Eco. Env. & Cons. 29 (January Suppl. Issue) : 2023; pp. (S404-S409)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i01s.062

Interaction effect of Zinc and Boron on quality parameters and storage of onion under temperate conditions

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(Received 26 June, 2022; Accepted 19 August, 2022)

ABSTRACT

A study for 2 consecutive years was carried out at SKUAST-K to produce high quality onions and having long storage under temperate conditions. The study revealed that application of boron in combination with zinc produce onions having better quality and storage. Sixteen treatments were applied in three replications in RCBD (randomized complete block design). Conjugation of 7.500 kg Zn ha^{-1} +1.500 kg B ha^{-1} recorded maximum values of quality traits like protein content (13.21 percent), vitamin C content (14.79 mg 100^{-1}g), T.S.S (13.89 °Brix), pyruvic acid (8.52 ìmol g^{-1}), dry matter content (15.78 percent) and significantly lower values for physiological weight loss (11.01 percent), sprouting (6.32 percent) and rotting (7.22 percent) followed by Z_3B_2 treatment.

Key words: *Onion, quality, sprouting, boron and zinc*

Introduction

Onion (*Allium cepa*) also known as "queen of kitchen" belongs to *Alliaceae* family, it posses high potential of foreign exchange earner for India. Anthocyanins, flavonols, quercetin and kaempferol of onion have antioxidant activity (Rhodes and Price, 1996). Sulfides of onions have been shown to reduce platelet aggregation (Ali *et al.*, 2000). Storage is an important aspect for post harvest life of onion. Storage can be enhanced by arresting metabolic break down and enzymatic activities. Nutrients are very critical for development of plants. Nutrients are macronutrients and micronutrients. Macronutrients are required in large concentration to plants while micronutrients are required in minute quantities. There are various micronutrients for growth and development of plants. Among them zinc is an important micronutrient for onion. Zinc as a micronutrient has a great role in achieving higher and sustainable bulb yields (Singh and Tiwari, 1996). It regulates growth, development and enzyme activities. Application of zinc significantly increased the yield and bulb quality of onion (Rafie *et al.*, 2016). Samad *et al.*, 2011 reported foliar application of zinc significantly improved quality parameters of onion in terms of total soluble solid (TSS) and pyruvic acid content while Ballabh *et al.* (2013) reported the influence of different levels of zinc (4 mg l^{-1} and 6 mg l^{-1}) on vitamin C content of onion and observed that application of zinc at the rate of 6 mg l^{-1} produced maximum vitamin C content of 17.4 mg 100 g^{-1}. Application of zinc (10 kg ha^{-1}) decreased rotting and physiological weight loss of onion (Aske *et al.*, 2017). Zinc deficient plants are stunted and have twisted, outward bending leaves. Deficiency of zinc decrease quality either directly or indirectly. Bulbing can be delayed and crops may not store well. Deficiencies are more on calcareous soils or during cold, wet weather (Diaz *et al.*, 2013). Zinc deficiency is a worldwide problem both in temperate and tropical climates (Fageria *et al.*, 2011). The critical level of zinc for soil is 0.64 ppm (Sanchez, 1996). Boron is other important micronutrient for onion bulb quality and storage. Boron is other important micronutrient playing an important role in bulb quality and storage of onion. Boron is one of the important micronutrients for onion production and is essential for cell division, nitrogen and carbohydrate metabolism, protein formation and water relation in plant growth (Brady, 2010). Boron increases sugar transport and production of carbohydrates during photosynthesis. Boron is needed for the production of uracil, a pre-curser of uridine-diphosphate-glucose (UDPG), an essential enzyme for the production of sucrose. Similar findings have been reported by Manna (2013) in onion. Application of boron enhanced the shelf life of tomato by 11 days (Jeanine *et al.*, 2003). Application of boron registered a reduction in physiological weight loss during storage (Alphonso, 2007). More quality is adversely affected in onion bulbs when grown under boron deficient soils. Most of the soils (fine as well as coarse textured) are considered to be low in available boron as it has been reported that <0.50 mg kg^{-1} boron is not sufficient for optimum plant growth (Reisenaure *et al.*, 2008). Conjugation of zinc sulphate with boron increases values for vitamin C content and total dry matter production in onion (Acharya *et al.*, 2015). Application of zinc along with boron increases shelf life of onion as it decreases physiological weight loss and rotting (Vijay *et al.*, 2015). Inadequate availability of zinc and boron in soils of Kashmir calls an urgent need for the standardization of an optimum dose of these micronutrients for harnessing higher quality and increase shelf of onion.

Materials and Methods

Description of the study area

The experiment was conducted at experimental farm of SKUAST-K for 2 successive years The altitude of the location is 1606 m amsl and situated 34°. 5 ^ north of latitude and 74°.89ˆ east of longitude. Analysis for quality parameters was done in the laboratory of vegetable division of SKUAST-K. Shelf life determination of onion samples were done after storage in well ventilated store.

Experimental designs and treatments

The experimental design was RCBD with 16 treatments in 3 different replications. Total number of plots were 48 plant spacing was 20 ×15. No of plants per plot was 132 and sample size was 10. Treatment combinations were sixteen and their detail are depicted below in tabular form

Treatment	Treatment combinations	Structure of the treatment Combination (kg ha^{-1})
T_1	$Z_0 B_0$ (control)	No Zinc + No Boron
T_2	$Z_0 B_1$	No Zinc + 0.500 Boron
T_3	$Z_0 B_2$	No Zinc + 1.000 Boron
T_4	$Z_0 B_3$	No Zinc + 1.500 Boron
T_5	$Z_1 B_0$	2.500 Zinc + No Boron
T_6	$Z_1 B_1$	2.500 Zinc + 0.500 Boron
T_7	$Z_1 B_2$	2.500 Zinc + 1.000 Boron
T_8	$Z_1 B_3$	2.500 Zinc + 1.500 Boron
T_9	$Z_2 B_0$	5.000 Zinc + No Boron
T_{10}	$Z_2 B_1$	5.000 Zinc + 0.500 Boron
T_{11}	$Z_2 B_2$	5.000 Zinc + 1.000 Boron
T_{12}	$Z_2 B_3$	5.000 Zinc + 1.500 Boron
T_{13}	$Z_3 B_0$	7.500 Zinc + No Boron
T_{14}	$Z_3 B_1$	7.500 Zinc + 0.500 Boron
T_{15}	$Z_3 B_2$	7.500 Zinc + 1.000 Boron
T_{16}	$Z_3 B_3$	7.500 Zinc + 1.500 Boron

FYM, Nitrogen (N), Phosphorus (P_2O_5), Potassium (K_2O) and Sulphur was applied as per recommended package for the region i.e., 25 t ha^{-1}, 100 kg ha^{-1}, 80 kg ha^{-1}, 60 kg ha^{-1} and 45 kg ha^{-1} respectively.

Curing

After harvesting, crop with foliage was kept under shade for few days for strengthening of outer periderm to reduce the moisture content upto the level of storage.

Storage

Cured bulbs about 5 kg from each treatment with intact neck (3 cm long) were kept in the store at room temperature (ambient conditions) for period of three months

Observations recorded

Protein content (%)

The protein content was calculated by multiplying a factor 6.23 (protein factor) with total nitrogen content in bulbs. Total nitrogen content in bulbs was determined by Kjeldahls method as outlined by Tandon (1993).

Vitamin C content (mg 100^{-1} g)

Ascorbic acid, generally known as vitamin C is present in all fresh vegetables and fruits. The fresh bulbs preferably of uniform size from representative plants were picked and cut into small pieces. Hundred gram of chopped fresh bulbs from each plot were then used for the estimation of Vitamin C content in the laboratory following 2,6- dichlorophenol indophenols visual titration method (A.O.A.C., 2000) and expressed as milligrams 100 g^{-1} of fresh bulbs

Total soluble solids (TSS) content (°Brix)

The juice obtained from bulbs was tested for °Brix value, which is an index of total soluble solids with the help of a calibrated refractometer. The average °Brix values of ten bubs was then computed.

Pyruvic acid (ìmoles of g^{-1})

Pungency develops when allianase enzyme interacts with precursors collectively known as S allyl cysteine sulfoxide, after cutting or crushing of onion tissue following the procedure of Ketter and Randle (1998) for pungency.

Dry matter (%)

The bulbs of ten sampled plants from each treatment were sliced separately and composite samples of 100 g were taken from each treatment and subjected to sun drying followed by oven drying at 60 °C to a constant weight. The dried material was weighed and recorded as dry matter content in percent.

Storage quality of onion (total weight loss%)

After curing 10 kg bulbs from each treatment were kept in perforated plastic crates keeping lower crates empty and stored in well-ventilated conditions at room temperature for a period of 90 days (3 months). The physiological weight loss, sprouting percent and rotting per cent during storage were recorded after each month and total weight loss was then calculated by following formulas:

$$\text{PWL (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

$$\text{Sprouing (\%)} = \frac{\text{No. of sprouted bulbs}}{\text{Total No. of bulbs}} \times 100$$

$$\text{Rotting (\%)} = \text{No. of rotted bulbs} \times 100$$

Statistical analysis

In order to test the significance of results, the experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984). Levels of significance used for 'F' and 'T' tests were p= 0.05 as given by Fisher (1970).

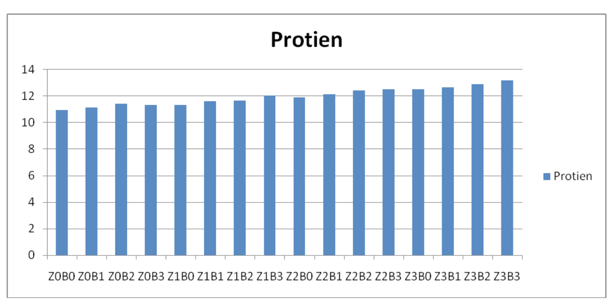
Results

Protein content

Pooled data revealed that combined application of zinc and boron (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) registered maximum protein content of 13.21 percent which was significantly superior to rest of other treatments but was at par with respect to Z_3B_2. Control treatment recorded significantly lower protein content of 10.93 percent was recorded with treatment combination Z_0B_0.

In terms of vitamin C pooled analysis revealed that Z_3B_3 treatment (7.500 kg Zn ha^{-1} + 1.500 kg B ha^{-1}) recorded maximum vitamin C content of 14.79 mg 100^{-1}g, which was significantly superior to rest of other treatments. Treatment Z_0B_0 recorded significantly lowest vitamin C content of 11.28 mg 100^{-1}g.

Pooled data revealed that combined application of zinc and boron @ 7.500 kg ha^{-1} and 1.500 kg ha^{-1} produced significantly maximum value (13.89 °Brix) for T.S.S content of bulbs and was statistically at par with amalgamation of zinc at the rate of 5.000 kg ha-

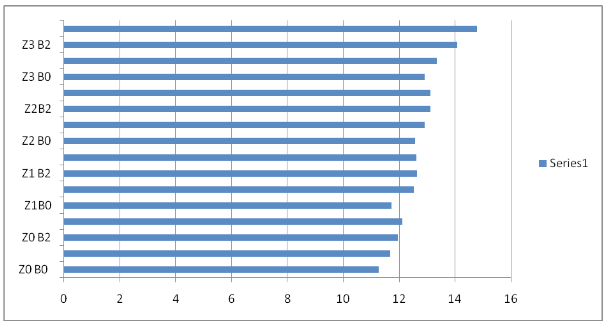


C.D (p≤0.05): 0.30, S.E (m): 0.092

Fig. 1. Interaction effect of different levels of zinc and boron on protein (%)

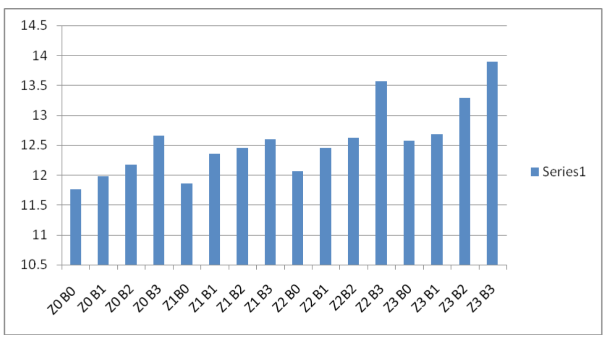
^{1} and boron at the rate of 1.500 kg ha^{-1} (13.57 ^{o}Brix). Control treatment Z_0B_0 recorded significantly lower value of 11.76 ^{o}Brix for T.S.S (^{o}Brix) content as compared to rest of treatments.

Fig 4 of pooled data revealed that conjugation of zinc and boron (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) recorded significantly maximum value of 8.52 ìmol g^{-}



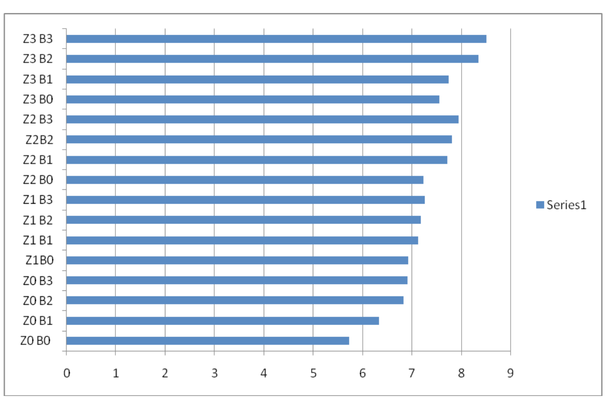
C.D (p≤0.05): 0.42, S.E (m): 0.14

Fig. 2. Interaction effect of different levels of zinc and boron on vitamin C (mg 100g^{-1})



C.D (p≤0.05): 0.32, S.E (m): 0.11

Fig. 3. Interaction effect of different levels of zinc and boron on TSS (^{0}Brix)



C.D (p≤0.05): 0.49, S.E (m): 0.16

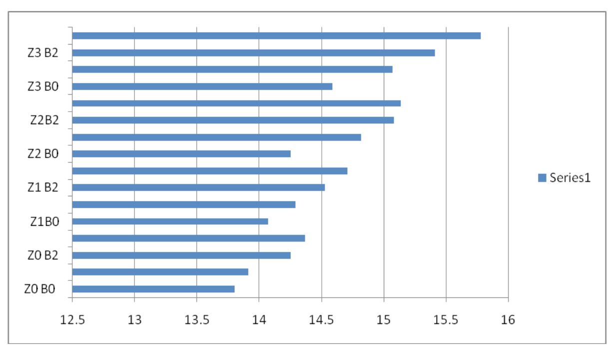
Fig. 4. Interaction effect of different levels of zinc and boron on pyruvic acid (µmol g^{-1})

^{1} for pyruvic acid content which was statistically at par with Z_3B_2 (8.35 µmol g^{-1}). Significantly lower pyruvic acid content of 5.73 µmol g^{-1} was recorded with Z_0B_0 treatment combination.

Significant interactions for dry matter content were found between zinc and boron. Z_3B_3 (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) recorded a highest value of 15.78 percent for dry matter content. Lowest dry matter content of 13.80 percent was r ecorded with Z_0B_0. Results are depicted on Table 2. Significant interactions for dry matter content were found between zinc and boron. Z_3B_3 (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) recorded a highest value of 15.78 percent for dry matter content. Lowest dry matter content of 13.80 percent was recorded with Z_0B_0 as depicted in Fig.5.

Physiological weight loss, sprouting and rotting (%)

Pooled analysis over years revealed significant influence in reducing the physiological weight loss, sprouting and rotting percent of onion bulbs. Treatment combination Z_3B_3 (7.500 kg Zn + 1.500 kg B ha^{-1}) recorded a minimum physiological weight loss of 11.01 per cent, sprouting 6.32 percent and 7.22 percent for rotting which was significantly lower as compared to the values recorded with other treatment combinations including Z_0B_0 which recorded maximum physiological weight loss 18.09 percent, 11.41 percent for sprouting and 13.66 percent rotting.



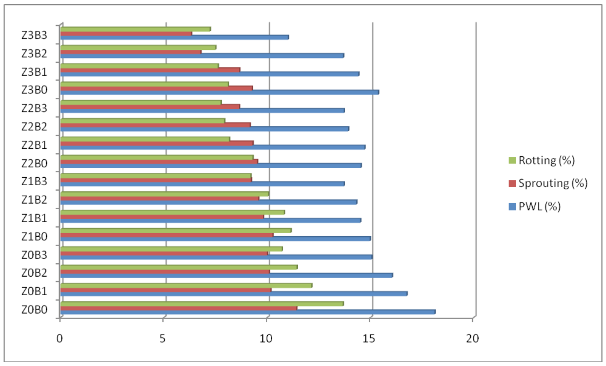
C.D (p≤0.05); 0.22, S.E (m): 0.076

Fig. 5. Interaction effect of different levels of zinc and boron on dry matter (%)

Discussion

Effect of zinc and boron on quality parameters of onion

Combined application of zinc and boron (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) has proved superior and benefi-



Rottimg (%) C.D (p≤0.05)= 0.74 S.E (m)= 0.24 Sprouting: C.D (p≤0.05)= 0.52, S.E (m)= 0.18, PWL (%) C.D (p≤0.05)= 1.09 S.E (m)= 0.36

Fig. 6. Interaction effect of different levels of zinc and boron on physiological weight loss (%), sprouting (%) and rotting (%)

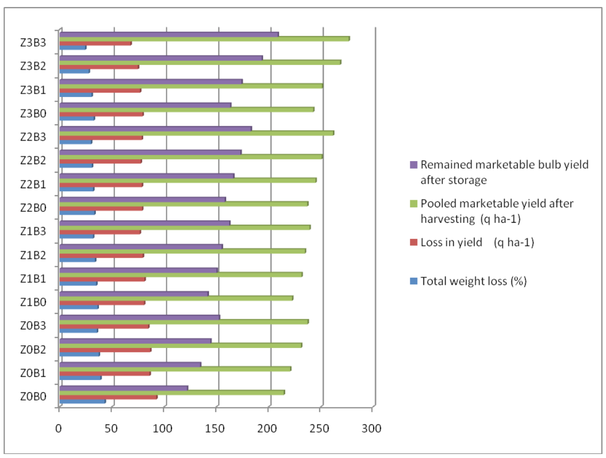


Fig. 7. Interaction effect of different levels of zinc and boron on total weight loss %, Loss in yield (q ha^{-1}).pooled marketable yield after harvesting (q ha^{-1}) and remained marketable yield after storage (q ha^{-1}).

cial to the crop for improving quality attributes as compared to their sole applications. Pooled analysis showed that treatment Z_3B_3 (7.500 kg ha^{-1} + 1.500 kg ha^{-1}) recorded significantly maximum value for protein content (13.21 percent), vitamin C (14.79 mg 100g^{-1}), TSS (13.89 °Brix), pyruvic acid (8.52 umol g^{-1}) and dry matter content (15.78 percent) as compared to other combinations. Treatment Z_3B_3 depicted an increasing 20.86 percent in protein content, 31.12 percent in vitamin C, 18.11 percent in TSS, 49.21 percent in pyruvic acid content and 19.80 percent in dry matter content over control. This might have been possible due to synergistic effect between zinc and boron on photosynthate's synthesis which in turn increases the synthesis of carbohydrates and other metabolic compounds as boron is needed for the production of uracil, a pre-curser of uridine-diphosphate-glucose (UDPG), an essential enzyme for the production of sucrose and this could be attributed to increased synthesis of amino acids with zinc application and due to increased uptake of nitrogen, potassium, sulphur, zinc and boron by crop which are the main constituents of many amino acids and nucleic acids which in turn have enhanced the replication, transcription and translation. In addition to this, application of zinc might have enhanced metabolic processes involved in biosynthesis of total soluble solid, such as carbohydrates, organic acid, volatile compounds, amino acids and other inorganic constituents. This may also be due to greater translocation of photosynthates from source to sink. Lal and Maurya (1981) observed that these two elements (zinc and boron) increases the content of reducing, non-reducing and total sugars, which are the components of dry matter. Similar findings have been reported by Singh *et al*. (2001), Mohsen *et al.* (2007) and Ballabh *et al.* (2013) in onion; Reddy and Reddy (1986) in brinjal and Salam *et al.* (2011) in tomato and Deepika and Anita in radish (2015).

Effect of zinc and boron on quality parameters of onion

Pooled analysis (4.17-4.19) revealed that interaction among zinc and boron, Z_3B_3 (7.500 kg Zn + 1.500 kg B ha^{-1}) recorded significantly lower values of 11.01 per cent for physiological weight loss, 6.32 per cent for sprouting and 7.22 per cent for rotting but exhibited at par results with Z_3B_2 (7.500 kg Zn + 1.000 kg B ha^{-1}) treatment with respect to sprouting (6.77%) and rotting (7.49%) after 3 months of storage. Significantly maximum value for physiological weight loss (18.09%), sprouting (11.41%) and rotting (13.66%) of onion bulbs was recorded with Z_0B_0. The improvement in storage quality/shelf life could be attributed due to synergistic relationship between zinc and boron which resulted in improvement of storage qualities of onion bulbs because of increased uptake of nutrients like nitrogen, potassium, sulphur, zinc and boron which increased dry matter content of onion bulbs. The reason may be due to increased synthesis of primary sulphur compounds such as S-allyl cysteine compounds which are positively correlated with keeping quality of bulb as it has also been reported by Diriba *et al.* (2013) in garlic. Similar findings were reported by Salam *et al.* (2011) in tomato and Vijay *et al.* (2015) in onion.

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