Eco. Env. & Cons. 30 (4) : 2024; pp. (1685-1690)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i04.038

Effect of Soil and Foliar Applied Zinc and Iron Fertilization on different Growth attributes of Bread Wheat (*Triticum aestivum* L.) Cropin Typic Haplustepts

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(Received 2 June, 2024; Accepted 20 July, 2024)

ABSTRACT

A two years investigation conducted at Instructional Farm, RCA, MPUAT, Udaipur during *Rabi* 2022-23 and 2023-24 to evaluate the impact of different methods of zinc and iron through soil and foliar application on growth attributes of bread wheat (*Triticum aestivum* L). The soil of experimental site was slightly alkaline in soil reaction (8.24 and 8.25) and clay loam in texture. The experiment was laid out under FRBD with three replications. The experiment comprised of 5 levels of soil applied Zn and Fe, S_1 (10 kg $ZnSO_4$ ha^{-1}) S_2 (20 kg $ZnSO_4$ ha^{-1}), S_3(25 kg $FeSO_4$ ha^{-1}), S_4(50 kg $FeSO_4$ ha^{-1}) S_5(10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}) and three levels of foliar applied zinc and iron namely F_1 (0.5% $ZnSO_4$ ha^{-1}), F_2 (0.5% $FeSO_4$ ha^{-1}) F_3 (0.5% $ZnSO_4$ ha^{-1} + 0.5% $FeSO_4$ ha^{-1}) at two different growth stages (30 DAS and 45 DAS) along with one absolute control. The result showed that soil application and foliar application of zinc and iron increased the growth parameters of crop significantly. The result showed that among control verses rest treatments, combined soil applied zinc and iron @10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1} (S_5) recorded highest dry matter accumulation (g) at 90 DAS and at harvest, plant height (cm and number of total tillers (0.5 m^2) at harvest in crop over control.

Key words: *Micronutrients, DTPA, Alkaline, Foliar application, Soil application.*

Introduction

Cereals are the important group of field crops belongs to family Poaceae. Cereals are rich source of minerals, vitamins, proteins and energy.Cereal crops which is widely used as a staple food for large proportion world population (Palmgren *et al*., 2008). In world around 50% of agricultural soils are deficient in available zinc for cereal productivity (Cakmak, 2008). Intensive cultivation with high yielding varieties along with continue application of NPK, fertilizers increased the grain production but emerged the issue of micronutrients deficiency especially zinc and iron in soils (Kumar *et al*., 2021). They are required in smaller quantities by crop plants but they affect the grain yield on larger scale. Iron plays a crucial role in crop production and it is essential for plant growth and development (Porkodi *et al*., 2023). In our country, about 11.2% cultivable soils are most deficient in iron (Singh, 1999; Porkodi *et al*., 2023) and about 43% soils are most deficient in available zinc (Shukla *et al*., 2014).

Bread wheat (*Triticum aestivum* L.) belongs to family of Poaceae. On global basis, It is most extensively cultivated cereal crop on larger scale from temperate to humid and from warm to dry climatic conditions under both irrigated and under rainfed conditions due to its wider adaptability towards agro climatic zones and a wider range of soils (Kumar *et al*., 2021).

Among all required micronutrients both Zn and Fe are crucial for metabolism in plant and animals. Zinc plays a vital role in the synthesis of auxin and formation of starch. It also enhances the uptake of essential elements in plant body through increased cation exchange capacity of roots and synthesis of IAA which directly contributes to vegetative growth of crop. It also plays a vital role in cellular growth, photo synthate translocation and metabolic activities which favours vigorous growth and extensive root system leading to growth attributes. Iron plays an important role in breakdown of nucleic acid and carbohydrates intonitrate and ammonium in plant cells (Havlin *et al.*, 2014). In plant system, Iron is necessary for respiratory enzymes and directly involved in various metabolic activities (Porkodi *et al*., 2023).

Materials and Methods

This two years study was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Raj.) during *Rabi*2022-23 and 2023-24. The experimental farm situated at 24° 35′ North latitude and 72° 42 East longitude with an altitude of 579.5 m above the mean sea level in the Sub-humid Southern Plain and Aravalli Hills Region of Rajasthan (IVth A agro-climatic Zone). The climate of this region is sub-tropical with mild winter and higher humidity level during summer. The annual rainfall of this region is 580.-630 mm annually. The soil of experimental site was slightly alkaline and clay loam in texture. The soil was medium in available nitrogen (255.60to 258.40 kg ha^{-1}) and available phosphorous (16.40to 16.80 kg ha^{-1}), high in available potassium (452.25 to 455.60 kg ha^{-1}), DTPA extractable zinc (2.10 to 2.25 mg kg^{-1}) and iron (2.40 to 2.60 mg kg^{-1}). The source of zinc and iron fertilization was zinc sulphate and iron sulphate. The experiment was laid out under FRBD design with three replications. The experiment comprised of five levels of soil applied zinc and iron namely S_1 (10 kg $ZnSO_4$ ha^{-1}) S_2 (20 kg $ZnSO_4$ ha^{-1}), S_3 (25 kg $FeSO_4$ ha^{-1}), S_4(50 kg $FeSO_4$ ha^{-1}) S_5(10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}) and three levels of foliar applied zinc and iron namely F_1 (0.5% $ZnSO_4$ ha^{-1}), F_2 (0.5% $FeSO_4$ ha^{-1}) F_3 (0.5% $ZnSO_4$ ha^{-1} + 0.5% $FeSO_4$ ha^{-1}) at two different growth stages (30 DAS & 45 DAS) along with one absolute control. The dry matter accumulation (g) by each plant at 30, 60, 90 DAS and at harvest with randomly 5 plants from each plot and after proper drying weighed and calculate the average dry matter accumulation by individual plant.The gathered data were then classified, tabulated, and statistically analysed at 5% level of significance standard procedure described by Panse and Sukhatme (1985).

Results

Results pertaining the effect of different levels of zinc and iron fertilization alone or in their combinations on growth and yield attributing characters are presented under following headings and sub-heading.

Growth and yield attributing characters

Data pertaining to the effect of soil application and foliar application and their combinations on plant height, dry matter accumulation at 90 DAS and at harvest, number of total tillers in 0.5 meter row length are presented in the Tables 1, 2 &3.

Growth attributes

Dry matter accumulation (g/ plant)

The data depicted in Table 1 shows that during both the years as well as in pooled mean, dry matter accumulation at different growth stages of wheat crop was significantly increased with combined application of zinc and iron through both soil and foliar application.

Dry matter accumulation (g/plant) at 90 DAS

Control verses rest treatments

The data (Table 1) pertain that among control verses rest treatments, during both the years as well as in pooled mean, the dry matter accumulation at 90 DAS of wheat crop was increased with combined application of zinc and iron through soil and foliar application, which is found highly significant. During both the years as well as pooled mean, the dry matter accumulation at 90 DAS increased with 31.83%, 30.32% & 31.08% , respectively, over control.

Effect of soil application of zinc and iron

The data (Table 1) pertain that during both the years and in pooled mean, dry matter accumulation at 90 DAS is increased by soil application of both zinc and iron. The maximum dry matter accumulation of wheat crop (16.86, 16.99 &16.92 g) was recorded in treatment S_5(10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}), which is found statistically significant and at par with treatment S_2 (20 kg $ZnSO_4$ ha^{-1}) with a dry matter accumulation of 16.06, 61.36 &16.21 g, respectively.

Effect of foliar application of zinc and iron

It is also evident from data (Table 1) that foliar application of zinc and iron increased the dry matter accumulation at 90 DAS. During both the years as well as pooled mean treatment F_3(0.5 % $ZnSO_4$ ha^{-1}+ 0.5 % $FeSO_4$ ha^{-1}) recorded highest dry matter accumulation (16.61, 16.51 &16.56 g) at 90 DAS, which is found statistically non-significant.

Control verses rest treatments

The data (Table 1) pertain that among control verses rest treatments, during both the years and in pooled mean, the dry matter accumulation at harvesting time of crop was increased highly significantly with application of zinc and iron through soil and foliar application. During both the years as well as pooled mean, the dry matter accumulation at harvesting time increased with 18.84, 17.22 & 18.28%, respectively, over control.

Effect of soil application of zinc and iron

The data (Table 1) pertain that during both the years as well as in pooled mean, dry matter accumulation at harvesting time is increased by soil application of both zinc and iron. The maximum dry matter accumulation of wheat crop (34.01, 33.89 & 33.95g) was recorded in treatment S_5 (10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}), which is found statistically significant and at par with treatment S_2 (20 kg $ZnSO_4$ ha^{-1}) with a dry matter accumulation of 30.96, 30.95 & 30.97 g, respectively.

Effect of foliar application of zinc and iron

It is also evident from data (Table 1) that foliar application of zinc and iron increased the dry matter accumulation at harvesting time. During both the years as well as pooled mean treatment F_3(0.5 % $ZnSO_4$ ha^{-1}+ 0.5 % $FeSO_4$ ha^{-1}) recorded highest dry matter accumulation (31.16 g, 31.20 g and 31.18 g) at 90 DAS, which is found statistically non-significant.

Table 1. Effect of soil and foliar application of zinc and iron on dry matter accumulation (g) at 90 DAS and at harvest in bread wheat crop

Treatments	Dry matter accumulation (g) at 90 DAS			Dry matter accumulation (g) at harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Control V/S Rest						
Control	12.00	12.27	12.13	25.47	25.73	25.60
Rest	15.82	15.99	15.90	30.28	30.29	30.28
F test	**	**	**	**	**	**
Soil Application						
10 kg $ZnSO_4$	15.17	15.42	15.30	28.62	28.52	28.57
20 kg $ZnSO_4$	16.06	16.36	16.21	30.96	30.98	30.97
25 kg $FeSO_4$	15.35	15.29	15.32	28.18	28.09	28.14
50 kg $FeSO_4$	15.66	15.87	15.76	29.64	29.96	29.80
10 kg $ZnSO_4$+25 kg $FeSO_4$	16.86	16.99	16.92	34.01	33.89	33.95
SEm±	0.328	0.353	0.241	0.620	0.650	0.449
C.D. at 0.05	0.948	1.019	0.682	1.792	1.878	1.271
Foliar application						
0.5% $ZnSO_4$	15.66	15.95	15.81	30.31	30.34	30.32
0.5% $FeSO_4$	15.19	15.49	15.34	29.38	29.32	29.35
0.5% $ZnSO_4$+ 0.5% $FeSO_4$	16.61	16.51	16.56	31.16	31.20	31.18
SEm±	0.254	0.273	0.187	0.480	0.504	0.348
C.D. at 0.05	0.734	0.789	0.528	1.388	1.455	0.985
Interaction	NS	NS	NS	NS	NS	NS

NS= Non-significant

Dry matter accumulation (g/ plant) at harvest

Plant height at harvest (cm)

Control verses rest treatments

The data (Table 2) pertain that among control verses rest treatments, during both the years, the plant height of wheat crop at harvesting was significantly increased but in pooled mean the plant eight was increased highly significantly by combined application of zinc and iron through soil and foliar application by 7.22%, 6.96% & 7.08%, respectively, over control.

Effect of soil application of zinc and iron

The data (Table 2) pertain that during both the years as well as in pooled mean, plant height at harvesting time is increased by soil application of both zinc and iron. The maximum plant height of wheat crop (98.86 cm, 99.79 cm and 99.33 cm) was recorded in treatment S_5 (10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}), which is found statistically significant and at par with treatment S_2 (20 kg $ZnSO_4$ ha^{-1}) with a plant height of 98.73, 99.12 and 99.83 cm, respectively.

Effect of foliar application of zinc and iron

It is also evident from data (Table 2) that foliar application of zinc and iron increased the plant height at harvesting time. During both the years as well as pooled mean treatment F_3(0.5 % $ZnSO_4$ ha^{-1}+ 0.5 % $FeSO_4$ ha^{-1}) recorded highest plant height (98.92, 99.90 and 99.41 cm), which is found statistically non-significant.

Number of total tillers at harvest (cm)

Control verses rest of the treatments

The data pertain (Table 2) that among control verses rest treatments, during both the years, the number of total tillers in 0.5 m^2 length of wheat crop at crop maturity was significantly affected but in pooled mean, it was affected highly significantly by combined application of zinc and iron by 14.03%, 13.87% & 13.96%, respectively.

Effect of soil application of zinc and iron

The data (Table 2) pertain that the number of total tillers in 0.5 m^2 length at crop maturity was significantly increased by soil application of zinc and iron. The maximum number of total tillers in 0.5 m^2 length (47.21, 47.87 and 47.54) was recorded in treatment S_5 (10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}) which is found statistically at par with treatment S_2 (20 kg$ZnSO_4$ ha^{-1}) with a mean of 46.78, 47.08 and 46.93 tillers in 0.5 m^2 length, respectively.

Table 2. Effect of soil and foliar application of zinc and iron on plant height (cm) and number of total tillers (0.5 m^2) in bread wheat crop

Treatments	Total tillers (0.5 m^2)			Plant height (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Control V/S Rest						
Control	39.77	40.30	40.03	89.33	89.92	89.63
Rest	45.35	45.89	45.62	95.78	96.18	95.98
F test	**	**	**	*	*	**
Soil Application						
10 kg $ZnSO_4$	43.91	44.40	44.15	93.96	93.93	93.96
20 kg $ZnSO_4$	46.78	47.08	46.93	99.12	98.93	99.12
25 kg $FeSO_4$	43.81	44.66	44.23	93.96	93.78	93.96
50 kg $FeSO_4$	45.03	45.43	45.23	94.07	93.96	94.07
10 kg $ZnSO_4$+25 kg $FeSO_4$	47.21	47.87	47.54	99.79	99.33	99.79
SEm±	0.697	0.699	0.494	1.628	1.164	1.628
C.D. at 0.05	2.013	2.020	1.397	4.702	3.292	4.702
Foliar application						
0.5% $ZnSO_4$	45.04	45.56	45.30	94.59	94.53	94.59
0.5% $FeSO_4$	44.56	45.07	44.81	94.06	94.01	94.06
0.5% $ZnSO_4$+ 0.5% $FeSO_4$	46.45	47.04	46.74	99.90	99.41	99.90
SEm±	0.540	0.542	0.382	1.261	0.902	1.261
C.D. at 0.05	1.559	1.565	1.082	3.642	2.550	3.642
Interaction	NS	NS	NS	NS	NS	NS

NS=Non-significant

Effect of foliar application of zinc and iron

It is also evident from data (Table 2) that foliar application of zinc and iron increased the number of total tillers in 0.5 m^2 length at crop maturity. During both the years as well as pooled mean treatment F_3(0.5 % $ZnSO_4$ ha^{-1}+ 0.5 % $FeSO_4$ ha^{-1}) recorded the highest number of total tillers in 0.5 m^2 length (46.45, 47.04 and 46.74) at harvesting time with which is found statistically non-significant.

Discussion

Effect of soil and foliar application of zinc and iron

Growth attributes

The findings of the present investigation evident in the previous chapter (Table 1 & 2) showed that the significant improvement in the dry matter accumulation at 90 DAS and at harvest, plant height at harvest and number of total tillers in 0.5 m^2crop length were recorded with different levels of soil applied and foliar applied zinc sulphate and iron sulphate. During both the years and on pooled mean study, the highest dry matter accumulation (90 DAS and at harvest), plant height at harvest and number of total tillers in 0.5m^2 length were recorded with the basal application of 10 kg $ZnSO_4$ + 25 kg $FeSO_4$ ha^{-1}. The dry matter accumulation (90 DAS and at harvest), plant height at harvest and number of total tillers in half meter length were increased by 31.08%, 18.28%, 7.08% and 13.96% on pooled basis due to basal application of 10 kg $ZnSO_4$ + 25 kg $FeSO_4$ ha^{-1} over control. The increase in the crop growth attributes due to soil application of zinc sulphate associated with increased availability of zinc to plant for their metabolic activities through soil solution which cause stimulatory effect on crop growth. The increase in growth attributes might be due to enhanced availability of zinc and iron to crop which improved chlorophyll formation and subsequent favours translocation of phostysnthate which results into vigorous growth and extensive root system leading to growth attributes (Wear and Hagler, 1968 and Kuldeep *et al*., 2018). This results is also in lined with Firdous *et al.* (2018) and Meena *et al*. (2021).

Summary

Effect of soil and foliar application of zinc and iron

Basal application of 10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1} significantly increased the dry matter accumulation at 90 DAS and at harvest, plant height at harvest and number of total tillers in half meter crop row length at harvest over control and other treatments during both the experimental years and in pooled data mean.

Foliar application of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$30 recorded maximum dry matter accumulation at 90 DAS and at harvest, plant height at harvest and number of total tillers in half meter crop row length over control and other treatments during both the experimental years and in pooled data mean.

Conclusion

Among control verse rest the treatments, the maximum level of zinc and iron in wheat grain and straw was recorded with basal application of 10 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}. In case of foliar application the maximum zinc and iron content in both grain and straw recorded with a foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at two growth stages (30 DAS and 45 DAS). So both the soil and foliar applied zinc and iron fertilization in slightly alkaline soil significantly improve the growth attributes in bread wheat crop.

Conflict of Interest- None

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