over 5000 years. Onion is the cool season crop. However, it can be grown under a wide range of agro-climatic condition.

India ranks the second position in both area and production after China in the world. The total area under onion production in India during 2016-17 was 12.94 lakhs ha and 217.18 lakhs tons with the productivity of 16.8 t/ha. In Tamil Nadu, the total area was 34.08 thousand ha with the production of 347.03 MT and 10.18 t/ha productivity (INDIASTAT 2016-17). In India, it is treated as the most important export-oriented vegetable crop, exporting to the tune of 2,415,757 MT at ₹310,650 lakhs during 2016-17 (NHB, 2017).

In India, Zn deficiency has been estimated as more than 60 % and 70 % in Tamil Nadu soils (Acharya, 2015). Deficiency of boron also occurs widely in different states of India viz., Tamil Nadu, Gujarat and Bihar. The low production of onion is due to improper application of fertilizers and growing unsuitable varieties under the agro-climatic condition of an area. Different level of nutrients affects the yield and taste of onion bulbs even with in a variety. The essential micronutrients especially zinc and boron are necessary for good growth development and more yield. Zinc and boron are important micronutrients having a different function in plants. They play a major role in plant metabolism *viz.,* the formation of auxin, amino acid, protein and translocation of sugars. However, the information on the use of zinc and boron with inorganic fertilizers for onion is scanty in Tamil Nadu, especially in southern districts. Keeping these in view, the present study was planned to elucidate the effect of zinc and boron with inorganic on yield and quality of onion in Alfisols of Tamirabarni tract.

MATERIAL AND METHODS

The investigation was carried out during *rabi* 2017-18 at Agricultural College and Research

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Institute, Killikulam, Thoothukudi District to study the effect of Soil test crop response application of N, P, K along with zinc and boron. Killikulam is situated in the southern agro-climatic zone of Tamil Nadu in Thoothukudi district at 80°46' latitude and 77°42' longitude and at an altitude of 40 m above MSL. The mean annual rainfall at Agricultural college and research institute, Killikulam is 750 mm. The minimum and maximum temperature prevailed during the crop growing season are from 26.3°C to 35°C respectively. The initial soil fertility was found nearly neutral pH value of 6.68, low in EC (0.22 dSm^{-1}), low in organic carbon (4.6 g kg^{-1}), Available N (236 kg ha^{-1}), P (16.8 kg ha^{-1}) and K (245 kg ha^{-1}) of the soil were grouped as low, medium and medium respectively. The available zinc was 1.02 mg kg^{-1} and boron 0.32 mg kg^{-1}.

STCR approach

The following STCR equation developed for onion (CO-5) to achieving 189 q ha^{-1} yield target in Alfisols (sandy clay loam type).

FN = 0.99T - 0. 34 SN, FP_2O_5 = 0.58T - 0.76 SP, FK_2O = 0.67T - 0.23 SK_2O.

Treatment details

There were eight treatments each replicated thrice in RBD design *viz.,* T_1 - Soil Test Crop Response dose (STCR) as 106:97:54 kg of NPK ha^{-1}, T_2 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1}, T_3 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 0.5% foliar spray, T_4 - STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% foliar spray, T_5 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 10 kg ha^{-1}, T_6 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 0.5% foliar spray, T_7 - STCR (106:97:54 kg of NPK ha^{-1}) + borax @ 10 kg ha^{-1} + 0.5% foliar spray, T_8 – control. The foliar application was done at 30 and 45 days after transplanting.

The crop was transplanted after 45 days at 45 x 12 cm spacing in 20m^2 plots (5m x 4m). The cultivation practices were followed as per the guidelines of Crop Production Guide of Tamil Nadu Agricultural University (2014). The fertilizer sources used were urea for N (46 per cent N), single superphosphate for P (16 per cent water soluble P_2O_5), muriate of potash for K (60 per cent of K_2O) and zinc sulphate for Zn (22 per cent Zn) and borax for B (11.36 percent B). A full dose of P, K, Zn, B and half dose of N were applied to onion as basal at the time of transplanting. The remaining dose of N was top dressed at 45 days after transplanting. Growth, yield and quality attributes were recorded as per standard procedures. The cost of cultivation, net returns and benefit: cost ratio was calculated on the basis of the prevailing market price of different inputs and outputs. The post-harvest soil samples were collected from 0-15 cm depth for analyzing available nutrient status. Soil sample was analyzed for alkaline permanganate oxidizable N, 0.5 M $NaHCO_3$ - extractable P and 1N NH_4OAc exchangeable K. The recorded values were analyzed statistically for drawing out definite conclusion.

RESULTS AND DISCUSSION

Yield and yield attributes

The yield attributes such as bulblets/clump, polar diameter, equatorial diameter, the weight of bulb and bulb yield were significantly influenced by various treatments (Table 1).

Table 1. Effect of treatments on yield and yield attributes of onion

Treatments	Bulb lets per clump	Polar diameter (cm)	Equatorial diameter (cm)	Bulb weight (g)	Bulb yield (t ha^{-1})
T_1 – STCR as 106:97:54 kg of NPK ha^{-1}	4.3	2.12	1.94	62.8	12.42
T_2 - STCR + $ZnSO_4$ @ 25 kg ha^{-1}	5.6	2.74	2.56	77.6	15.14
T_3 - STCR + $ZnSO_4$ @ 0.5% foliar spray	5.1	2.53	2.32	69.8	13.73
T_4 - STCR + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% Foliar spray	6.4	3.35	2.98	85.2	16.85
T_5 - STCR + Borax @ 10 kg ha^{-1}	5.3	2.58	2.37	73.7	14.3
T_6 - STCR + Borax @ 0.5% foliar spray	4.8	2.38	2.18	66.6	13.23
T_7 - STCR + Borax @ 10 kg ha^{-1} + 0.5% Foliar spray	6.1	2.97	2.62	81.5	15.92
T_8 – Control	3.7	1.84	1.63	57.8	9.67
SEd	0.11	0.1	0.12	1.74	0.35
CD (0.05)	0.26	0.22	0.26	3.54	0.74

The maximum number of bulblets $clump^{-1}$ (6.4 $clump^{-1}$), polar (3.35 cm) and equatorial diameter (2.98 cm) and weight of bulb (85.2g) was better in application of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} with 0.5% foliar spray followed by the treatment of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK ha^{-1} with borax @ 10 kg ha^{-1} and foliar spray 0.5 per cent which recorded the next maximum bulb lets per $clump^{-1}$ (6.1 $clump^{-1}$), (2.97 and 2.62 cm, respectively), bulb weight (81.5g) compare to the control. This might be due to the translocation and storage of food materials from leaf to the bulb for which

micronutrients were the responsible factors. These findings are in agreement with the findings of Alam *et al.* (2010), Ballabh and Rana (2012) and Ballabh *et al.* (2013).

Significantly highest bulb yield (16.85 t ha^{-1}) was recorded with the application of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK $ha^{-1}$and $ZnSO_4$ @ 25 kg ha^{-1} with 0.5% foliar spray.

Table 2. Effect of treatments on quality parameters in onion bulb

Treatments	TSS (^{0}Brix)	Ascorbic acid (mg 100g^{-1})	Protein (%)	Pyruvic acid (mol g^{-1})
T_1 – STCR as 106:97:54 kg of NPK ha^{-1}	10.3	9.72	7.18	3.12
T_2 - STCR + $ZnSO_4$ @ 25 kg ha^{-1}	12.7	12.38	7.92	4.25
T_3 - STCR + $ZnSO_4$ @ 0.5% foliar spray	12.1	10.62	7.42	3.86
T_4 - STCR + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% Foliar spray	15.7	13.95	8.46	4.82
T_5 - STCR + Borax @ 10 kg ha^{-1}	12.7	11.56	7.68	4.23
T_6 - STCR + Borax @ 0.5% foliar spray	11.2	10.51	7.31	3.56
T_7 - STCR + Borax @ 10 kg ha^{-1} + 0.5% Foliar spray	13.9	12.67	8.21	4.52
T_8 – Control	9.2	7.92	7.03	2.82
SEd	0.4	0.3	0.09	0.1
CD (0.05)	0.85	0.65	0.21	0.22

The treatment of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK ha^{-1} with borax @ 10 kg ha^{-1} and foliar spray 0.5 per cent resulted next highest bulb yield (15.92 t ha^{-1}) than the control. The results of the present investigation well corroborate with the findings of Abedin *et al.* (2012) in onion. Yield parameters highly responded to zinc and boron with balanced NPK, so the application of these two micronutrients provided the highest yield. A similar finding was also reported Yadav *et al.* (2003), El-Tohamy *et al*. (2009) and El-Samad *et al.* (2011).

Quality attributes

Bulb qualities like total soluble solids, ascorbic acid content, protein and pyruvic acid content were significantly influenced by various treatments (Table 2). The maximum content of total soluble solids (15.7 ^{o}Brix), ascorbic acid content (13.95 mg 100g^{-1}), protein (8.46%) and pyruvic acid content (4.82 µmol g^{-1}) were found in application of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK ha^{-1} and $ZnSO_4$ @ 25 kg ha^{-1} with 0.5% foliar spray followed by the treatment of soil test-crop response (STCR) recommendation as 106:97:54 kg of NPK ha^{-1} with borax @ 10 kg ha^{-1} and foliar spray 0.5 per cent (13.9 ^{o}Brix), (12.67 mg 100g^{-1}), (8.21 %) and (4.52 µmol g^{-1}) respectively. This might be attributed to enhanced metabolic processes involved in the biosynthesis processes such as carbohydrates, organic acid, amino acid and other inorganic constituents (Acharya *et al*. 2015). These results are in accordance with the findings of Shrivastava *et al*. (2005), Kamal *et al.* (2013), Diriba-Shiferaw *et al.* (2014) and Khatemenla (2018).

Table 3. Effect of treatments on benefit cost ratio

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit : Cost ratio
T_1 – STCR as 106:97:54 kg of NPK ha^{-1}	77141	248400	171259	3.22
T_2 - STCR + $ZnSO_4$ @ 25 kg ha^{-1}	80316	301600	219684	3.75
T_3 - STCR + $ZnSO_4$ @ 0.5% foliar spray	79582	274600	195018	3.45
T_4 - STCR + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% Foliar spray	82757	337000	254243	4.07
T_5 - STCR + Borax @ 10 kg ha^{-1}	81576	286000	204424	3.51
T_6 - STCR + Borax @ 0.5% foliar spray	79937	264600	184663	3.31
T_7 - STCR + Borax @ 10 kg ha^{-1} + 0.5% Foliar spray	84372	318400	234028	3.77
T_8 – Control	67971	193400	125429	2.85

*Cost of Fertilizers - Urea (Rs.5.52/kg), SSP (Rs.5.24/kg), OP (Rs.16/kg), $ZnSO_4$ (Rs.58/kg) and Borax (Rs.200/kg)

*Value of produce (Rs.20/kg) *BCR = Gross income / Cost of cultivation (Gittinger, 1982)

Economics

The economics worked out in the field experiment revealed the beneficial effect of application of STCR as 106:97:54 kg of NPK ha^{-1} with $ZnSO_4$ soil application @ 25 kg ha^{-1} and 0.5 per cent foliar spray that recorded the best treatment with net income of Rs.254243 ha^{-1} with B:C ratio of 4.07 followed by the soil and foliar application of borax @ 10 kg ha^{-1} and 0.5 per cent with STCR as 106:97:54 kg of NPK ha^{-1} recorded the next best treatment with net income of Rs.234028 ha^{-1} and B:C ration of 3.77 (Table 3). The higher net return in this treatment might be due to the soil application of zinc and boron fertilizer, which were locally availed in abundant resulted in obtaining of higher benefit: cost ratio. The earlier findings of Yadav *et al.* (2003), Goyal *et al*. (2015), Singh *et al.* (2017) support the present investigation.

CONCLUSION

The experimental results indicate that, the application of STCR as 106:97:54 kg of NPK ha^{-1} with $ZnSO_4$ @ 25 kg ha^{-1} and 0.5 per cent foliar spray (T_4) increased the bulb yield (16.85 t ha^{-1}) and better net income (Rs.2,54,243 ha^{-1}) of onion CO (On) 5 in the Alfisols of Tamirabarni tract. Hence, the present study concluded that the application STCR as 106:97:54 kg of NPK ha^{-1} with $ZnSO_4$ @ 25 kg ha^{-1} and 0.5 per cent foliar spray (T_4) is effective to maximize the yield and income of onion cultivating farmers in Alfisols of Tamirabarni tract.

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