

EFFECT OF IRON, ZINC AND BORON ON GROWTH AND GROWTH PARAMETERS OF ONION (*Allium cepa* L.) cv. AGRIFOUND LIGHT RED

ABSTRACT

This experiment was undertaken to compare the effect of certain micronutrient on growth and development of onion. The result revealed that the treatment ^{iron} i_1 (20 kg iron/ha) significantly showed maximum plant height (22.20 cm and 68.64 cm) at 30 and 90 DAT, number of leaves per plant (4.16, 6.95 and 9.16) and neck thickness (0.61 cm, 1.41 cm and 2.23 cm at 30, 60 and 90 DAT, respectively), minimum neck thickness (1.20 cm) at the time of harvesting and minimum days taken to maturity (116.98) after transplanting.

Zinc, 25Kg/ha (z_1) effected significantly

Significantly, maximum plant stand in field (99.23 %) at 30 DAT, plant height (48.25 cm and 69.75 cm), number of leaves per plant (7.01 and 9.35 at 60 and 90 DAT, respectively) and neck thickness (0.63 cm and 2.28 cm at 30 and 90 DAT, respectively) and minimum days taken to maturity (118.20) after transplanting were recorded with treatment z_1 (25 kg zinc/ha).

In continuation, Boron prompted

Significantly maximum plant height (21.30 cm at 30 DAT), number of leaves per plant (3.95 and 6.79 at 30 and 60 DAT), neck thickness (2.20 cm at 90 DAT) as well as minimum neck thickness at the time of harvesting (1.22 cm) and per cent bolting (3.83 %) were recorded with treatment b_2 (5.0 kg boron/ha). The treatment b_1 (2.5 kg boron/ha) was found to have significantly maximum plant height (67.44 cm) and number of leaves per plant (8.89) at 90 DAT.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable bulb crops grown in India from ancient time. The edible portion is a modified leaves which is known as “bulb” and develops underground. Onion is popularly used as green as well as mature bulb. It is widely used as a cooked vegetable in soups, mix vegetable and flavouring agent in many additional dishes. Because of its importance in cookery, onion is called as “Queen of the kitchen” (Selvaraj, 1976). It can be kept for a fairly long period and can safely withstand the hazards of rough handling including long distance transportation. Onion belongs to family Alliaceae. The other members of this family are asparagus, garlic, leek etc. The origin of onion is said to be

central Asia. The *Allium* genus comprises of 300 to 500 species, which are widely distributed in the northern temperate region. The common onion grown for the dry bulb is *Allium cepa* L.

✓ (Thompson and Kelley, 1957).

India is prominent in the production and export of onion in the world. In India onion is being grown in an area of 12.03 lakh hectare with total bulb production of 197.01 lakh metric tonnes (Anonymous., 2014). In the world, India ranks 2nd in area and 5th in production of onion. Maharashtra, Gujarat, Karnataka, Tamil Nadu, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Bihar are the major onion growing states in India. In Gujarat, onion occupied an area of about 72.79 thousand hectares with total bulb production of 18.51 lakh metric tonnes. (Anonymous., 2014). The major onion growing districts in Gujarat state are Bhavnagar, Amreli, Junagadh, Rajkot, Mehsana, Jamnagar, Surat and Anand.

Indian soil ^{had} have been chronically poor in nitrogen, phosphorus, iron, zinc, boron, magnesium and sulphur and due to continuous cropping, multiple nutrient deficiencies have been noticed. Zinc deficiency in onion is fairly wide spread and is noticed also in garlic in the sandy soils. Deficiency of iron in onion, garlic, brinjal, tomato and potato is also noticed in sandy soils. Boron deficiency is also noticed in tomato, carrot, onion, garlic, radish and pomegranate in sandy and loamy sand soil in Gujarat and Rajasthan region.

Micronutrients can be restored, maintained and sustained by three procedures *e.g.* addition of organic residues from plant and animal sources, strengthening the soil biological process and use of synthetic micronutrients and soil amendments as per needs. The availability of the essential micronutrients to plants is often poorly related to the total quantity of the particular element in the soil. Iron and zinc are the most abundant metal to be found in living organisms, where it plays a major structural, catalytic and co-catalytic role in enzymes.

~~Iron is very important element as it plays active role in chlorophyll formation and chlorophyll being used in photosynthesis by plants, is of greater significance. It is a constituent of prophyrin compounds-cytochromes, haem, non-haem enzymes and of other functional metalloproteins, *e.g.* ferredoxin and hemoglobin in plants. Deficiency symptoms of iron causes intervenial chlorosis primarily on young tissues which may become white. It shows deficiency symptoms on poorly drained soil. Soil high in calcium, copper, zinc, phousphorus and high pH shows unavailability of iron. Toxicity symptoms are rarely observed except on flooded soils.~~

~~(Mishra and Rajesh Kumar 2014). Zinc is essentially required for chlorophyll production, carbohydrates and starch formation. In deficiency of zinc, young leaves become very small, sometimes even missing leaf blades. It showed short leaf length, distorted or puckered leaf margin and also chlorosis. Boron helps in the use of nutrients and regulates other nutrients. It~~

~~helps in translocation of sugar and carbohydrates. It is essential for seed and fruit development. Deficiency symptoms of boron may cause plant failure to set fruit. Its deficiency cause internal break down of fruit and vegetables, giving rise to witches broom, young leaves become thick, lathery and scorcking on young stem petioles and flower stalks.~~ Keeping into consideration the above facts in mind an experiment entitled “Effect of iron, zinc and boron on growth of onion (*Allium cepa* L.) cv. Agrifound Light Red” was planned and executed .

MATERIAL AND METHODS

Field investigation on influenced of combined application of micronutrient^s with varied level on growth and development of onion bulbs were conducted during rabi season of was conducted at Department of Vegetable Science, College of Horticulture, S. D. Agricultural University, Sardarkrushinagar. Sardarkrushinagar is located at a distance of about 170 km from Ahmedabad and geographically, situated on 24° 19' North latitude and 72o 19' East longitude at an altitude of 154.32 meters above mean sea level. It represents the North Gujarat Agro-climatic zone (AES-IV) of Gujarat.

The climate of Sardarkrushinagar is typically sub-tropical characterized by semi-arid and arid condition having warm and humid monsoon, cool and dry winter and quite hot summer. Generally, monsoon commences in the middle of June and retreats by the middle of September. Most of the precipitation is received from South-West monsoon, concentrating in the month of July and August. The normal annual average rainfall of Sardarkrushinagar is 688.42 mm received in about 28 rainy days during last 15 years. The winter season starts from the end of October and continues till the end of February. The minimum temperature of the year is reached during middle December to middle January. The temperature starts rising from February and reaches maximum in the month of May. April and May are the hottest months of the summer season.

The experiment was laid out in factorial Randomized Block Design with twenty seven ~~treatments were employed and replicated thrice.~~ ^{with three replicates.} Comprising twenty seven treatment combinations with three levels of each viz., iron, zinc and boron were tested during the rabi season of the year 2013 and 2014. The treatments were evaluated on the basis of growth and development observations which were subjected to statistical analysis. The treatments were applied in the form of zinc sulphate, iron sulphate and borax. There were altogether 27 treatment combinations with viz., Iron (0, 20 and 40 kg/ha), Zinc (0, 25 and 50 kg/ha) and Boron (0, 2.5 and 5.0 kg/ha) from different source of FeSO₄, ZnSo₄ and borax were applied as soil application. The crop was fertilized with recommended doses of 100:50:50 NPK/ha for

onion. The 20% N was added as basal and remaining 80% in four equal splits at an interval of 30, 45, 60 and 75 days after transplanting. Proper care for weeding, intercultural operations, and plant protection measures were taken from transplanting to harvesting. Observations on bulb quality parameters *viz*, diameter of bulb and neck thickness after curing of onion bulbs was measured with the help of vernier caliper and average was calculated. The observations were made from the selected tagged 10 plants for each treatment. Statistical analysis was done by using standard techniques (Panse and Sukhatme, 1995).

RESULTS AND DISCUSSION

1. Effect of iron, zinc and boron on plant stand in field at 30 days after transplanting (%)

Influence of different levels of iron, zinc and boron on plant stand are presented in Table 1. The effect of different levels of iron on plant stand was found to be not significant during both the years of experiment and in pooled data. The data revealed that the effect of various levels of zinc treatments on plant stand was found not significant during both the years of experiment. Effect of different levels of zinc in pooled data was found significant. The significantly maximum plant stand (99.23 %) was obtained with treatment z₁. The treatment z₂ recorded minimum plant stand (98.28 %) in pooled analysis. The effect of various levels of boron treatments on plant stand was found not significant during both the years of experiment and in pooled data. Interaction effect between different levels of iron, zinc and boron on plant stand was found not significant during both the years of experiment and in pooled data.

2. Effect of iron, zinc and boron on plant height at 30, 60 and 90 DAT (cm)

The data pertaining to influence of iron, zinc and boron on plant height at 30, 60 and 90 DAT are presented in Table 1 and graphically depicted in Fig. 1. The effect of various levels of iron on plant height at 30 DAT was found to be significant during both the years of experiment and in pooled data. The maximum plant height (22.82 cm, 21.57 cm and 22.20 cm) was observed under treatment i₁ during the year 2013-14, 2014-15 and in pooled data, respectively.

The minimum plant height was observed with treatment i₂ (20.80 cm, 18.50 cm and 19.65 cm) during both the years i.e. 2013-14, 2014-15 and in pooled data, respectively. Influence of different levels of iron on plant height at 60 DAT was found significant during

both the years of experiment. Significantly maximum plant height was observed with treatment i_1 (53.75 cm and 43.92 cm) during the year 2013-14 and 2014-15, respectively which was statistically at par with treatment i_0 during the year 2014-15. The minimum plant height was found under treatment i_2 (47.80 cm and 41.38 cm) during both the years of experiment. The influence of different levels of iron on plant height at 90 DAT was found significant. The maximum plant height (72.68 cm, 64.59 cm and 68.64 cm) was observed with treatment i_1 during the year 2013-14, 2014-15 and in pooled analysis, respectively. The minimum plant height (69.77 cm, 60.10 cm and 64.93 cm) was observed with treatment i_2 during the year 2013-14, 2014-15 and in pooled data, respectively. Iron is an important catalyst in the enzymatic reactions of the metabolism would have helped in the high biosynthesis of photo assimilates thereby ~~used efficiently in onion growth so that plant height was increased.~~ ^{increasing plant height} These findings are in close accordance with the findings of Jawaharlal *et al.* (1986), Tohamy *et al.* (2009), Ballabh *et al.* (2013), Singh *et al.* (2015^a) ~~and Singh *et al.* (2015^b)~~ ^(2025a, 2015b) in onion. Influence of different levels of zinc treatments on plant height at 30 DAT was found significant. Significantly maximum plant height (22.77 cm and 22.35 cm) was observed with treatment z_1 during the year 2013-14 and 2014-15, respectively. The minimum plant height was recorded under treatment z_2 (20.94 cm and 17.61 cm) during both the years of experiment. The Influence of different levels of zinc on plant height at 60 and 90 DAT were found significant during both the years of experiment and in pooled data. Significantly maximum plant height (52.00 cm, 44.50 cm and 48.25 cm) and (73.61 cm, 65.90 cm and 69.75 cm) was obtained with treatment z_1 at 60 and 90 DAT during the year 2013-14, 2014-15 and in pooled data, respectively. Treatment z_1 was statistically at par with treatment z_0 at 60 DAT in the year 2013-14 and in pooled data. The minimum plant height (49.43 cm, 40.53 cm and 44.98 cm) and (68.45 cm, 58.10 cm and 63.27 cm) was observed with treatment z_2 at 60 and 90 DAT during both the years of experimentation and in pooled data, respectively. (Table-1)

Zinc has a vital role in growth of plant. It regulates the oxidation-reduction processes in plants. This increase in height of plant may be due to the active synthesis of tryptophan in the presence of zinc, which stimulates the growth of plant. There is an enhancement in cell multiplication and cell elongation resulting in more plant height. This is similar to findings of Abedin *et al.* (2012), Ballabh *et al.* (2012), Ballabh *et al.* (2013), Verma *et al.* (2014), Manna *et al.* (2014), Rizk *et al.* (2014), Shukla *et al.* (2015), Acharya *et al.* (2015) and Begum *et al.* (2015) in onion. ^{Ballabh and Rana (2012)}


Effect of boron with respect to plant height at 30 DAT was found significant. Significantly maximum plant height (22.19 cm, 20.41 cm and 21.30 cm) was observed with

treatment b_2 during the year *i.e.* 2013-14, 2014-15 and in pooled data, respectively which was statistically at par with treatment b_1 in the year 2013-14. Minimum plant height (21.31 cm, 19.36 cm and 20.33 cm) was observed under treatment b_0 during both the years of experiment and in pooled data, respectively. The influence of different levels of boron on plant height at 60 DAT was found not significant during both the years of experiment and in pooled data. Influence of different levels of boron on plant height at 90 DAT was found to be significant during both the years of experimentation and in pooled data. The maximum plant height was found with treatment b_1 (72.16 cm and 67.44 cm) during the year 2013-14 and in pooled data, respectively and it was statistically at par with treatment b_2 . The significantly maximum plant height (63.25 cm) was obtained under treatment b_2 in the year 2014-15, which was at par with treatment b_1 . The minimum plant height (69.12 cm, 60.80 cm and 64.96 cm) was observed with treatment b_0 during both the years of experiment and in pooled data, respectively. The interaction effect between iron, zinc and boron was not found significant **variation** at different stages of plant growth during both the years of experimentation. The favourable effect of boron on plant growth may be due to its role in many physiological process and cellular functions within the plant. In addition, boron plays an essential role in improving plant growth through the biosynthesis of endogenous hormones which is responsible for promotion of plant growth. These results are in accordance with the findings of Alam *et al.* (2010), Abedin *et al.* (2012), Ballabh *et al.* (2012), Manna *et al.* (2014), Singh *et al.* (2015^a) and Singh *et al.* (2015^b) in onion.

3. Effect of iron, zinc and boron on number of leaves per plant at 30, 60 and 90 DAT

The influence of different levels of iron, zinc and boron on number of leaves per plant at 30, 60 and 90 DAT are presented in Table 2 and graphically depicted in Fig. 2. The effect of various levels of iron on number of leaves per plant at 30, 60 and 90 DAT were found to be significant during both the years of experimentation and in pooled data. Significantly maximum number of leaves per plant (4.32, 3.99 and 4.16), (7.06, 6.85 and 6.95) and (9.46, 8.86 and 9.16) was obtained with treatment i_1 at 30, 60 and 90 DAT, respectively during both the years *i.e.* 2013-14, 2014-15 and in pooled analysis, which was statistically at par with treatment i_0 at 60 DAT in the year 2014-15. The minimum number of leaves per plant (3.73, 3.62 and 3.67), (6.40, 6.48 and 6.44) and (8.68, 7.90 and 8.29) was observed under treatment i_2 during the year 2013-14, 2014-15 and in pooled data, respectively.

The favourable effect of iron on plant growth might be due to its role in many physiological processes and cellular functions within the plants and its effective role in biosynthesis of endogenous hormones. These findings are in close accordance with the findings

of Jawaharlal *et al.* (1986), Tohamy *et al.* (2009), Ballabh *et al.* (2013), Singh *et al.* (2015^a) and Singh *et al.* (2015^b) in onion. 

Effect of zinc with respect to number of leaves per plant was found to be significant at 30 DAT during both the years of experiment and found to be not significant in pooled data. Significantly maximum number of leaves per plant (4.42 and 4.07) was obtained with treatment z_1 during the year *i.e.* 2013-14 and 2014-15, respectively. The minimum number of leaves per plant (3.61 and 3.53) was observed with treatment z_2 during year *i.e.* 2013-14 and 2014-15, respectively. Effects of various levels of zinc on number of leaves per plant were found to be significant at 60 and 90 DAT during both the years of experiment and in pooled data. Significantly maximum number of leaves per plant (7.08, 6.93 and 7.01) and (9.65, 9.05 and 9.35) were observed under treatment z_1 at 60 and 90 DAT, respectively during both the years *i.e.* 2013-14, 2014-15 and in pooled data, respectively and it was statistically at par with treatment z_0 at 90 DAT during the year 2013-14. While minimum number of leaves per plant (6.29, 6.38 and 6.33), (8.40, 7.60 and 8.00) were observed with treatment z_2 during both the years *i.e.* 2013-14, 2014-15 and in pooled data, respectively. Zinc is essential for tryptophan synthesis which is a prerequisite for auxin formation. The favourable effect of zinc on plant growth may be due to its role in many physiological processes and cellular functions within plants. The present findings are in close accordance with findings of Abedin *et al.* (2012), Ballabh *et al.* (2012), Ballabh *et al.* (2013), Manna *et al.* (2014), Rizk *et al.* (2014), Verma *et al.* (2014), Shukla *et al.* (2015), Acharya *et al.* (2015) and Begum *et al.* (2015) in onion. The effect of different levels of boron on number of leaves per plant at 30 and 60 DAT was not found significant in individual years of experiment and found significant in pooled data. The treatment b_2 produced significantly maximum number of leaves per plant (3.95 and 6.79) at 30 and 60 DAT in pooled data, respectively which was statistically at par with treatment b_1 . The minimum number of leaves per plant (3.81 and 6.54) was observed with treatment b_0 at 30 and 60 DAT in pooled data.

The effect of different levels of boron on number of leaves per plant at 90 DAT was found significant during both the years of experiment and in pooled data also. Significantly maximum number of leaves per plant (9.35 and 8.89) was obtained with treatment b_1 at 90 DAT during the year 2013-14 and pooled analysis, respectively. The treatment b_2 showed maximum number of leaves per plant (8.55) in the year 2014-15. While minimum number of leaves per plant (8.90, 8.05 and 8.47) was observed with treatment b_0 during both the years 2013-14, 2014-15 and in pooled data, respectively.

It is quite obvious that the experimental soil is deficient in boron and external application favorably enhanced the growth of onion. The same trends were also reported by Alam *et al.* (2010), Ballabh *et al.* (2012), Abedin *et al.* (2012), Manna *et al.* (2014), Singh *et al.* (2015^a) and Singh *et al.* (2015^b) in onion. The interaction effect between iron and zinc was found to be significant with respect to number of leaves per plant in the year 2013-14 and in pooled data at 30 DAT. Effect of remaining treatment combinations of iron, zinc and boron were not significant on number of leaves per plant during both the years of experimentation and in pooled data. ✓

4. Effect of iron, zinc and boron on neck thickness at 30, 60 and 90 DAT and at the stage of harvesting (cm)

The influence of iron, zinc and boron on neck thickness at 30, 60 and 90 DAT and at harvesting as affected by various treatments are presented in Table 3, graphically depicted in Fig. 3. Different levels of iron on neck thickness at 30, 60 and 90 DAT were found to be significant during both the years of experiment and in pooled data. Significantly maximum neck thickness (0.68 cm, 0.54 cm and 0.61 cm), (1.52 cm, 1.30 cm and 1.41 cm) and (2.35 cm, 2.11 cm and 2.23 cm) was observed with treatment i_1 at 30, 60 and 90 DAT during the year 2013-14, 2014-15 and in pooled data, respectively. It was statistically at par with treatment i_0 at 60 and 90 DAT. The minimum neck thickness (0.60 cm, 0.49 cm and 0.54 cm), (1.43 cm, 1.21 cm and 1.32 cm) and (2.16 cm, 1.99 cm and 2.08 cm) was observed at 30, 60 and 90 DAT with treatment i_2 during the year *i.e.* 2013-14, 2014-15 and in pooled data, respectively. Influence of different levels of iron on neck thickness at the stage of harvesting was found to be significant during both the years of experiment and in pooled data. Significantly minimum neck thickness (1.22 cm, 1.19 cm and 1.20 cm) was found with treatment i_1 during the year *i.e.* 2013-14, 2014-15 and in pooled data, respectively which was statistically at par with treatment i_0 during the year 2013-14 and 2014-15. The maximum neck thickness (1.34 cm, 1.24 cm and 1.29 cm) was observed with treatment i_2 at the stage of harvesting during the year *i.e.* 2013-14, 2014-15 and in pooled analysis, respectively. Iron plays an important role in promoting growth characters, being a component of ferredoxin, an electron transport protein and is associated with chloroplast. Since it help in photosynthesis, it might have helped in better vegetative growth. Iron is critical for chlorophyll formation and photosynthesis activity and that might be the reason for increasing growth of onion. These findings are in close accordance with the findings of Ballabh *et al.* (2013), Singh *et al.* (2015^a) and Singh *et al.* (2015^b) in onion. ✓

The effect of different levels of zinc on neck thickness at 30 DAT was found significant during both the years of experimentation and in pooled analysis. Significantly maximum neck thickness was observed with treatment z_1 (0.70 cm, 0.56 cm and 0.63 cm) during the year 2013-14, 2014-15 and in pooled data, respectively. The minimum neck thickness (0.56 cm, 0.47 cm and 0.52 cm) was observed with treatment z_2 during both the years and in pooled analysis, respectively. The effect of different levels of zinc on neck thickness at 60 DAT were found to be significant during both the years of experiment, however it was not significant in pooled data. The maximum neck thickness was observed with treatment z_1 (1.57 cm and 1.28 cm) during the year 2013-14 and 2014-15, respectively. The minimum neck thickness (1.37 cm and 1.22 cm) was observed with treatment z_2 during both years. Influence of different levels of zinc on neck thickness at 90 DAT was found significant during both the years of experimentation and in pooled data. Maximum neck thickness (2.41 cm, 2.15 cm and 2.28 cm) was found with treatment z_1 during the year 2013-14, 2014-15 and in pooled data, respectively which was statistically at par with treatment z_0 during the year 2013-14. The minimum neck thickness (2.10 cm, 2.93 cm and 2.02 cm) was found under treatment z_2 at 90 DAT during the year *i.e.* 2013-14, 2014-15 and in pooled data, respectively.

The increase in neck thickness might be due to application of zinc, which influenced the cell division, meristematic activating of plant tissues and expansion of cells and formation of cell wall by activating synthesis of aromatic amino acids *i.e.* tryptophane, which is the precursor of auxin and stimulate the growth of plant tissues by cell elongation and cell division. This finding is similar to that of Abedin *et al.* (2012), Ballabh *et al.* (2012), Ballabh *et al.* (2013), Manna *et al.* (2014), Verma *et al.* (2014), Shukla *et al.* (2015) and Acharya *et al.* (2015) in onion.

Influence of different levels of zinc on neck thickness at the stage of harvesting was to be found significant during both the years but it was not significant in pooled data. Significantly minimum neck thickness (1.21 cm and 1.18 cm) was observed with treatment z_1 during the year *i.e.* 2013-14 and 2014-15, respectively which was statistically at par with treatment z_0 during the year 2014-15. The maximum neck thickness (1.32 cm and 1.24 cm during first year and second year, respectively) was observed with treatment z_2 .

Influence of different levels of boron on neck thickness was not found significant at 30, 60 and 90 days after transplanting during both the years of experiment and in pooled data except pooled data at 90 DAT. Significantly maximum neck thickness (2.20 cm) was observed with treatment b_2 , which was statistically at par with treatment b_1 and minimum neck thickness (2.10 cm) was found under treatment b_0 in pooled analysis.

Influence of different levels of boron on neck thickness at harvesting was not found significant in the year 2013-14 but it was found to be significant during the year 2014-15 and in pooled data.✓

Significantly minimum neck thickness (1.19 cm and 1.22 cm) was observed with treatment b_2 in the year 2014-15 and in pooled data, respectively which was statistically at par with treatment b_1 . The maximum neck thickness at the harvesting stage (1.25 cm and 1.27 cm) was found under treatment b_0 in the year 2014-15 and in pooled analysis, respectively. Boron plays an essential role in improving plant growth through the biosynthesis of endogenous hormones which are responsible for promotion of plant growth. These findings are in close accordance with the findings of Alam *et al.* (2010), Abedin *et al.* (2012), Ballabh *et al.* (2012) and Manna *et al.* (2014) in onion. The interaction effect between iron and zinc was found significant in pooled analysis at 30 DAT. Interaction effect between iron, zinc and boron was found significant at the stage of harvesting in the year 2013-14.

5. Effect of iron, zinc and boron on days taken to maturity

The days taken to maturity as influenced by different treatments are presented in Table 4, graphically illustrated in Fig. 4. The effect of various levels of iron on days taken to maturity was found significant during both the years of experimentation and in pooled data. The minimum days (116.70, 117.26 and 116.98) taken for maturity was observed with treatment i_1 during the year 2013-14, 2014-15 and in pooled data, respectively. The maximum days taken for maturity (120.63, 120.41 and 120.52 during both the years 2013-14, 2014-15 and in pooled data, respectively) was observed with treatment i_2 . The influence of various levels of zinc on days taken to maturity was found significant during both the years and in pooled data. Minimum days were taken for maturity (117.96, 118.07 and 118.20) under treatment z_1 during the year *i.e.* 2013-14, 2014-15 and in pooled analysis, respectively which was statistically at par with treatment z_0 . The maximum days (119.52, 119.67 and 119.59) taken to maturity was observed with treatment z_2 during the year 2013-14, 2014-15 and in pooled analysis, respectively. Influence of different levels of boron on days taken to maturity was found significant during both the years, whereas it was not found significant in pooled data. Minimum days (117.67 and 118.85) taken for maturity were observed with treatment b_1 during the year 2013-14 and 2014-15, respectively, which was statistically at par with treatment b_1 during the year 2014-15. Maximum days (118.89 and 119.85) taken for maturity was observed with treatment b_0 during the year 2013-14 and 2014-15 respectively. The interaction effect between iron, zinc and boron were found not significant on days taken to maturity during both the years of experimentation and in pooled data. ✓

6. Effect of iron, zinc and boron on per cent bolting

Influence of different levels of iron, zinc and boron on per cent bolting are summarized in Table 4. The influence of different levels of iron on per cent bolting was found significant during both the years of experiment and not significant in pooled data. The significantly minimum per cent bolting (3.49 % and 3.38 %) was observed with treatment i_1 during the year 2013-14, 2014-15, respectively. Maximum bolting per cent (4.65 % each) was observed with treatment i_2 during the year 2013-14 and 2014-15. This finding is similar to that of Rohidas *et al.* (2010) in garlic.

✓ The effect of various levels of zinc on per cent bolting were found significant during both the years of experiment, however it was not significant in pooled data. The minimum per cent bolting (3.21 % and 3.49 %) was observed with treatment z_1 during the year 2013-14 and 2014-15, respectively. The maximum per cent bolting (4.91 % and 4.53 %) was found under treatment z_2 during the year 2013-14 and 2014-15, respectively. The present findings are in close accordance with finding of Rohidas *et al.* (2010) in garlic. ✓

Influence of different levels of boron on per cent bolting was found significant during both the years of experiment and in pooled data. Minimum per cent bolting (3.75 %, 3.91 % and 3.83 % during the year *i.e.* 2013-14, 2014-15 and in pooled analysis, respectively) was observed with treatment b_2 , which was statistically at par with treatment b_1 during the year 2014-15 and in pooled data. Maximum per cent bolting (4.17 %, 4.53 % and 4.35 %) was found under treatment b_0 during the year 2013-14, 2014-15 and in pooled analysis, respectively. These results are in accordance with the findings of Rohidas *et al.* (2010) in garlic. ✓ The interaction effect between iron and boron was observed to be a significant variation on per cent bolting in pooled data. ✓

CONCLUSION

~~The experimental evidences warrant the following specific conclusion which may be adopted for profitable cultivation of onion during rabi season. It is concluded from present investigation, application of 20 kg iron/ha, 25 kg zinc/ha and 5.0 kg boron/ha should be achieve higher growth and growth parameters of onion in cultivar Agrifound Light Red..~~

From the present experiment, it can be concluded that application of 20Kg iron/ha, 25 Kg/ha zinc and 5.0Kg boron/ha to the soil of North Gujarat, appears to give better yield of green onions and bulbs by 90 days of cultivation of Agrifound Light Red cultivar of onion.

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I x Z x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	1.78	1.44	1.62	7.31	6.32	6.88	7.04	7.81	7.40	6.13	6.03	6.10

NS: not significant

✓

UNDER PEER REVIEW

Table 2 : Effect of iron, zinc and boron on number of leaves at 30, 60 and 90 DAT ✓

Treatments	Number of leaves at 30 DAT			Number of leaves at 60 DAT			Number of leaves at 90 DAT		
	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled
Iron (I)									
i ₀	3.87	3.82	3.85	6.71	6.63	6.67	9.28	8.28	8.78
i ₁	4.32	3.99	4.16	7.06	6.85	6.95	9.46	8.86	9.16
i ₂	3.73	3.62	3.67	6.40	6.48	6.44	8.68	7.90	8.29
S.Em.±	0.07	0.06	0.04	0.10	0.09	0.07	0.13	0.11	0.09
C.D. at 5%	0.19	0.16	0.12	0.28	0.25	0.19	0.36	0.32	0.24
Zinc (Z)									
z ₀	3.89	3.84	3.86	6.79	6.65	6.72	9.38	8.40	8.89
z ₁	4.42	4.07	4.24	7.08	6.93	7.01	9.65	9.05	9.35
z ₂	3.61	3.53	3.57	6.29	6.38	6.33	8.40	7.60	8.00
S.Em.±	0.07	0.06	0.08	0.10	0.09	0.07	0.13	0.11	0.09
C.D. at 5%	0.19	0.16	NS	0.28	0.25	0.19	0.36	0.32	0.24
Boron (B)									
b ₀	3.85	3.76	3.81	6.54	6.54	6.54	8.90	8.05	8.47
b ₁	4.01	3.83	3.92	6.76	6.70	6.73	9.35	8.44	8.89
b ₂	4.05	3.84	3.95	6.87	6.72	6.79	9.18	8.55	8.86
S.Em.±	0.07	0.06	0.04	0.10	0.09	0.07	0.13	0.11	0.09
C.D. at 5%	NS	NS	0.12	NS	NS	0.19	0.36	0.32	0.24
Interaction effect									
I x Z	*	NS	*	NS	NS	NS	NS	NS	NS
I x B	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z x B	NS	NS	NS	NS	NS	NS	NS	NS	NS
I x Z x B	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	8.60	7.51	8.10	7.58	7.00	7.30	7.32	7.10	7.23

Table 3 : Effect of iron, zinc and boron on neck thickness at 30, 60, 90 DAT and at the stage of harvesting (cm) ✓

Treatments	Neck thickness at 30 DAT			Neck thickness at 60 DAT			Neck thickness at 90 DAT			Neck thickness at harvesting		
	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled
Iron (I)												
i ₀	0.64	0.51	0.57	1.48	1.25	1.37	2.28	2.03	2.16	1.27	1.21	1.24
i ₁	0.68	0.54	0.61	1.52	1.30	1.41	2.35	2.11	2.23	1.22	1.19	1.20
i ₂	0.60	0.49	0.54	1.43	1.21	1.32	2.16	1.99	2.08	1.34	1.24	1.29
S.Em.±	0.01	0.01	0.01	0.02	0.02	0.01	0.05	0.03	0.02	0.02	0.01	0.01
C.D. at 5%	0.03	0.02	0.01	0.06	0.05	0.04	0.15	0.08	0.07	0.05	0.04	0.02
Zinc (Z)												
z ₀	0.65	0.50	0.57	1.49	1.26	1.38	2.28	2.05	2.16	1.30	1.22	1.26
z ₁	0.70	0.56	0.63	1.57	1.28	1.43	2.41	2.15	2.28	1.21	1.18	1.20
z ₂	0.56	0.47	0.52	1.37	1.22	1.29	2.10	1.93	2.02	1.32	1.24	1.28
S.Em.±	0.01	0.01	0.01	0.02	0.02	0.04	0.05	0.03	0.03	0.02	0.01	0.02
C.D. at 5%	0.03	0.02	0.02	0.06	0.05	NS	0.15	0.08	0.08	0.05	0.04	NS
Boron (B)												
b ₀	0.62	0.50	0.56	1.46	1.23	1.35	2.21	1.99	2.10	1.30	1.25	1.27
b ₁	0.64	0.51	0.57	1.48	1.26	1.37	2.27	2.06	2.16	1.27	1.20	1.23
b ₂	0.65	0.52	0.59	1.49	1.28	1.38	2.31	2.09	2.20	1.25	1.19	1.22
S.Em.±	0.01	0.01	0.02	0.02	0.02	0.01	0.05	0.03	0.03	0.02	0.01	0.01
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.08	NS	0.04	0.03
Interaction effect												
I x Z	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
I x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Z x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I x Z x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
CV %	7.90	7.92	7.96	7.03	7.08	7.07	12.16	7.08	10.21	6.88	5.50	6.26

✓

UNDER PEER REVIEW

Table 4 : Effect of iron, zinc and boron on days taken to maturity after transplanting and boron on per cent bolting (%) ✓

Treatments	Days taken to maturity			Per cent bolting (%)		
	Year 2013-14	Year 2014-15	Pooled	Year 2013-14	Year 2014-15	Pooled
Iron (I)						
i₀	118.11	119.07	118.59	3.84	4.38	4.11
i₁	116.70	117.26	116.98	3.49	3.38	3.44
i₂	120.63	120.41	120.52	4.65	4.65	4.65
S.Em.±	0.35	0.34	0.25	0.10	0.10	0.17
C.D. at 5%	1.00	0.97	0.69	0.29	0.30	NS
Zinc (Z)						
z₀	117.96	119.00	118.48	3.86	4.39	4.13
z₁	117.96	118.07	118.20	3.21	3.49	3.35
z₂	119.52	119.67	119.59	4.91	4.53	4.72
S.Em.±	0.35	0.34	0.25	0.10	0.10	0.24
C.D. at 5%	1.00	0.97	0.69	0.29	0.30	NS
Boron (B)						
b₀	118.89	119.85	119.37	4.17	4.53	4.35
b₁	117.67	118.85	118.26	4.06	3.98	4.02
b₂	118.89	118.04	118.46	3.75	3.91	3.83
S.Em.±	0.35	0.34	0.56	0.10	0.10	0.07
C.D. at 5%	1.00	0.97	NS	0.29	0.30	0.20
Interaction effect						
I x Z	NS	NS	NS	NS	NS	NS
I x B	NS	NS	NS	NS	NS	*
Z x B	NS	NS	NS	NS	NS	NS
I x Z x B	NS	NS	NS	NS	NS	NS
CV %	1.55	1.49	1.52	13.25	13.05	13.15

