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Effect of iron, zinc and boron on nutrients status of soil, yield and yield attributes of onion (*Allium cepa* L.) CV. agrifound light red

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Abstract

The field experiment entitled “Effect of iron, zinc and boron on nutrient status of soil, yield and yield attributes of onion (*Allium cepa* L.) cv. Agrifound Light Red” was conducted at Horticulture Instructional Farm, Department of Horticulture, C. P. College of Agriculture, Sardarkrushinagar, Distt. Banaskantha, Gujarat during *rabi* 2013-14 and 2014-15. Experiment was laid out in Randomized Block Design (under factorial concept) with twenty seven treatment combinations comprising three levels of each *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) was tested three replications.

The results revealed that the status of available iron, zinc and boron in soil before crop transplanting were not significant. The interaction effect between iron, zinc and boron on available boron before crop transplanting (0.958 mg/kg) was found to be significant under treatment combination $i_2z_2b_2$. The result revealed that the status of available iron and zinc in soil after crop harvesting were found not significant. Treatment b_2 (5.0 kg boron/ha) obtained maximum boron content (2.424 mg/kg) in the soil after crop harvesting.

In case of yield and yield attributes, the significantly superior treatment was i_1 (20 kg iron/ha) with 142.47 g bulb weight, 19.220 kg yield/plot and 547.58 q yield/ha. Application of zinc @ 25 kg/ha was reported to have produce significant results with yield and yield attributes. Boron @ 5.0 kg/ha) was found significantly superior for yield attributes *i.e.* 138.71 g bulb weight, 18.741 kg yield/plot and 533.93 q bulb yield/ha. Interaction between iron and zinc significant for weight of bulb (157 g) was observed with treatment combination i_1z_1 .

In order to achieve the optimum yield and yield attributes of onion cultivar Agrifound Light Red, 20 kg iron/ha, 25 kg zinc/ha and 5 kg boron/ha should be applied.

Keywords: micronutrients, yield, nutrient, iron, zinc, boron, onion, alliaceae

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) [21]. 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) [29]. Onion also possesses nutritional and medicinal importance. The outstanding characteristic of onion is the pungency, which is due to volatile oil known as Allyl- propyl- disulphide, which is sulphur rich compound. It acts as gastric stimulant and promotes digestion (Yawalkar, 2004) [33]. It contains 86.6 per cent Moisture, 40 kcal Calories, 1.10 g Protein, 9.34 mg Carbohydrates, 23 mg Calcium, 2 IU Vitamins A, 7.4 mg Vitamins C, 0.027 mg Riboflavin, 0.0116 mg Niacin per 100 g of fresh edible portion. It is used as a remedy for various diseases like dysentery, convulsions, headaches, hysterical fits, rheumatic pain, malaria, fever and as a fine demulcent to give relief in piles (Sharma, 2014) [22].

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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)^[4]. 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)^[4]. The major onion growing districts in Gujarat state are Bhavnagar, Amreli, Junagadh, Rajkot, Mehsana, Jamnagar, Surat and Anand.

Indian soil 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, phosphorus and high pH shows unavailability of iron. Toxicity symptoms are rarely observed except on flooded soils. (Mishra and Rajesh Kumar 2014)^[15]. 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 scorching 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 yield and yield attributes of onion (*Allium cepa* L.) cv. Agrifound Light Red" was planned and executed at Horticulture Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season 2013-14 and 2014-15.

Materials and Methods

The investigation was conducted at Horticulture Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The three different micronutrient applied as a basal dose *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) as a source of FeSO₄, ZnSO₄ and borax, respectively were tested during *rabi* season 2013- 14 and 2014-15. The experiment was laid out in a Factorial Randomized Block Design with twenty seven treatments were employed and replicated thrice. The plot size of 4.5 m² (spacing 15 x 10 cm) on onion cv. Agrifound Light Red at. Variety Agrifound Light Red of onion was selected for the investigation, as it is promising one and most of the cultivators in North Gujarat and Maharashtra area grow it extensively. The seed of this variety was obtained from National Horticultural Research Development Foundation, Nashik, Maharashtra. To raise the crop recommended package of practices were followed. Proper care for weeding, intercultural operations, and plant protection measures were taken from transplanting to harvesting. The crop was fertilized with recommended doses of 100:50:50 NPK/ha for onion and five tonnes vermicompost. 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. Observations on yield and yield attributes *viz.*, Average weight of bulb (g) was recorded with the help of electronic balance and expressed in gram and average weight of bulb was worked out, yield of bulb per plot (kg) was recorded after curing separately per net plot weight of onion bulb and yield of bulb per hectare (q) was calculated on the basis of yield of bulb per net plot.

The soil of experimental field was well drained and loamy sand with appropriate textural make up. The mechanical and chemical analysis of the soil was under taken prior to initiation of the experiment to ascertain the nutritional status of soil of the experimental field the soil status of experimental field as follows Table 1.

Table 1: Physico-chemical properties of soil

Sr. No.	Properties	Soil depth (15-30cm)	Method employed
[A]	Physical		
(a)	Coarse Sand (%)	45.68	International Pipette method (Piper, 1966)
(b)	Fine Sand (%)	40.66	
(c)	Silt (%)	7.34	
(d)	Clay (%)	6.32	
(e)	Textural classes	Loamy sand	
[B]	Chemical		
(a)	Soil pH (1:2.5, soil: water ratio)	7.66	Potentiometric method (Jackson, 1973)
(b)	Electrical conductivity (dSm ⁻¹) (1:2.5, soil water ratio)	0.16	Schofield method (Jackson, 1973)
(c)	Organic carbon (%)	0.21	Walkley and Black's rapid titration method (Jackson, 1973)
(d)	Available N (Kg ha ⁻¹)	173.76	Alkaline permanganate method (Subbiah and Asija, 1956)

(e)	Available P ₂ O ₅ (Kg ha ⁻¹)	35.76	Olsen method (Jackson, 1973)
(f)	Available K ₂ O (Kg ha ⁻¹)	187	Flame photometer method (Jackson, 1973)
(g)	Fe (mg/kg)	1.163	DTPA extractant (Lindsay and Norvell (1978))
(h)	Zn (mg/kg)	0.254	
(i)	Hot Water Soluble B (mg/kg)	0.474	Azomethine-H method (Gupta, 1967)

The mean data were subjected to statistical analysis following analysis of variance technique Panse and Sukhatme (1978) [16].

Result and discussion

1. Nutrients status of soil before crop transplanting and after crop harvesting

1.1 Status of available iron, zinc and boron (mg/kg) in the soil before crop transplanting during the year 2013-14 and 2014-15

The status of available iron, zinc and boron (mg/kg) in soil before crop transplanting is presented in Table 2.

The data furnished in the table reveal that the status of available iron, zinc and boron (mg/kg) in the experimental plots were found not significant in the year 2013-14. It shows that soil of the experimental field was homogenous in fertility level (iron, zinc and boron) and most suitable for this type of experiment.

The available iron in the soil before transplanting was found significant during the second year of experimentation. Maximum available iron content (3.696 mg/kg) was found under treatment i₂ in the year 2014-15.

The available zinc in the soil before transplanting was found significant during the second year of experimentation. The maximum available zinc content (0.760 mg/kg) was found with treatment z₂ during the second year of experimentation.

The presence of available boron in the soil before transplanting was found significant during the second year of experiment. Maximum available boron content (2.119 mg/kg) was found under treatment b₂ in the year 2014-15.

Interaction between zinc and boron were found significant in the second year of experimentation before crop transplanting.

1.2. Status of available iron, zinc and boron (mg/kg) in the soil after crop harvesting

The status of available iron (mg/kg) after crop harvesting are presented in Table 3 and graphically depicted in Fig.1.

Influence of different levels of iron on available iron was found significant during both the years of experimentation. However, it was not significant in pooled data. Significantly maximum available iron (3.759 mg/kg and 5.381 mg/kg) was obtained under treatment i₂ after crop harvesting during the year 2013-14 and 2014-15, respectively. The minimum available iron (1.161 mg/kg and 1.088 mg/kg during the year 2013-14 and 2014-15, respectively) was found with treatment i₀.

Effect of different levels of zinc on available zinc was found significant during both the years and not significant in pooled data. Significantly maximum available zinc (0.798 mg/kg and 1.306 mg/kg) was obtained under treatment z₂ after crop harvesting during the year 2013-14 and 2014-15, respectively. The minimum available zinc (0.244 mg/kg and 0.227 mg/kg) was found with treatment z₀ during the year 2013-14, 2014-15, respectively.

Effect of different levels of boron on available boron was found significant during both the years and in pooled data. The maximum available boron (2.142 mg/kg, 2.705 mg/kg and 2.424 mg/kg during the year 2013-14, 2014-15 and in pooled data, respectively) was observed with treatment b₂

after crop harvesting. The minimum available boron (0.481 mg/kg, 0.459 mg/kg and 0.470 mg/kg) was found with treatment b₀ during the year 2013-14, 2014-15 and in pooled data, respectively.

The interaction effect between iron and zinc on available iron was found significant during the year 2014-15, pooled data and not significant in the year 2013-14.

Influence of combination of iron and zinc on available zinc was found significant during the year 2014-15 and it was not significant in the year 2013-14 and in pooled data. Interaction effect between zinc and boron on available zinc was found significant during the year 2014-15 and it was not significant in the year 2013-14 and in pooled data.

The interaction between iron and zinc on available boron were found not significant during both the years while it was significant in pooled data. Interaction effect between iron and boron on available boron was found not significant during the both years while it was significant in pooled analysis. The interaction effect between zinc and boron on available boron was found not significant during the both years while it was significant in pooled analysis. Interaction effect between iron, zinc and boron on available boron was found not significant during the both years and found significant in pooled data.

3. Effect of iron, zinc and boron on yield and yield attributes

1. Effect of iron, zinc and boron on weight of bulb (g)

The data pertaining to influence of various levels of iron, zinc and boron on weight of bulb are furnished in Table 4, graphically illustrated in Fig. 2.

The data showed that the effect of various levels of iron on weight of bulb was found significant during both the years of experiment and in pooled data. Significantly highest weight of bulb (147.35 g, 137.60 g and 142.47 g) was observed with treatment i₁ during the year 2013-14, 2014-15 and in pooled data, respectively. The lowest weight of bulb (130.12 g, 124.50 g and 127.31 g) was observed with treatment i₂ during the year *i.e.* 2013-14, 2014-15 and in pooled data, respectively. The improvement in weight of bulb is a result of soil application of iron which would have enhanced photosynthesis and other metabolic activities which leads to increase in cell division and cell elongation. The present findings are in close accordance with the findings of Jawaharlal *et al.* (1986) [12], Singh *et al.* (1993) [27], Sindhu *et al.* (1993) [24], Tohamy, *et al.* (2009) [30] and Singh *et al.* (2015^a) [25] in onion.

The influence of different levels of zinc on weight of bulb was found significant during both the years and found not significant in pooled data. Significantly the highest weight of bulb (152.21 g and 141.26 g during year 2013-14 and 2014-15, respectively) was obtained with treatment z₁. The lowest weight of bulb (122.39 g and 121.66 g) was found under treatment z₂ during the year 2013-14 and 2014-15, respectively. Zinc is one of the most important elements and plays important role to activate enzymes that play an active role in carbohydrate metabolism. The carbonic anhydrase, fructose-1, 6- biphosphate and aldolase enzymes are activated by zinc. The activity of these enzymes decreases in zinc deficiency condition which results in carbohydrate

accumulation in plant leaves and ultimately in dry matter accumulation in leaves. This result is in agreement with the finding of Alam *et al.* (2010) [3], Samad *et al.* (2011) [20], Abedin *et al.* (2012) [1], Ballabh *et al.* (2012) [7], Ballabh *et al.* (2013) [8], Trivedi and Dhumal (2013) [31], Rizk *et al.* (2014) [19], Manna *et al.* (2014) [14], Verma *et al.* (2014) [32], Acharya *et al.* (2015) [2], Assefa *et al.* (2015) [5] and Shukla *et al.* (2015) [23] in onion.

Influence of different levels of boron on weight of bulb was found significant during both the years and in pooled data. Significantly the highest weight of bulb (143.84 g, 133.58 g and 138.71 g during the year 2013-14, 2014-15 and in pooled analysis, respectively) was recorded with treatment b₂, which was statistically at par with treatment b₁. The lowest weight of bulb (131.95 g, 126.07 g and 129.01 g) was observed with treatment b₀ during the year 2013-14, 2014-15 and in pooled data, respectively. This may be due to the boron application which enhances the enzyme activity which in turn triggers the physiological processes like carbohydrate metabolism in plant which results into high growth. Similar results were also reported by Paul *et al.* (2007) [17], Alam *et al.* (2010) [3], Abedin *et al.* (2012) [1], Ballabh *et al.* (2012) [7], Manna *et al.* (2014) [14], Begum *et al.* (2015) [9] and Singh *et al.* (2015^a) [25] in onion.

The interaction effect between iron and zinc on weight of bulb was found significant in pooled analysis. Significantly maximum weight of bulb (157.11 g) was observed with treatment combination i₁z₁ in pooled analysis. Iron and zinc stimulate the photosynthesis activity and better photosynthesis activity might have resulted in higher weight of bulb. Similar results were reported by Verma *et al.* (2014) [32].

2. Effect of iron, zinc and boron on yield of bulb per plot (kg)

Yield of bulb per plot as influenced by various levels of iron, zinc and boron are summarized in Table 4, graphically illustrated in Fig. 3.

The effect of different levels of iron with respect to yield of bulb per plot was found significant during both the years of experiment and in pooled analysis. Significantly maximum yield per plot (19.691 kg, 18.748 kg and 19.220 kg) was found with treatment i₁ during the year 2013-14, 2014-15 and in pooled data, respectively. The minimum yield of bulb per plot (18.014 kg, 17.457 kg and 17.736 kg) was recorded under treatment i₂ during both years and in pooled data, respectively. The favourable effect of iron on yield could be attributed to higher rate of chlorophyll synthesis and cytochrome photo-oxidase activity which contribute to more photosynthetic activity and higher production of sugars. Being a constituent part of metabolically active compound, iron is responsible for all major metabolic processes in plant which ultimately turn in improved yield. The results are in conformity with Jawaharlal *et al.* (1986) [12], Singh *et al.* (1993) [27], Sindhu *et al.* (1993) [24], Tohamy, *et al.* (2009) [30] and Singh *et al.* (2015^a) [25] in onion.

Effect of different levels of zinc on yield of bulb per plot were found significant during both the years of experimentation and in pooled data. Significantly maximum yield of bulb per plot (20.301 kg, 19.341 kg and 19.821 kg) was recorded under treatment z₁ during the year 2013-14, 2014-15 and in pooled data, respectively. Minimum yield of bulb per plot (17.080 kg, 16.384 kg and 16.732 kg during the year 2013-14, 2014-15 and in pooled data, respectively) was obtained with treatment z₂. The enzymes are activated by zinc 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 results are in conformity with the results obtained by Alam *et al.* (2010) [3], Samad *et al.* (2011) [20], Abedin *et al.* (2012) [1], Ballabh *et al.* (2012) [7], Ballabh *et al.* (2013) [8], Trivedi and Dhumal (2013) [31], Manna *et al.* (2014) [14], Rizk *et al.* (2014) [19], Verma *et al.* (2014) [32], Acharya *et al.* (2015) [2], Assefa *et al.* (2015) [5] and Shukla *et al.* (2015) [23] in onion.

Influence of different levels of boron on yield of bulb per plot were found to be significant during both the years of experimentation and in pooled data. Significantly maximum yield of bulb per plot (19.153 kg, 18.329 kg and 18.741 kg) was observed with treatment b₂ during the year 2013-14, 2014-15 and in pooled data, respectively. Treatment b₂ was found statistically at par with treatment b₁. Minimum yield of bulb per plot (18.275 kg, 17.504 kg and 17.890 kg during the year 2013-14, 2014-15 and in pooled data, respectively) was found under treatment b₀. It may be due to the enhanced enzymatic and photosynthetic activity and greater translocation rate due to the influence of boron. The favourable effects of boron might be attributed to the involvement in cell division and cell expansion, which resulted in better growth and yield. These findings are in close accordance with that of Paul *et al.* (2007) [17], Alam *et al.* (2010) [3], Abedin *et al.* (2012) [1], Ballabh *et al.* (2012) [7], Manna *et al.* (2014) [14], Begum *et al.* (2015) [9] and Singh *et al.* (2015^a) [25] in onion.

The interaction effect between iron, zinc and boron was found not significant on yield of bulb per plot during both the years of experimentation and in pooled data.

3. Effect of iron, zinc and boron on yield of bulb per hectare (q)

Yield of bulb per hectare as influenced by various levels of iron, zinc and boron are summarized in Table 4, graphically illustrated in Fig. 4.

The influence of different levels of iron on yield of bulb per hectare was found to be significant during both years of experiment and in pooled data. Significantly maximum yield of bulb per hectare (561.00 q, 534.13 q and 547.58 q) was recorded with treatment i₁ during the year 2013-14, 2014-15 and in pooled data, respectively. The minimum yield of bulb per hectare (513.22 q, 497.35 q and 505.30 q during the year 2013-14, 2014-15 and in pooled data, respectively) was obtained with treatment i₂. Iron is associated with metabolism of chloroplast RNA, leading to increase in biosynthesis. Consequently the yield was enhanced. Iron is also used by enzymes to regulate transpiration in plants. These findings are in close accordance with Jawaharlal *et al.* (1986) [12], Singh *et al.* (1993) [27], Sindhu *et al.* (1993) [24], Tohamy, *et al.* (2009) [30], Singh *et al.* (2015^a) [25] and Singh *et al.* (2015^b) in onion.

Effect of different levels of zinc on yield of bulb per hectare were found significant during both the years of experimentation and in pooled data. Significantly maximum yield of bulb per hectare (578.38 q, 551.03 q and 564.70 q during the year 2013-14, 2014-15 and in pooled data, respectively) was obtained with treatment z₁. The minimum yield of bulb per hectare (486.61 q, 466.78 q and 476.70 q) was obtained under treatment z₂ during the year 2013-14, 2014-15 and in pooled data, respectively. Zinc plays an important role in attributing to higher rate of photosynthesis, sugar formation due to enhanced chlorophyll contents and enzyme activity and their direct involvement in metabolism

and ultimately lead to higher production of dry matter and consequently more yield. The favourable effect of zinc on yield may be due to its involvement in the synthesis of tryptophan which is a precursor of the growth promoting substance. The increase in yield due to zinc fertilization may be due to the fact that zinc plays an important role in plant metabolism. The improvement in yield might be due to application of zinc, which accelerated and stimulated the physiological form and functions of cell, tissue and whole plant that resulted in increase the yield parameters. The similar results are obtained by Alam *et al.* (2010)^[3], Samad *et al.* (2011)^[20], Abedin *et al.* (2012)^[1], Ballabh *et al.* (2012)^[7], Ballabh *et al.* (2013)^[8], Trivedi and Dhumal (2013)^[31], Manna *et al.* (2014)^[14], Rizk *et al.* (2014)^[19], Verma *et al.* (2014)^[32], Acharya *et al.* (2015)^[2], Assefa *et al.* (2015)^[5] and Shukla *et al.* (2015)^[23] in onion.

Influence of different levels of boron on yield of bulb per hectare was found significant during both the years of

experimentation and in pooled data. Significantly maximum yield of bulb per hectare (545.67 q, 522.19 q and 533.93 q) was obtained with treatment b₂ during the year 2013-14, 2014-15 and in pooled data, respectively. The treatment b₂ was statistically at par with treatment b₁. The minimum yield of bulb per hectare (520.66 q, 498.69 q and 509.69 q during the year 2013-14, 2014-15 and in pooled data, respectively) was recorded with treatment b₀. These findings are in close agreement with the findings of Paul *et al.* (2007)^[17], Alam *et al.* (2010)^[3], Abedin *et al.* (2012)^[1], Ballabh *et al.* (2012)^[7], Manna *et al.* (2014)^[14], Begum *et al.* (2015)^[9] and Singh *et al.* (2015)^[25] in onion.

The interaction effect between iron, zinc and boron did not exerted significant variation with respect to yield of bulb per hectare during both the years of experimentation and in pooled analysis.

Table 2: Status of available iron, zinc and boron content (mg/kg) in soil before transplanting

Treatments	Iron (I)			Zinc (Z)			Boron (B)		
	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	1.163	1.118	1.141	0.254	0.229	0.242	0.474	0.454	0.464
i ₁	1.157	2.111	1.634	0.246	0.489	0.368	0.521	1.061	0.791
i ₂	1.147	3.696	2.422	0.239	0.478	0.359	0.525	1.904	1.215
S.Em.±	0.023	0.064	0.654	0.004	0.013	0.007	0.016	0.023	0.014
C.D. at 5%	NS	0.182	NS	0.011	NS	NS	NS	0.066	0.040
Zinc (Z)									
z ₀	1.193	1.162	1.178	0.252	0.236	0.244	0.475	0.457	0.466
z ₁	1.116	2.317	1.717	0.244	0.481	0.363	0.526	1.100	0.813
z ₂	1.158	2.479	1.819	0.241	0.760	0.501	0.519	1.746	1.133
S.Em.±	0.023	0.064	0.098	0.004	0.013	0.138	0.016	0.023	0.014
C.D. at 5%	NS	0.182	NS	NS	0.037	NS	NS	NS	0.040
Boron (B)									
b ₀	1.166	1.156	1.161	0.248	0.229	0.239	0.494	0.475	0.485
b ₁	1.134	2.292	1.713	0.242	0.490	0.366	0.523	1.863	1.193
b ₂	1.167	2.415	1.791	0.250	0.504	0.377	0.503	2.119	1.311
S.Em.±	0.023	0.111	0.034	0.004	0.013	0.007	0.016	0.023	0.154
C.D. at 5%	NS	0.316	NS	NS	NS	NS	NS	0.066	NS
Interaction effect									
I x Z	NS	NS	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
I x Z x B	NS	NS	NS	NS	NS	NS	NS	NS	*
CV %	10.28	14.45	14.45	8.47	13.86	13.62	16.56	11.42	13.29

Table 3: Status of available iron, zinc and boron content (mg/kg) in soil after crop harvesting

Treatments	Iron (I)			Zinc (Z)			Boron (B)		
	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	1.161	1.088	1.125	0.243	0.207	0.225	0.459	0.437	0.448
i ₁	2.143	3.490	2.817	0.516	1.294	0.905	1.076	2.416	1.746
i ₂	3.759	5.381	4.570	0.511	1.223	0.867	1.986	2.550	2.268
S.Em.±	0.066	0.07	0.455	0.011	0.03	0.142	0.038	0.060	0.036
C.D. at 5%	0.189	0.19	NS	NS	0.08	NS	0.109	0.172	0.100
Zinc (Z)									
z ₀	1.179	1.142	1.161	0.244	0.227	0.236	0.461	0.434	0.448
z ₁	2.367	3.336	2.852	0.528	1.147	0.838	1.112	2.441	1.777
z ₂	2.480	3.604	3.042	0.798	1.306	1.052	1.774	2.500	2.137
S.Em.±	0.066	0.07	0.047	0.011	0.03	0.367	0.038	0.060	0.111
C.D. at 5%	0.189	0.19	0.13	0.030	0.08	NS	0.109	0.172	NS
Boron (B)									
b ₀	1.159	1.141	1.150	0.233	0.219	0.226	0.481	0.459	0.470
b ₁	2.340	3.267	2.804	0.522	1.152	0.837	1.904	2.389	2.147

b ₂	2.464	3.536	3.000	0.540	1.230	0.885	2.142	2.705	2.424
S.Em.±	0.066	0.07	0.047	0.011	0.03	0.069	0.038	0.060	0.036
C.D. at 5%	NS	0.19	0.13	0.030	0.08	NS	0.109	0.172	0.100
Interaction effect									
I x Z	NS	*	*	NS	*	NS	NS	NS	*
I x B	NS	*	*	NS	NS	NS	NS	NS	*
Z x B	NS	NS	NS	NS	*	NS	NS	NS	*
I x Z x B	NS	NS	NS	NS	NS	NS	NS	NS	*
CV %	14.68	10.21	12.06	10.48	13.70	13.99	10.46	13.22	12.29

Table 4: Effect of iron, zinc and boron on weight of bulb (g), bulb yield per plot (kg) and bulb yield per hectare (q)

Treatments	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	139.00	130.30	134.65	18.693	17.757	18.225	532.56	505.90	519.23
i ₁	147.35	137.60	142.47	19.691	18.748	19.220	561.00	534.13	547.58
i ₂	130.12	124.50	127.31	18.014	17.457	17.736	513.22	497.35	505.30
S.Em.±	1.60	1.58	1.13	0.260	0.241	0.177	7.42	6.85	5.05
C.D. at 5%	4.56	4.49	3.16	0.737	0.683	0.496	21.06	19.45	14.14
Zinc (Z)									
z ₀	141.87	129.47	135.67	19.017	18.237	18.627	541.79	519.57	530.68
z ₁	152.21	141.26	146.73	20.301	19.341	19.821	578.38	551.03	564.70
z ₂	122.39	121.66	122.03	17.080	16.384	16.732	486.61	466.78	476.70
S.Em.±	1.60	1.58	3.18	0.260	0.241	0.177	7.42	6.85	5.05
C.D. at 5%	4.56	4.49	NS	0.737	0.683	0.496	21.06	19.45	14.14
Boron (B)									
b ₀	131.95	126.07	129.01	18.275	17.504	17.890	520.66	498.69	509.69
b ₁	140.67	132.74	136.71	18.970	18.129	18.549	540.46	516.50	528.46
b ₂	143.84	133.58	138.71	19.153	18.329	18.741	545.67	522.19	533.93
S.Em.±	1.60	1.58	1.13	0.260	0.241	0.177	7.42	6.85	5.05
C.D. at 5%	4.56	4.49	3.16	0.737	0.683	0.496	21.06	19.45	14.14
Interaction effect									
I x Z	NS	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 %	6.01	6.29	6.15	7.18	6.95	7.07	7.18	6.95	7.07

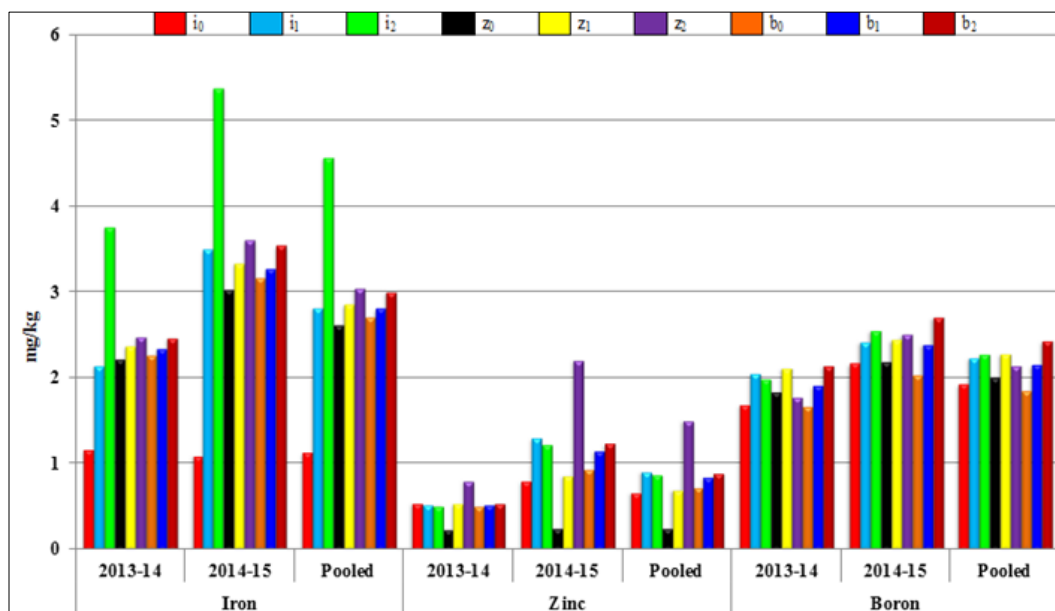


Fig 1: Status of available iron content (mg/kg) in the soil after crop harvesting

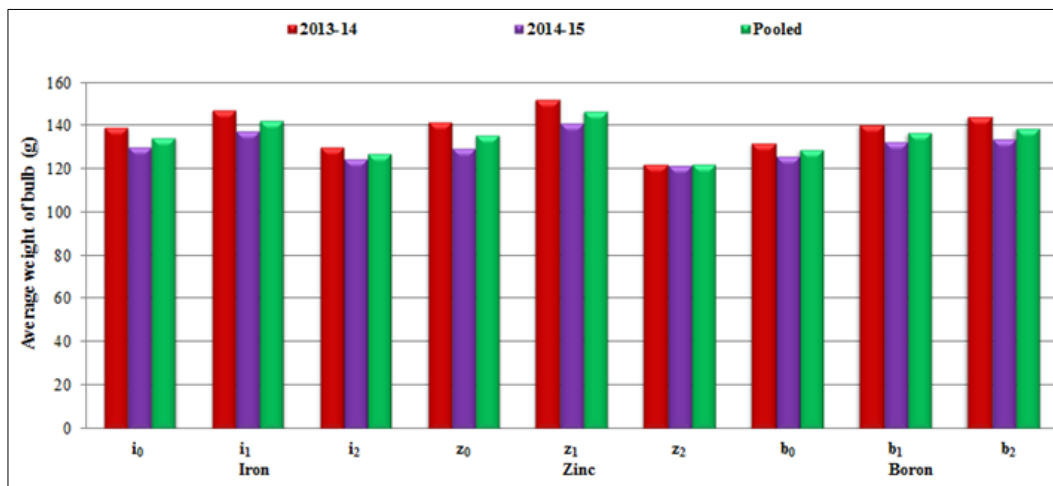


Fig 2: effect of iron, zinc and boron on average weight of bulb (g)

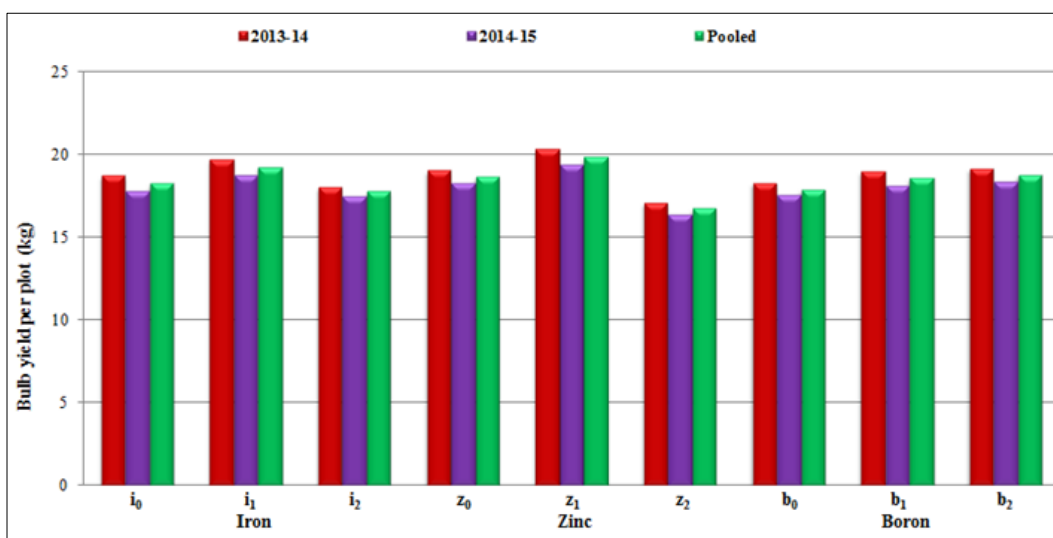


Fig 3: effect of iron, zinc and boron on bulb yield per plot (kg)

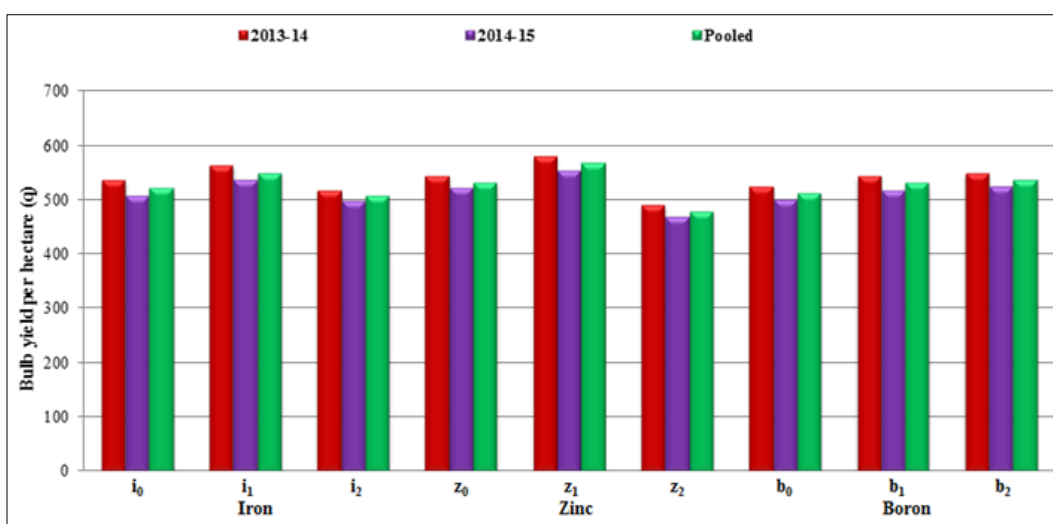


Fig 4: effect of iron, zinc and boron on bulb yield per hectare (q)

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 yield and yield attributes of onion in cultivar Agrifound Light Red.

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