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PS Deshmukh
P. G. Student, Department of Vegetable Science, College of Horticulture, Nagpur, Maharashtra, India

SS Moon
Assistant Professor, College of Horticulture, Nagpur, Maharashtra, India

MS Sirsat
P. G. Student, Department of Fruit Science, College of Horticulture, Nagpur, Maharashtra, India

P Panherkar
P. G. Student, Department of Vegetable Science, College of Horticulture, Nagpur, Maharashtra, India

UM Tagalpallewar
P. G. Student, Department of Vegetable Science, College of Horticulture, Nagpur, Maharashtra, India

Corresponding Author:
PS Deshmukh
P. G. Student, Department of Vegetable Science, College of Horticulture, Nagpur, Maharashtra, India

Effect of zinc and iron on growth parameters of summer okra

PS Deshmukh, SS Moon, MS Sirsat, P Panherkar and UM Tagalpallewar

Abstract
An experiment entitled "effect of zinc and iron on yield and quality of summer okra" was carried out during summer season of the year 2020-21 at the farm of Horticulture section, College of Agriculture, Nagpur. The treatment comprised of the four zinc levels *viz.*, 0% control i.e. (water spray), 0.25% $ZnSO_4$, 0.5% $ZnSO_4$, 0.75% $ZnSO_4$ and four iron levels 0% control i.e. water spray, 0.25% $FeSO_4$, 0.5% $FeSO_4$, 0.75% $FeSO_4$. The experiment was laid out in Factorial Randomized Block Design with three replications. The result obtained the present investigation indicated that, the growth parameter in terms of plant height (cm), stem diameter (cm), branches plant^{-1}, leaf area (cm^2) maximum in 0.5% $ZnSO_4$ as well as 0.5% $FeSO_4$. The interaction effect of zinc and iron for the growth parameters were found non Significant.

Keywords: Zinc, Iron, growth, and summer okra

Introduction
Okra *[Abelmoschus esculentus* (L.) Moench] commonly known as lady's finger or that, belongs to the family *Malvaceae*. It is widely adopted and popular vegetable in Indian kitchens and can be grown in summer and rainy seasons throughout India. It is widely adopted and popular vegetable in Indian kitchens and can be grown in summer and rainy seasons throughout India. India is the highest producer in the world and exported there by helping in earning foreign exchange. Okra is an important vegetable grown for its tender fruits which are used as a vegetable in various ways. Matured fruits and stem containing crude fibers are used in the paper industry, roots and stems are used for clarification of sugar cane juice in preparation of jaggery.

Now-a-days, micronutrients especially zinc and iron are gradually gaining momentum among the flower growers because of their beneficial nutritional support and to ensure better harvest and returns. These micronutrients generally activate several enzymes and envolve themselves in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged. Hence, considering the above facts, the present investigation was undertaken to study the growth parameters of. summer okra as influenced by zinc and iron.

Materials and Methods
An experiment entitled yield and quality of summer okra as influenced by zinc and iron" was laid out at the field of Horticulture Section, College of Agriculture, Nagpur during 2020-2021. The treatment comprised of the four zinc levels *viz.*, 0% control i.e. (water spray), 0.25% $ZnSO_4$, 0.5% $ZnSO_4$, 0.75% $ZnSO_4$ and four iron levels 0% control i.e. water spray, 0.25% $FeSO_4$, 0.5% $FeSO_4$, 0.75% $FeSO_4$. The experiment was laid out in Factorial Randomized Block Design (FRBD) with sixteen treatment combinations and three replications. The seed were sowing in field on 10th jan 2021 at 45 cm × 60 cm spacing. A standard dose of NPK at the rate of 150 Kg N, 100 Kg P and 100 Kg K hectare^{-1} was applied through urea, single super phosphate and murriate of potash. The basal dose of 50 Kg N and full dose of P and K was applied at the time of sowing. The foliar application was done by solution of zinc and iron each of 0.25%, 0.5% and 0.75% were prepared on molecular weight basis by dissolving respective amount of zinc sulphate and ferrous sulphate respectively in distilled water. Then the prepared solution was spread at 45 and 60 days after planting individually and in combinations as per the treatment. Five uniform plants were selected randomly from each plot for recording growths parameters terms of plant height (cm), stem diameter (cm), branches plant^{-1}, leaf area (cm^2), Data were statistically analyzed in FRBD.

Results and Discussion

The data presented in table revealed that, different levels of zinc and different levels iron had significant effect on all growth parameters of summer okra.

Growth parameters

The data presented in table 1 revealed that, different levels of zinc and different levels iron had significant effect on plant height of summer okra.

1) Plant height (cm)

a) Effect of zinc

The data of plant height recorded at 30, 60 and 90 days after sowing was significantly influenced by different levels of zinc

Table 1: Treatments Plant height (cm)

Treatments	Plant height (cm)		
	Days after sowing		
A) Zinc (Z)	30 Days	60 Days	90 Days
Z_0- Control (water spray)	24.53	60.94	81.85
Z_1- 0.25% $ZnSO_4$	24.62	62.22	82.39
Z_2- 0.50% $ZnSO_4$	25.55	65.42	85.39
Z_3- 0.75% $ZnSO_4$	24.88	63.00	82.42
F test	N.S.	Sig.	Sig.
SE (m) ±	0.52	0.80	0.64
CD at 5%	-	2.33	1.85
B) Iron (F)			
F_0 - Control (water spray)	24.80	60.91	80.91
F_1 - 0.25% $FeSO_4$	24.65	62.98	83.19
F_2 - 0.50% $FeSO_4$	25.40	64.13	84.41
F_3 - 0.75% $FeSO_4$	24.80	63.77	83.14
F test	N.S.	Sig.	Sig.
SE (m) ±	0.52	0.80	0.64
CD at 5%	-	2.33	1.85
C) Interaction effect (ZxF)			
F test	N.S.	N.S.	N.S.
SE (m) ±	1.28	0.31	1.57
CD at 5%	-	-	-

At 30 days after sowing, plant height was found non significant. This might be due to less effect of treatment combinations on plant height at 30 days after sowing. Significantly, maximum plant height (65.42 cm) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by Z_3 (63.00 cm) i.e. 0.75% $ZnSO_4$. However, significantly minimum plant height (60.94 cm) was recorded in control at 60 days after sowing.At the stage of 90 days after sowing, Z_2 (0.50% $ZnSO_4$) recorded significantly maximum plant height (85.39 cm) which was followed by Z_3 (82.42 cm) i.e. 0.75% $ZnSO_4$. Significantly minimum plant height was recorded in control (81.85 cm).Similar results were also obtained by. Satpute *et al*. (2013) [4] in tomato and Uikey *et al*. (2018) [7] in brinjal.

b) Effect of iron

At 30 days after sowing, plant height was found non significant. This might be due to less effect of treatment combinations on plant height at 30 days after sowing.Similarly at 60 days after sowing, significantly maximum plant height (64.13cm) was recorded in F_2 (0.50% $FeSO_4$) which was found at par with F_3 (63.77 cm) i.e. 0.75% $FeSO_4$. F_0 and F_1 were found at par with each other. F_1 and F_3 were also found at par with each other. Significantly, minimum plant height was recorded under control treatment (60.91 cm) at the stage of 60 days after sowing. At the stage of 90 days after sowing, significantly maximum plant height (84.41 cm) was recorded in F_2 (0.50% $FeSO_4$) which was found at par with F_3 (83.14 cm) i.e. 0.75% $FeSO_4$. However, significantly minimum plant height was recorded in control treatment (80.91 cm). Similar results were also obtained by in Satpute *et al*. (2013) [4] in tomato and Uikey *et al*.(2018) [7] in brinjal.

c) Interaction effect

The interaction effect of zinc and iron on plant height was found non significant at all growth stages *viz*., 30, 60 and 90 days after.

2) Stem diameter (cm)

The data presented in table 2 revealed that, different levels of zinc and different levels iron had significant effect on stem diameters of summer okra.

a) Effect of zinc

At 30 days after sowing, stem diameter was found non significant. This might be due to less effect of treatment combinations on plant height at 30 days after sowing.At 60 days after sowing, significantly maximum stem diameter (4.16 cm) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by treatment Z_3 (0.75% $ZnSO_4$) (3.46 cm).Significantly minimum stem diameter (3.37 cm) was recorded in control (water spray). At 90 days after sowing, significantly maximum stem diameter (4.59 cm) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by treatment Z_3 (0.75% ZnSO4) (4.59). Z_0 and Z_1 were found statistically at par with each other. Significantly minimum stem diameter (4.04 cm) was recorded in control (water spray). Result obtained in this study is similar with the observation of Sivakumar *et al*. (2005) [6] in okra and Chingakham *et al*. (2013) [2] in chilli.

Table 2: Stem diameter

Treatments	Stem diameter (cm)		
	Days after sowing		
A) Zinc (Z)	30 Days	60 Days	90 Days
Z_0- Control (water spray)	2.30	3.37	4.04
Z_1- 0.25% $ZnSO_4$	2.49	3.39	4.09
Z_2- 0.50% $ZnSO_4$	2.87	4.16	4.59
Z_3- 0.75% $ZnSO_4$	2.65	3.46	4.12
F test	N.S.	Sig.	Sig.
SE (m) ±	0.15	0.11	0.09
CD at 5%	-	0.32	0.28
B) Iron (F)			
F_0 - Control (water spray)	2.36	3.02	3.81
F_1 - 0.25% $FeSO_4$	2.57	3.44	4.13
F_2 - 0.50% $FeSO_4$	2.74	4.04	4.59
F_3 - 0.75% $FeSO_4$	2.63	3.89	4.31
F test	N.S.	Sig.	Sig.
SE (m) ±	0.15	0.11	0.09
CD at 5%	-	0.32	0.28
C) Interaction effect (ZxF)			
F test	N.S.	N.S.	N.S.
SE (m) ±	0.36	0.27	0.23
CD at 5%	-	-	-

Effect of iron

At 30 days after sowing, stem diameter was found non significant. This might be due to less effect of treatment combinations on plant height at 30 days after sowing.At 60 days after sowing, significantly maximum stem diameter

(4.04 cm) was recorded in F_2 (0.50% $FeSO_4$) which was found at par with F_3 (3.89 cm) i.e. 0.75% $FeSO_4$. Significantly minimum stem diameter (3.02 cm) was recorded in control. At 90 days after sowing, significantly maximum stem diameter (4.59 cm) was recorded in F_2 (0.50% $FeSO_2$) which was found at par with F_3 (4.31 cm) i.e. 0.75% $FeSO_4$ However, significantly minimum stem diameter (3.81 cm) was found in control. It is observed that stem diameter increased with increasing concentration of iron. Result obtained in this study is similar with the observation of Sivakumar *et al*. (2005) [6] in okra and Chingakham *et al*. (2013) [2] in chilli.

Interaction effect

Data presented in the Table revealed that, the interaction effect of zinc and iron on stem diameter was found non significant at all growth stages, *viz*., 30, 60 and 90 days after sowing.

3) Number of branches plant^{-1}

The data presented in table 3 revealed that, different levels of zinc and different levels iron had significant effect on number of branches of summer okra.

a) Effect of zinc

Data presented in the Table 3 revealed that, an effect due to different levels of zinc on the number of branches plant^{-1} was found significant at all growth stages.At 30 days after sowing, number of branches plant^{-1} was found non significant. This might be due to less effect of treatment combinations on number of branches plant^{-1} at 30 days after sowing.At 60 days after sowing, significantly maximum number of branches plant^{-1} (9.59) was recorded in Z_2 (0.50% $ZnSO_4$) which was found at par with Z_3 (9.44) i.e. 0.75% $ZnSO_4$. However, significantly minimum number of branches plant^{-1} (5.95) was recorded in control (water spray).

Table 3: Number of branches

Treatments	Number of branches plant^{-1}		
	Days after sowing		
A) Zinc (Z)	30 Days	60 Days	90 Days
Z_0- Control (water spray)	1.91	5.95	7.30
Z_1- 0.25% $ZnSO_4$	2.10	6.56	8.79
Z_2- 0.50% $ZnSO_4$	2.18	9.59	11.06
Z_3- 0.75% $ZnSO_4$	2.17	9.44	9.73
F test	N.S.	Sig.	Sig.
SE (m) ±	0.05	0.17	0.19
CD at 5%	-	0.49	0.56
B) Iron (F)			
F_0 - Control (water spray)	1.91	7.28	8.45
F_1 - 0.25% $FeSO_4$	2.12	7.39	9.14
F_2 - 0.50% $FeSO_4$	2.21	8.65	10.00
F_3 - 0.75% $FeSO_4$	2.13	8.24	9.24
F test	N.S.	Sig.	Sig.
SE (m) ±	0.05	0.17	0.19
CD at 5%	-	0.49	0.56
C) Interaction effect (ZxF)			
F test	N.S.	Sig.	Sig.
SE (m) ±	0.14	0.46	0.47
CD at 5%	-	1.22	1.37

b) Effect of iron

Data presented in the Table revealed that, an effect due to different levels of iron on number of branches plant^{-1} was found significant at all growth stages. At 30 days after sowing, number of branches plant^{-1} was found non significant. This might be due to less effect of treatment combinations on plant height at 30 days after sowing.At 60 days after sowing, significantly maximum number of branches plant^{-1} (8.65) was recorded in F_2 (0.50% $FeSO_4$) which was found at par with F_3 (8.24) i.e. 0.75% $FeSO_4$. However, significantly minimum number of branches plant^{-1} (7.28) was recorded in control (water spray). Similarly at 90 days after sowing, significantly maximum number of branches plant^{-1} (10.0) was recorded in F_2 (0.50% $FeSO_4$) which was followed by F_3 (9.24) i.e. 0.75% $FeSO_4$. The results are in close agreement with the findings of Chingakham *et al*. (2013) [2] in chilli.

c) Interaction effect

Data presented in the Table 3 (a) and 3(b) revealed the interaction effect due to different levels of zinc and iron on number of branches plant^{-1}. Interaction effects due to various levels of zinc and iron on number of branches plant^{-1} were found non-significant in earlier growth stages i.e. 30 days after sowing and significant at later growth stages i.e. 60 and 90 days after sowing.

Table 3 (a): Effect of zinc and iron on number of branches plant^{-1} in summer okra at 60 days after sowing.

Treatments	Number of branches plant^{-1}				
	Iron ($FeSO_4$)				
Zinc (Z)	F_0 0% $FeSO_4$ (Control)	F_1 0.25% $FeSO_4$	F_2 0.50% $FeSO_4$	F_3 0.75% $FeSO_4$	Mean
Z_0 - 0% $ZnSO_4$ (Control)	4.61	7.14	6.12	5.93	5.95
Z_1 - 0.25% $ZnSO_4$	5.80	5.77	5.80	6.90	6.56
Z_2 - 0.50% $ZnSO_4$	9.04	8.00	11.05	10.30	9.59
Z_3 - 0.75% $ZnSO_4$	9.67	8.65	9.63	9.83	9.44
Mean	7.28	7.39	8.65	8.25	
	Factor A (Z)	Factor B (F)		Interaction Z X F	
'F' test	Sig.	Sig.		Sig.	
SE (m) ±	0.17	0.17		0.42	
CD at 5%	0.49	0.49		1.22	

Table 3 (b): Effect of zinc and iron on number of branches plant-1 in summer okra at 90 days after sowing

Treatments	Number of branches plant^{-1}				
	Iron (F)				
Zinc (Z)	F_0 0% $FeSO_4$ (Control)	F_1 0.25% $FeSO_4$	F_2 0.50% $FeSO_4$	F_3 0.75% $FeSO_4$	Mean
Z_0 - 0% $ZnSO_4$ (Control)	6.7	7.5	8.4	6.5	7.30
Z_1 - 0.25% $ZnSO_4$	7.4	8.4	9.3	9.7	8.79
Z_2 - 0.50% $ZnSO_4$	10.3	11.13	12.26	10.55	11.06
Z_3 - 0.75% $ZnSO_4$	9.30	9.48	10.83	9.99	9.73
Mean	8.45	9.14	10.0	9.24	
	Factor A (Z)	Factor B (F)		Interaction Z X F	
'F' test	Sig.	Sig.		Sig.	
SE (m)	0.19	0.19		0.47	
CD at 5%	0.56	0.56		1.37	

At 60 days after sowing, summer okra produced the maximum number of branches plant^{-1} (11.05) in the treatment combination of Z_2F_2 (0.50% $ZnSO_4$ and 0.50% FeSO4) which was at par with treatment combination Z_2F_2 (10.30) i.e. 0.50% ZnSO4 and 0.75% $FeSO_4$. However, minimum number of branches plant^{-1} (4.61) was recorded in Z_0F_0 control (water spray). At 90 days after sowing, summer okra produced the maximum number of branches plant^{-1} (12.26) in the treatment combination of Z_2F_2 (0.50% $ZnSO_4$ and 0.50% $FeSO_4$) which was followed by Z_2F_3 (10.55) i.e. 0.50% $ZnSO_4$ and 0.75% $FeSO_4$. However, minimum number of branches plant^{-1} (6.7) was recorded in Z_0F_0(control). Similar findings were reported by Ali *et al*. (2013) in tomato and Kumar *et al*. (2019) in tomato.

Leaf area (cm)^2

The data in respect of leaf area at 50% flowering stage in summer okra at 45, 60 and 75 days after sowing as influenced by zinc and iron on leaf area was presented in Table 4

Effect of zinc

Significantly, maximum leaf area (193.75 cm^2) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by treatment Z_3 (182.78 cm^2) i.e. 0.75% $ZnSO_4$. Z_0 and Z_1 were at par with each other. Z_1 and Z_3 were at par with each other. However, significantly minimum leaf area (169.24 cm^2) was recorded in control at 30 days after sowing. Significantly, maximum leaf area (240.02 cm^2) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by treatment Z_3 (231.67 cm2) i.e. 0.75% $ZnSO_4$. Z_0, Z_1 and Z_3 were at par with each other. However, significantly minimum leaf area (227.26 cm^2) was recorded in control at 60 days after sowing. Similarly at 90 days after sowing, significantly maximum leaf area (337.22 cm^2) was recorded in Z_2 (0.50% $ZnSO_4$) which was followed by Z_3 (331.85) i.e. 0.75% $ZnSO_4$). Z_0, Z_1 and Z_3 were at par with each other. Significantly minimum leaf area (328.62 cm^2) was recorded in control (water spray). Similar observations were also recorded by, Ali *et al*. (2015) [1] in tomato and Sharma *et al*. (2017) [5] in okra

Table 4: Leaf area

Treatments	Leaf area (cm^2)		
	Days after sowing		
A) Zinc (Z)	**45 Days**	**60 Days**	**75 Days**
Z_0- Control (water spray)	169.24	227.26	328.62
Z_1- 0.25% $ZnSO_4$	177.62	230.89	330.65
Z_2- 0.50% $ZnSO_4$	193.75	240.02	337.22
Z_3- 0.75% $ZnSO_4$	182.78	231.67	331.85
F test	Sig.	Sig.	Sig.
SE (m) ±	3.13	1.91	1.52
CD at 5%	9.05	5.52	4.39
B) Iron (F)			
F_0 - Control (water spray)	172.93	227.01	327.11
F_1 - 0.25% $FeSO_4$	177.62	230.89	331.53
F_2 - 0.50% $FeSO_4$	191.08	239.56	335.61
F_3 - 0.75% $FeSO_4$	181.76	232.40	334.08
F test	Sig.	Sig.	Sig.
SE (m) ±	3.13	1.91	1.52
CD at 5%	9.05	5.52	4.39
C) Interaction effect (ZxF)			
F test	N.S.	N.S	N.S
SE (m) ±	7.68	4.68	3.72
CD at 5%	-	-	-

Effect of iron

Significantly, maximum leaf area (191.08 cm^2) was recorded in F_2 (0.50% $FeSO_4$) which was followed by treatment F_3 (181.76 cm^2) i.e. 0.75% $FeSO_4$. However, significantly minimum leaf area (172.93 cm^2) was recorded in control at 30 days after sowing. Significantly, maximum leaf area (239.56 cm^2) was recorded in F_2 (0.50% $FeSO_4$) which was followed by treatment F_3 (232.40 cm^2) i.e. 0.75% $FeSO_4$. However, significantly minimum leaf area (227.01 cm^2) was recorded in control at 60 days after sowing. Similarly at 90 days after sowing, significantly maximum leaf area (335.61 cm^2) was recorded in F_2 (0.50% $FeSO_4$) which was at par with F_3 (334.08) i.e. 0.75% $FeSO_4$. Significantly minimum leaf area (327.11 cm^2) was recorded in control (water spray). Similar observations were also recorded by, Ali *et al*. (2015) [] in tomato and Sharma *et al*. (2017) [5] in okra.

Interaction effect

The data presented in Table revealed that, interaction effect due to different levels of zinc and iron on leaf area of summer okra was found non significant at 50% flowering.

Conclusions

The growth parameters *viz*., plant height, diameter of stem, number of branches plant^{-1} and leaf area were recorded significantly maximum with individual application of Z_2 - 0.50% $ZnSO_4$ and F_2 - 0.50% Fe The interaction effect of zinc and iron for the growth parameters were found non significant. The significantly maximum number of branches plant^{-1} was observed in treatment combination of Z_2F_2 - 0.50% $ZnSO_4$ and 0.50% $FeSO_4$.

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