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RESEARCH PAPER

Effect of zinc and iron on growth, yield and quality parameters of onion

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Abstract: A field experiment was conducted to study the effect of micronutrients application in onion in medium black soils at Regional Agricultural Research Station, Vijayapur, during *Rabi,* 2021-22. The experiment was laid out in factorial RBD with single control design with three replications.There were ten treatment combinations, consisting three levels of zinc (0, 15 and 30 kg $ZnSO_4$ ha^{-1}) in first factor and three three levels of iron (0, 15 and 30 kg $FeSO_4$ ha^{-1}) in second factor these nine combinations were compared with absolute control.The results revealed that the soil application of 30 kg $ZnSO_4$ ha^{-1} + 30 kg $FeSO_4$ ha^{-1} recorded significantly higher plant height (48.08 cm), number of leaves (13.42), leaf dry matter (4.58 g $plant^{-1}$), bulb dry matter (12.09 g $plant^{-1}$), polar diameter (6.28 cm), equatorial diameter (5.16 cm),bulb index (1.37), average weight of fresh bulb (76.04 g), average weight of cured bulb (64.43 g), bulb yield (18.56 t ha^{-1}), 'A' grade bulbs (11.83%), 'B' grade bulbs (74.15 %) and significantly lower 'C' grade bulbs (14.02%),While, lower plant height (39.36 cm), number of leaves(11.23), leaf dry matter (3.43 g $plant^{-1}$), bulb dry matter (8.69 g $plant^{-1}$), polar diameter (4.87 cm), equatorial diameter (4.17 cm), bulb index (0.92), average weight of fresh bulb (63.96 g), average weight of cured bulb (52.91 g), bulb yield (10.30 t ha^{-1}),'A' grade bulbs (9.01%) and 'B' grade bulbs (52.35%) were recorded in treatment receiving only RDF. The soil application of zinc sulphate and iron sulphate either alone or in combination helped to improve growth, yield and quality parameters of onion.

Key words: Iron, Micronutrients, Onion, Zinc

Introduction

Onion (*Allium cepa* L.), a member of the alliaceae family, is one of the most significant monocotyledonous, cross-pollinated, and cool-season commercial vegetable crops. In Kannada, onions are commonly referred to as *Ullagaddi* or *Irulli* and *Pyaaj* in Hindi. Onion has a unique flavor and is cooked as a vegetable in addition to being used in soups, meat dishes, salads, and sandwiches. It is used in the preparation of almost all food of our daily diet and is primarily consumed for its unique flavor or its ability to enhance the flavor of other foods (Randle, 2000). So, it is called as the queen of the kitchen (Selvaraj, 1976). Pungency of onion is due to the presence of volatile oil named "Allyl propyl disulphide" (Khan *et al*., 2007). India is the second largest onion producer in the world after china and occupies area of 16.24 lakh hectares with a production of 26.64 million tonnes and 16.40 MT ha^{-1} of productivity. In the year 2020-21, Maharashtra was the first in the country's onion production of 10476.46 thousand tonnes with 703.80 thousand hectares of area and productivity of 14.89 MT ha^{-1}. The state alone contributes for about 43.30 per cent of the total area under onion cultivation. Madhya Pradesh is the second largest in terms of production (17.07%) followed by Karnataka (9.98%) and Gujarat (6.22%) (Anon, 2021). In Karnataka, onion is grown in all three seasons and is the third largest onion producer in the country with a share of 9.98 per cent in the total onion production and onion occupies area of 2.30 lakh hectares with a production of 2.67 million tonnes and 11.55 MT ha^{-1} of productivity (Anon, 2021).

The lower productivity of Indian onion is primarily due to cultivation of low yield potential varieties/hybrids, susceptibility to both biotic (pests and diseases) and abiotic factors (*i.e.* moisture stress, high temperature, imbalance nutrition *etc.*). Imbalanced nutrition is treated as one of the major abiotic stresses which adversely affects crop growth and yield in onion. Indian soils are deficient in micronutrients, particularly zinc deficiency is widely prevalent and it has been estimated that 60% of Indian soils are deficient in zinc. So to overcome the deficiency of micronutrients, application of micronutrient fertilizer is essential in order to achieve the good yield of crops. Application of these to deficit soil has shown remarkable increase in yield and quality of onion and several crops by playing an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation. Among the micronutrients zinc and iron play a major role in onion production.

The previous studies showed that deficiency or toxicity of micronutrients causes considerable losses in yield and quality and hence limiting the productivity of onion crop (Mandal *et al.,* 2020). The growth, yield and quality of onion bulbs is found to be improved with the supply of adequate amount of micronutrients in a proper proportion (Trivedi and Dhumal, 2013). The use of micronutrients are also responsible for efficient utilization of major nutrients. Hence, the present investigation was intended to find the influence of soil application of different levels of iron and zinc on growth, yield and yield attributes of onion.

Material and methods

A field experiment was conducted during *rabi*, 2021-22 at Regional Agricultural Research Station, Vijayapur, Karnataka on vertisol. The experimental site was located at a latitude of

16°77' North, longitude of 75° 74' East and an altitude of 516.29 meters above mean sea level in Northern Dry Zone of Karnataka (Zone 3). During the year 2021, a total rainfall of 632.8 mm was received in 52 rainy days from January 2021 to December 2021 as against the normal rainfall of 594.4 mm which was received in 38 rainy days. The highest rainfall of 161.7 mm was received in the month of September followed by July (146.4 mm). The total rainfall received during cropping period (September-2021 to March-2022) was 246.5 mm. The soil was texturally clay, alkaline in reaction (pH 8.20), with salinity of 0.21 dSm^{-1}, low in available Nitrogen (176 kg N ha^{-1}), medium in available Phosphorus (32 kg P_2O_5 ha^{-1}), high in available Potassium (358 kg K_2O ha^{-1}) and deficient in Zinc (0.41 ppm) and Iron (3.8 ppm).

The experiment was laid out in a factorial randomized block design with single control and replicated thrice. Ten treatment combinations consisting of three levels of zinc (0, 15 and 30 kg $ZnSO_4$ ha^{-1}) in first factor and three levels of iron (0, 15 and 30 kg $FeSO_4$ ha^{-1}) in second factor and these nine combinations were compared with absolute control. The land was ploughed once after the harvest of the previous crop, followed by two harrowing. At the time of sowing, the land was prepared to a fine seedbed and the plots were laid out. The variety Panchaganga was used and fertilizer application was followed on the basis of the plant population occupied by crop. The FYM @ 30 t ha^{-1} and full amount of fertilizer in the form of urea, di ammonium sulphate,murriate of potash and borax as per recommended package of practice 125:50:125:5 kg N, P_2O_5, K_2O and borax per ha was applied. The crop was sown on 15th September 2021 with a spacing of 15 × 10 cm. Irrigations were given as and when required to maintain uniform and optimum soil moisture throughout the crop growth period. As a precautionary measure to avoid infestation of thrips and yellowing of leaves, spray of Sulfex + Optra (80% Sulphur WP + Thiamethoxam 25% WG) was used for twisting disease, Merger (Tricyclazole 18% + Mancozeb 62% wp) 40 g + Borax 20 g per tank were used at 30 and 45 days after transplanting and to control purple blotch, spray of Avatar (Hexaconazole 4% + Zineb *a.i.* 68%) 60 g + Borax 20 g per tank. Harvesting was done at physiological maturity of the crop *i.e.* when 50 per cent of onion leaves showed neck fall. After harvesting, the bulbs were allowed to sun cure for 7 days in the field. The bulb yield in each plot were weighed separately and recorded in tonnes per hectare.

The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used for 'F' and 't' tests was P=0.05. Critical Difference (CD) values were calculated at 5 per cent probability level if the F test found significant.

Results and discussion

Effect on growth parameters

The growth parameters like plant height, number of leaves, leaf dry matter and bulb dry matter at harvest were greatly influenced by soil application of different levels of zinc and iron (Table 1). Application of different levels of zinc had significant influence on growth parameters of onion. Significantly the highest plant height (45.80 cm),number of leaves (12.57), leaf dry matter (4.41 g plant^{-1}) and bulb dry matter (10.84 g plant^{-1}) were recorded with soil application of 30 kg $ZnSO_4$ ha^{-1} as compared to other Zn levels. This increase in growth parameters with higher levels of zinc might be due to its role in the formation of several enzymatic action which governs the metabolic reactions in the plant system. Zinc might have also regulated the oxidation-reduction reaction in the plant which may induce the formation of chlorophyll for photosynthetic activity. These results are in close agreement with the findings of Rohidas *et al.* (2011) and Trivedi and Dhumal (2013).

Among the different levels of iron, soil application of 30 kg $FeSO_4$ ha^{-1} recorded significantly higher plant height (46.46 cm), number of leaves (12.83), leaf dry matter (4.42 g plant^{-1}) and bulb dry matter (10.75 g plant^{-1}).This micronutrient helps to formation of different growth hormones specially IAA in the plant which directly encouraged the vegetative growth and yield traits. Similar observations were also made by Alam *et al.* (2010) and Ballabh and Rana, (2012).

Interaction effect showed that combined application of 30 kg $ZnSO_4$ ha^{-1} + 30 kg $FeSO_4$ ha^{-1} significantly higher plant height (48.08 cm), number of leaves (13.42), leaf dry matter (4.58 g plant^{-1}) and bulb dry matter (12.09 g plant^{-1}), these were on par with application of 30 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1}as

Table 1. Plant height, number of leaves and dry matter of onion at harvest as influenced by micronutrients application

Treatment	Plant height (cm)	Number of leaves per plant	Dry matter at harvest	
			Leaves (g plant^{-1})	Bulbs (g plant^{-1})
Zn Levels ($ZnSO_4$, kg ha^{-1})				
0	42.39	11.47	3.87	8.92
15	45.53	12.49	4.41	9.93
30	45.80	12.57	4.41	10.84
S.Em ±	0.57	0.17	0.05	0.23
C.D. at 5%	1.72	0.50	0.14	0.69
Fe Levels ($FeSO_4$, kg ha^{-1})				
0	42.84	11.26	3.97	8.86
15	44.42	12.44	4.31	10.09
30	46.46	12.83	4.42	10.75
S.Em ±	0.57	0.17	0.05	0.23
C.D. at 5%	1.72	0.50	0.14	0.69
Interactions				
Z_0F_0	39.36	11.23	3.43	8.69
Z_0F_{15}	42.24	11.35	4.05	8.78
Z_0F_{30}	45.58	11.84	4.14	9.30
$Z_{15}F_0$	44.01	11.18	4.25	8.89
$Z_{15}F_{15}$	46.84	13.05	4.40	10.04
$Z_{15}F_{30}$	45.73	13.24	4.54	10.85
$Z_{30}F_0$	45.16	11.36	4.22	8.99
$Z_{30}F_{15}$	44.17	12.93	4.48	11.43
$Z_{30}F_{30}$	48.08	13.42	4.58	12.09
S.Em ±	0.99	0.29	0.08	0.40
C.D. at 5 %	2.98	0.87	0.24	1.20
Absolute control	36.62	9.17	3.24	7.06
S.Em ±	1.02	0.40	0.16	0.40
C.D. at 5 %	3.04	1.20	0.47	1.18

compared to other treatment combinations. If we compared these treatment combinations with absolute control treatment, all these growth parameters were significantly lower in absolute control. Improvement in plant growth might be due to the better availability of nutrients from basal fertilizers and soil applied micronutrients such as Fe and Zn available at the site of photosynthesis. These results are in close conformity with those of Rohidas *et al*. (2011), Alam *et al*. (2010) and Ballabh and Rana (2012).

Effect on yield and yield attributes

The yield attributes like polar diameter, equatorial diameter, bulb index, average weight of fresh bulb, average weight of cured bulb and bulb yield were greatly influenced by soil application of different levels of zinc and iron (Table 2 and 3). Application of different levels of zinc had significant influence on yield and yield attributes of onion. Significantly the highest polar diameter (5.53 cm), equatorial diameter (4.68 cm), bulb index (1.18), average weight of fresh bulb (73.81 g), average weight of cured bulb (62.20 g) and bulb yield (16.55 t ha^{-1})were recorded with soil application of 30 kg $ZnSO_4$ ha^{-1} as compared to other Zn levels.This improvement in turn was due to improved growth attributes such as higher dry matter production and distribution in different parts. Correlation studies also supports the view. The results clearly indicated a positive and significant correlation between bulb yield with yield components *viz.,* bulb dry matter ($r=0.969^{**}$), average weight of cured bulb ($r=0.942^{**}$) (Table 5). These results are in close agreement with those of Baghel and Sarnak (1988) and Ballah and Rana (2012).

Table 2. Polar diameter, equatorial diameter, bulb index of onion as influenced by micronutrients application

Treatment	Polar diameter (cm)	Equatorial diameter (cm)	Bulb index
0	4.99	4.26	0.97
15	5.21	4.29	1.06
30	5.53	4.68	1.18
S.Em ±	0.10	0.08	0.03
C.D. at 5%	0.31	0.24	0.08
0	4.95	4.13	0.95
15	5.21	4.45	1.10
30	5.57	4.64	1.16
S.Em ±	0.10	0.08	0.03
C.D. at 5%	0.31	0.24	0.08
Z_0F_0	4.87	4.17	0.92
Z_0F_{15}	5.03	4.27	0.97
Z_0F_{30}	5.07	4.33	1.01
$Z_{15}F_0$	5.07	4.18	0.93
$Z_{15}F_{15}$	5.22	4.25	1.15
$Z_{15}F_{30}$	5.35	4.43	1.11
$Z_{30}F_0$	4.92	4.04	1.01
$Z_{30}F_{15}$	5.38	4.83	1.17
$Z_{30}F_{30}$	6.28	5.16	1.37
S.Em ±	0.18	0.14	0.05
C.D. at 5%	0.53	0.42	0.14
Absolute control	4.05	3.76	0.85
S.Em ±	0.17	0.14	0.04
C.D. at 5%	0.51	0.42	0.13

Table 3. Fresh bulb weight, cured bulb weight and bulb yield of onion as influenced by micronutrients application

Treatment	Fresh bulb weight(g)	Cured bulb weight(g)	Bulb yield (t ha^{-1})
Zn Levels ($ZnSO_4$, kg ha^{-1})			
0	67.11	56.06	11.16
15	71.29	61.26	14.71
30	73.81	62.20	16.55
S.Em ±	0.56	0.36	0.30
C.D. at 5 %	1.68	1.08	0.89
Fe Levels ($FeSO_4$, kg ha^{-1})			
0	67.62	56.49	12.17
15	71.15	60.77	14.62
30	73.44	62.26	15.63
S.Em ±	0.56	0.36	0.30
C.D. at 5 %	1.68	1.08	0.89
Interactions			
Z_0F_0	63.96	52.91	10.30
Z_0F_{15}	67.13	56.24	11.16
Z_0F_{30}	70.24	59.02	12.02
$Z_{15}F_0$	66.08	56.94	12.55
$Z_{15}F_{15}$	73.75	63.53	15.26
$Z_{15}F_{30}$	74.05	63.32	16.32
$Z_{30}F_0$	72.83	59.61	13.65
$Z_{30}F_{15}$	72.56	62.55	17.43
$Z_{30}F_{30}$	76.04	64.43	18.56
S.Em ±	0.97	0.62	0.51
C.D. at 5 %	2.91	1.87	1.54
Absolute control	53.39	42.35	6.22
S.Em ±	1.21	0.73	0.51
C.D. at 5 %	3.60	2.16	1.52

Among the different levels of iron, soil application of 30 kg $FeSO_4$ ha^{-1} recorded significantly higher polar diameter (5.57 cm), equatorial diameter (4.64 cm), bulb index (1.16), average weight of fresh bulb (73.44 g), average weight of cured bulb (62.26 g) and bulb yield (15.63 t ha^{-1}). The higher bulb yield and yield attributes might be attributed to higher plant height with more no of leaves per plant, leaf dry matter and bulb dry matter. The results clearly indicated a positive and significant correlation between bulb yield and yield components *viz.,* bulb dry matter ($r=0.969^{**}$), average weight of cured bulb ($r=0.942^{**}$), N uptake ($r=0.984^{**}$), P uptake $r=0.826^{**}$), K uptake $r=0.939^{**}$), Zn uptake $r=0.956^{**}$), Fe uptake ($r=0.948^{**}$) (Table 5). These results are in close agreement with the findings of Alam *et al.* (2010) and Trivedi and Dhumal (2013).

Interaction effect showed that combined application of 30 kg $ZnSO_4$ ha^{-1} + 30 kg $FeSO_4$ ha^{-1} recorded significantly higher polar diameter (6.28 cm), equatorial diameter (5.16 cm), bulb index (1.37), average weight of fresh bulb (76.04 g), average weight of cured bulb (64.43 g) and bulb yield (18.56 t ha^{-1}), these were on par with application of 30 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1} as compared to other treatment combinations. If we compared these treatment combinations with absolute control treatment, all these yield and yield attributes were significantly lower in absolute control. Application of iron and zinc have been considered as the essential components for cell division which is very necessary for the growth and development of the

Table 4. Grading of bulbs of onion as influenced by micronutrients application

Treatment	Grading of bulbs (%)		
	A	B	C
Zn Levels ($ZnSO_4$, kg ha^{-1})			
0	9.74	63.08	27.18
15	10.75	68.67	20.59
30	11.17	72.11	16.71
S.Em ±	0.15	0.65	0.62
C.D. at 5%	0.45	1.95	1.86
Fe Levels ($FeSO_4$, kg ha^{-1})			
0	10.02	63.39	26.59
15	10.47	68.85	20.68
30	11.17	71.61	17.22
S.Em ±	0.15	0.65	0.62
C.D. at 5%	0.45	1.95	1.86
Interactions			
Z_0F_0	9.01	52.35	38.64
Z_0F_{15}	9.82	66.82	23.36
Z_0F_{30}	10.40	70.06	19.54
$Z_{15}F_0$	9.88	67.09	23.03
$Z_{15}F_{15}$	11.08	68.28	20.64
$Z_{15}F_{30}$	11.28	70.63	18.09
$Z_{30}F_0$	11.17	70.73	18.10
$Z_{30}F_{15}$	10.52	71.45	18.03
$Z_{30}F_{30}$	11.83	74.15	14.02
S.Em ±	0.26	1.12	1.07
C.D. at 5 %	0.78	3.37	3.21
Absolute control	8.07	48.71	43.21
S.Em ±	0.27	1.13	1.05
C.D. at 5 %	0.79	3.35	3.12

plant and also due to combined application of these helped in better photosynthetic capacity of plant which in turn increased translocation of photosynthates to sink and these results are in close agreement with those of Alam *et al*. (2010), Ballabh *et al*. (2013), Chattopadhyaya and Mukhopadhay (2004).

Effect on quality

Application of micronutrient greatly influenced the production of good grade bulbs. The'A' grade, 'B' grade and 'C' grade bulbs were greatly influenced by soil application of different levels of zinc and iron. Significantly higher number of 'A' grade (11.17%) and 'B' grade bulbs (72.1%) and significantly less number of 'C' grade bulbs (16.71%) were produced with soil application of 30 kg $ZnSO_4$ ha^{-1} as compared to other Zn levels, which is depicted in Table 4.

Among the different levels of iron, soil application of 30 kg $FeSO_4$ ha^{-1} recorded significantly higher 'A' grade bulbs (11.17%), 'B' grade bulbs (71.61%)and a few 'C' grade bulbs (17.22%) over the other levels of iron.

Interaction effect showed that combined application of 30 kg $ZnSO_4$ ha^{-1} + 30 kg $FeSO_4$ ha^{-1} recorded significantly higher 'A' grade bulbs (11.83%), 'B' grade bulbs (74.15%) and lesser number of number of 'C' grade bulbs (14.02%) these were on par with application of 30 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1} as compared to other treatment combinations. If we compared these treatment combinations with absolute control treatment, 'A' grade bulbs and 'B' grade bulbs were significantly lower in absolute control and 'C' grade bulbs were significantly higher in absolute control.

The higher 'A' and 'B' graded bulbs were due to higher yield attributing characters like bulb index, polar diameter and equatorial diameter of bulb differed significantly with the application of different levels of zinc and iron. Similar findings were also made by Tohamy *et al.* (2009) and Alam *et al.* (2010).

Conclusion

Soil application of either zinc sulphate or iron sulphate @ 30 kg ha^{-1} alone or in combination of both iron sulphate @ 30 kg + zinc sulphate @ 30 kg or 30 kg zinc sulphate + 15 kg iron sulphate per hectare helped to improve the growth, yield and quality of onion.

Table 5. Correlation coefficient values (r) as influenced by micronutrients application

Characters	Plant height	No of leaves	Leaf dry matter	Bulb dry matter	Cured bulb weight	Bulb yield	Total soluble solids	Ascorbic acid	N uptake	P uptake	K uptake	Zn uptake	Fe uptake
Plant height	1												
No of leaves	0.869**	1											
Leaf dry matter	0.926**	0.872**	1										
Bulb dry matter	0.787**	0.944**	0.838**	1									
Cured bulb weight	0.962**	0.952**	0.941**	0.876**	1								
Bulb yield	0.871**	0.948**	0.918**	0.969**	0.942**	1							
Total soluble solids	0.772**	0.905**	0.834**	0.968**	0.859**	0.936**	1						
Ascorbic acid	0.769**	0.914**	0.839**	0.994**	0.853**	0.959**	0.968**	1					
N uptake	0.861**	0.946**	0.905**	0.984**	0.923**	0.984**	0.948**	0.984**	1				
P uptake	0.898**	0.892**	0.921**	0.784**	0.918**	0.826**	0.756*	0.773**	0.852**	1			
K uptake	0.774**	0.921**	0.840**	0.985**	0.851**	0.939**	0.952**	0.991**	0.976**	0.807**	1		
Zn uptake	0.899**	0.858**	0.969**	0.882**	0.917**	0.956**	0.861**	0.888**	0.934**	0.828**	0.874**	1	
Fe uptake	0.924**	0.909**	0.978**	0.909**	0.946**	0.948**	0.900**	0.913**	0.956**	0.913**	0.922**	0.970**	1

* indicates significant at 1% and ** indicates 5% level of significance

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