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Response of iron and zinc on nutrition quality of wheat (*Triticum aestivum* L.)

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Abstract
An experiment was conducted during *rabi* season of 2019-20 on "Response of Iron and Zinc on nutrition quality of Wheat (*Triticum aestivum* L.)" at Research Farm of Vivekananda Global University, Jaipur, Rajasthan. Results showed that the nutrient contents in grain and straw of wheat was significantly increased due to application of different treatment combinations of zinc and iron. The maximum nitrogen content in grain and straw was obtained with RDF + $ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 50 kg/ha (Soil application) at RDF + foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% at tillering stage (40-45 DAS). Similarly maximum phosphors content in grain and straw was obtained with absolute control (No fertilizer + no spray), RDF (120 kg N/ha, 30 kg $P2O_5$/ha, 40 kg K_2O/ha) and RDF + Water Spray. The maximum zinc content in grain and straw was obtained RDF + $ZnSO_4$ @ 25 kg/ha (Soil application), RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (40-45 DAS) RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS). The maximum zinc content in grain and straw was obtained with RDF + $FeSO_4$ @ 50 kg/ha (Soil application), RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (40-45 DAS) and RDF + $FeSO_4$ @ 50 kg/ha (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS). The different treatment combinations were responsible for maximum nutrients content in grain as well as straw; however treatment combination showed the maximum nutrient contents in grain also showed maximum in straw.

Keywords: Treatment, straw, wheat

Introduction
The wheat, not only in terms of area cultivated, but also due to its adaptability to a variety of agro-climatic conditions and crop-growing situations, is one of India's most significant crops. The largest cereal crop in the world, wheat is grown on an area of about 220.76 million hectares and yields 770.88 million tonnes of grain at a productivity of 3492 kg/ha (FAOSTAT, 2021) [5]. In terms of area and production, India comes in second and first, respectively. India produces 14.20% of the world's wheat and occupies 14.31% of the global land area. With a yield of 109.52 million tonnes, wheat is grown on 31.61 million hectares in India (Anonymous, 2021) [1]. In Florida in the 1920s, micronutrients were initially identified as a limiting factor in crop yield in the United States. Crop productivity is greatly increased by micronutrients. Micronutrient shortage was caused by the intensification of agriculture using high yielding varieties, ongoing use of high analysis fertilisers, limited availability of organic manures, and minimal crop residue return to the soil. Overall micronutrient deficiencies in Indian soil were discovered to be 47% for Zn, 13% for Fe, 4% for Mn, and 2% for Cu (Sakal and Singh, 2001) [16].

In the plant system, zinc is important for a number of enzymatic and physiological processes. In addition to being a key nutrient for the synthesis of several enzymes, including alcohol dehydrogenase, carbonic anhydrase, and superoxide dismutase, zinc is also essential for the growth of plants (Pedler *et al*., 2000) [14]. The formation of ribosomes depends on zinc, which is their primary component. Tryptophan synthesis, which is a need for the creation of auxin, depends on zinc. Foliar application of nutrients is an important crop management strategy to maximize crop yields and concentrations of micronutrients in edible parts. Several studies have demonstrated that foliar application of micronutrients including Zn and Fe showed good behavior in increasing their concentration in wheat grain. However, little information is available on the combined effect of Zn and Fe on wheat grain quality. Hence, it is essential to assess the foliar application of Zn and Fe at different growth stages of wheat on crop growth, grain yield and grain quality.

Material and Methods

An experiment was conducted to determine of soil and foliar application of iron and zinc on wheat quality at Research Farm of Vivekananda Global University, Jaipur during *Rabi* season of 2019-20. This region falls under agro-climatic zone III A of Rajasthan (Semi-arid Eastern Plain Zone). The experiment was laid out in randomized block design (RBD) with three replications, assigning eleven combinations of micronutrients. Soils of the area have 0.73 ppm Fe and 5.39 ppm Zinc. The seeds of wheat variety Raj-4120 were sown on 15th November, 2019. The sowing was done at row spacing of 20 cm using a seed rate of 100 kg ha- 1 by "Kera" method with the help of desi plough. The seeds were dropped manually in furrow opened by plough at a depth of 4-5 cm. The soil samples were collected from 0-15 cm depth of soil profile with the help of screw auger before sowing wheat (Table 2). It was air dried in shade, grinded and analyzed for determination of physical and chemical properties of soil. Soils are loamy sand with 0.22% organic carbon, 136.84 kg/ha N, 17.25 kg/ha P_2O_5 and 241.69 kg/ha K_2O. The total rainfall received during the crop season was 46.2 mm. On the basis of gross plot size (5.0 m x 3.0 m = 15 m^2) the quantity of fertilizer required as per treatment was calculated and weighed for different plots. The recommended dose of N, P_2O_5 and K_2O was applied to all plots as basal in the form of urea, DAP and MOP, respectively. The required micronutrients were weighted and dissolved in water @ 500 liters/ha. The solution was neutralized with 0.5% calcium oxide. The micronutrients $ZnSO_4$ @ 0.5% and $FeSO_4$ @ 0.5% were sprayed as per treatments at tillering stages. The statistical analysis was done according to Fisher, 1950.

Table 1: Treatments details with their symbols

S. No.	Treatments	Symbol
1.	Absolute Control (No fertilizer + no spray	T1
2.	RDF (120 kg N ha^{-1}, 30 kg P2O5 ha^{-1}, 40 kg K2O ha^{-1})	T2
3.	RDF + Water Spray	T3
4.	RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	T4
5.	RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (40-45 DAS)	T5
6.	RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T6
7.	RDF + $FeSO_4$ @ 50 kg ha^{-1} (Soil application)	T7
8.	RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (40-45 DAS)	T8
9.	RDF + $FeSO_4$ @ 50 kg ha^{-1} (soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T9
10.	RDF + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (soil application)	T10
11.	RDF + foliar application of $ZnSO_4$ and $FeSO_4$ @ 0.5% at tillering stage (40-45 DAS)	T11

Table 2: Initial Physico-chemical characteristics of the experimental soil

Soil properties	Value (0-15 cm)	Methods of analysis with reference
A. Mechanical Composition		
Sand (%)	85.5	
Silt (%)	9.5	
Clay (%)	5	
Texture	Loamy sand	Triangular method (Brady, 1983) [2]
B. Physical properties		
Bulk density (Mg m-3)	1.59	Method No. 38, USDA Hand Book No. 60 (Richards, 1972) [15]
Particle density (Mg m-3)	2.63	Method No. 39, USDA Hand Book No. 60 (Richards, 1972) [15]
Porosity (%)	39.55	Method No. 40, USDA Handbook No. 60 (Richards, 1972) [15]
C. Chemical properties		
Organic carbon (%)	0.21	Walkley and Black"s rapid titration method (Walkley and Black, 1934) [19]
Available N (kg ha^{-1})	149.66	Alkaline KMnO4 method (Subbiah and Asija, 1956) [18]
Available P2O5 (kg ha^{-1})	21.21	Olsen"s method (Olsen *et al.*, 1954) [13]
Available K2O (kg ha^{-1})	257.76	Flame photometric Method (Jackson, 1973) [8]
Available Zn (ppm)	0.71	Diethylene Triamine Pentaacetic Acid (DTPA) method developed by Lindsay and Norvell (1978) [12]
Available Fe (ppm)	5.39	
EC (dsm-1) (1:2 soil water suspension at 250C	0.33	Method No. 4 USDA Handbook No.60 (Richards, 1972) [15]
Soil pH (1:2 soil water suspension at 250C)	8.18	Method No. 21 b, USDA Handbook No. 60 (Richards, 1972) [15]

Results and discussion

The significantly highest nitrogen content in grain and straw of wheat was obtained with application of RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T10) which was significantly higher as compared to Control (T1), RDF (T2), RDF + Water Spray (T3), RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (T5), RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application (T7), RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (T8) and RDF+ $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9) (Table 3). The application of RDF (T2) was recorded significantly higher phosphorus content in grain and straw of wheat over RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} (T4), RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (T5), RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ (0.5%) at tillering stage (T6), RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application (T7), RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (T8), RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9), RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T10) and RDF + $ZnSO_4$ + $FeSO_4$ @ 0.5% foliar application at tillering stage (T11). The significantly highest zinc content in grain and straw of wheat was obtained with application of RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ (0.5%) at tillering stage (T6) which was significantly higher as compared to Control (T1), RDF (T2), RDF + Water Spray (T3), RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application (T7), RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (T8), RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9), RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (T10) and RDF + $ZnSO_4$ + $FeSO_4$ @ 0.5% foliar application at tillering stage (T11) and remained at par with RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} (T4) and RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage. The application of RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9) was recorded significantly highest iron content in grain and straw of wheat as compared to treatment T1, T2, T3, T4, T5, T6, T10 and T11 but remained at par with RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application (T7) and RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (T8).

The maximum nitrogen content and uptake by grain and straw, phosphorus and iron uptake by grain and straw, protein content in grain and protein yield of wheat was obtained with RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1}+ $FeSO_4$ @ 50 kg ha^{-1} (T10). Application of RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ (0.5%) at tillering stage (T6) gave highest zinc content and uptake by grain and straw. The application of RDF (T2) was recorded significantly highest phosphorus content in grain and straw of wheat. The application of RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9) was recorded significantly highest iron content in grain and straw of wheat (Table 4). Increase in nutrient content in plant ascribed to the beneficial role of nutrients in soil through added fertilizers in addition of its own nutrient content which enhanced the available nutrient pool of the soil. The favourable conditions for microbial as well as chemical activities due to addition of fertilizers application in combination with micronutrient increase the mineralization of nutrients and ultimately the available nutrient pool of the soil led to higher content of nutrients in grain and straw.

The significant response of wheat to micro-nutrients is due to low availability of these nutrients in experimental soil. The plant absorbed greater zinc and iron through well-developed root system which ultimately increased the content and uptake of nutrients in grain and straw. The beneficial role of zinc and iron in increasing the cation exchange capacity of roots helped in increased absorption of nutrients from the soil. The uptake of nutrient under present study is the function of crop yield and its content in grain and straw. The higher nutrient content with increased grain and straw yields probably led to the more uptake of nitrogen by the wheat crop. Significant increase in nutrient content and uptake under the present study due to effect of micronutrient are in close agreement with the findings of Kumar and Babel (2011) [11], Jat *et al*. (2013) [9], Yadav *et al*. (2014) [20], Singh *et al*. (2015) [17], Kumar *et al*. (2018) [10] and Goyal *et al*. (2018) [7] in wheat crop. The reduction in the content of phosphorus due to application of zinc and iron may be due to the antagonistic reaction between zinc and iron with phosphorus. The increased concentration of zinc created hindrance in absorption and translocation of phosphorus from the roots to the above ground parts. Their interaction in soil may also be partially responsible for this. The findings of this investigation are in conformity with those of Dwivedi *et al*. (2002) [4], Dewal and Pareek (2004) [3].

Table 3: Effect of iron and zinc on nitrogen and phosphorus content in seed and straw of wheat

Treatments	Symbol	Nitrogen content (%)		Phosphorus content (%)	
		Grain	Straw	Grain	Straw
Absolute Control (No fertilizer + no spray)	T1	1.20	0.502	0.478	0.249
RDF (120 kg N ha^{-1}, 30 kg P2O5 ha^{-1}, 40 kg K2O ha^{-1})	T2	1.33	0.566	0.483	0.254
RDF + Water Spray	T3	1.36	0.575	0.482	0.252
RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	T4	1.64	0.725	0.374	0.197
RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (40-45 DAS)	T5	1.50	0.656	0.421	0.219
RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T6	1.66	0.732	0.371	0.196
RDF + $FeSO_4$ @ 50 kg ha^{-1} (Soil application)	T7	1.49	0.645	0.423	0.221
RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (40-45 DAS)	T8	1.47	0.640	0.432	0.226
RDF + $FeSO_4$ @ 50 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T9	1.52	0.662	0.415	0.217
RDF + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (Soil application)	T10	1.68	0.746	0.368	0.195
RDF + foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% at tillering stage (40-45 DAS)	T11	1.67	0.742	0.370	0.195
SEM+		0.03	0.01	0.008	0.004
CD (P = 0.05)		0.09	0.04	0.024	0.010

Table 4: Effect of iron and zinc on zinc and iron content in seed and straw of wheat

Treatments	Symbol	Zinc content (ppm)		Iron content (ppm)	
		Grain	Straw	Grain	Straw
Absolute Control (No fertilizer + no spray)	T1	23.47	17.83	39.91	65.50
RDF (120 kg N ha^{-1}, 30 kg P2O5 ha^{-1}, 40 kg K2O ha^{-1})	T2	23.65	17.94	40.08	65.97
RDF + Water Spray	T3	23.82	18.12	40.38	66.32
RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	T4	26.43	20.36	37.19	60.83
RDF + $ZnSO_4$ @ 0.5% foliar application at tillering stage (40-45 DAS)	T5	26.14	20.07	36.82	60.53
RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T6	26.72	20.59	36.26	60.07
RDF + $FeSO_4$ @ 50 kg ha^{-1} (Soil application)	T7	21.65	16.18	44.02	72.20
RDF + $FeSO_4$ @ 0.5% Foliar application at tillering stage (40-45 DAS)	T8	21.47	16.02	43.69	71.87
RDF + $FeSO_4$ @ 50 kg ha^{-1} (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T9	21.11	15.76	44.38	72.59
RDF + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 50 kg ha^{-1} (Soil application)	T10	24.30	18.50	40.98	66.91
RDF + foliar application of $ZnSO_4$ + $FeSO_4$ @ 0.5% at tillering stage (40-45 DAS)	T11	24.06	18.28	40.67	66.59
SEM+		0.55	0.42	0.87	1.38
CD (P = 0.05)		1.62	1.24	2.57	4.08

Conclusion
The application of RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} + foliar application of $ZnSO_4$ (0.5%) at tillering stage (T6) gave highest zinc content in grain which was 13.01% higher in the comparison of RDF (T2) treatment. Application of RDF + $FeSO_4$ @ 50 kg ha^{-1} soil application + 0.5% foliar application at tillering stage (T9) gave highest iron content in grain which was 10.72% higher in the comparison of RDF (T2) treatment. Therefore, obtaining the highest zinc and iron content in grain, application of zinc and iron was found profitable.

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