



## Response of Iron and Zinc on Yield Attributes, Yield and Economics of Wheat (*Triticum aestivum* L.)

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### **Authors' contributions**

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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### **ABSTRACT**

A field study was conducted during *Rabi* season of 2019-20 on "Response of Iron and Zinc on Yield Attributes, Yield and Economics of Wheat (*Triticum aestivum* L.)" at Research Farm of Vivekananda Global University, Jaipur. The treatments comprised different combinations of recommended dose of fertilizer and micronutrients. Results showed that the yield attributes and yield net returns and benefit cost ratio of wheat was significantly increased due to application of different treatment combinations of zinc and iron. The maximum number of effective tillers m<sup>-2</sup>, grains spike<sup>-1</sup>, spike length, grain yield (4887 kg ha<sup>-1</sup>), straw yield (6718 kg ha<sup>-1</sup>) and biological yield (11606 kg ha<sup>-1</sup>) of wheat was obtained with RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> (T<sub>10</sub>). Application of RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + foliar application of ZnSO<sub>4</sub> (0.5%) at tillering stage (T<sub>6</sub>) gave highest net returns (₹65168 ha<sup>-1</sup>) and B: C ratio (2.83).

*Keywords:* Economics, iron; wheat; yield; zinc.

## 1. INTRODUCTION

India ranks first in area and second in production of wheat in the world. India accounts about 12 per cent of the total wheat production of the world. In India, wheat is cultivated in 29.14 million hectares area with production of 102.19 million tons [1]. The average wheat yield is only 3507 kg per hectare in India which is much lower than most of wheat growing countries of the world. In India, Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Bihar, Haryana, Maharashtra and Gujarat are major wheat growing states. Rajasthan accounts for 7.49 per cent of total production and 7.24 per cent of area under wheat in India. Major prouder districts in Rajasthan are Ganganagar, Hanumangarh, Bharatpur, Kota, Alwar, Jaipur, Chittorgarh, Tonk, Sawai Madhopur, Udaipur and Pali. Average productivity of wheat in Rajasthan is low. For the optimal growth of crops, sufficient amount of nutrients should be available in the root zone of the crops. Those nutrients can partly be supplied by the soil and partly added through organic manures and fertilizers. Soils contain different amount of available nutrients depending on the parent material present in the soil and management history such as preceding crops, use of manure and fertilizers in the past and climatic conditions. Micronutrients play a vital role in enhancing crop productivity. Intensification of agriculture with high yielding varieties, continuous use of high analysis fertilizers, restricted supply of organic manures and negligible crop residue return to soil led to micronutrient deficiency. The overall deficiency of micronutrient in Indian soil was found to be 47 per cent for Zn, 13 per cent for Fe 4 per cent for Mn and 2 per cent for Cu. [2]. Zinc plays a significant role in various enzymatic and physiological activities in the plant system. Zinc is main nutrient in building part of some enzymes like alcohol dehydrogenase, carbonic anhydrous and superoxide dismutase and is needed for the plant enzymes formation in addition to many enzymatic reactions become active by zinc [3]. Iron is taken up as ferrous ions by plants. Its concentration in the range of 100-500 mg kg<sup>-1</sup> in mature leaf tissues is regarded sufficient for optimum crop production. Iron is necessary for the synthesis and maintenance of chlorophyll in plants and it is essential component of many enzymes viz., nitrogenase, catalase, peroxydase, aconitase and cofactor like ferredoxin, cytochromes etc. 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. Information of iron and zinc on wheat is meagre. Therefore an experiment on response of iron and zinc on yield attributes, yield and economics of wheat (*Triticum aestivum* L.) has been undertaken.

## 2. MATERIALS AND METHODS

The field experiment was conducted 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 with three replications, assigning eleven combinations of micronutrients viz. Control (T<sub>1</sub>), Recommended dose of fertilizer (T<sub>2</sub>), RDF + Water Spray (T<sub>3</sub>), RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> (T<sub>4</sub>), RDF + ZnSO<sub>4</sub> @ 0.5% foliar application at tillering stage (T<sub>5</sub>), RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + foliar application of ZnSO<sub>4</sub> (0.5%) at tillering stage (T<sub>6</sub>), RDF + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> soil application (T<sub>7</sub>), RDF + FeSO<sub>4</sub> @ 0.5 % Foliar application at tillering stage (T<sub>8</sub>), RDF + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> soil application + 0.5% foliar application at tillering stage (T<sub>9</sub>), RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> (T<sub>10</sub>) and RDF + foliar application of ZnSO<sub>4</sub> + FeSO<sub>4</sub> @ 0.5% at tillering stage (T<sub>11</sub>). Soils of the area have 0.73 ppm Fe and 5.39 ppm Zinc. The seeds of wheat variety Raj-4120 were sown on 15<sup>th</sup> November, 2019. The sowing was done at row spacing of 20 cm using a seed rate of 100 kg ha<sup>-1</sup> 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. 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<sup>-1</sup> N, 17.25 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> and 241.69 kg ha<sup>-1</sup> K<sub>2</sub>O. 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<sup>2</sup>) the quantity of fertilizer required as per treatment was calculated and weighed for different plots. The recommended dose of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O was applied in the form of urea, DAP and MOP to all plots as basal. The required micronutrients were weighted and dissolved in water @ 500 liters ha<sup>-1</sup>. 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. One hoeing and weeding was done manually at 30 day after sowing to facilitate aeration and removing the weeds. In all six post sowing irrigation were applied through sprinkler. All the plant protection measures were adopted to take healthy crop at maturity stage, after leaving two rows on each side as well as 60 cm along the width of each side, a net plot area was harvested separately for recording the yield. The gross and net realization in term of rupees per hectare was worked out separately for each treatment considering the seed and straw yields. Yield and yield attributes and economics were statistically analyzed as guidelines of Fisher [4].

### 3. RESULTS AND DISCUSSION

The application of RDF + soil application of  $ZnSO_4 @ 25 \text{ kg ha}^{-1} + FeSO_4 @ 50 \text{ kg ha}^{-1}$  ( $T_{10}$ ) significantly increased the number of effective tillers  $\text{m}^{-2}$ , number of grains  $\text{spike}^{-1}$  and spike length of wheat which remained at par with treatment  $T_4$  and  $T_6$  and significantly higher than other treatments (Table 1). The test weight of wheat did not influenced due to application of different treatments. The positive effect of macro and micronutrient on yield attributing characters of wheat seems to be due to cumulative effect on growth and vigour of plants. By virtue of increased supply of metabolites, there might have been significant improvement in dry matter production with increasing fertilizer application.

Increased growth components due to increased fertilizer levels might have provided stability in higher supply of photosynthates towards the sink ( $\text{grain spike}^{-1}$ ). The increased growth in terms of plant height and dry matter accumulation might also provide better sites for spike formation and grain development. As a result, almost all yield attributes of crop resulted into significant improvement due to fertilizer application. Results of present study are in close agreement with the findings of Dogra [5], Yadav et al. [6], Singh et al. [7], Arshad et al. [8], Goyal et al. [9] and Kumar et al. [10].

Among different treatment combinations, maximum grain yield ( $4887 \text{ kg ha}^{-1}$ ), straw yield ( $6718 \text{ kg ha}^{-1}$ ) and biological yield ( $11606 \text{ kg ha}^{-1}$ ) of wheat was recorded with application of RDF + soil application of  $ZnSO_4 @ 25 \text{ kg ha}^{-1} + FeSO_4 @ 50 \text{ kg ha}^{-1}$  ( $T_{10}$ ) which was closely followed by application of RDF + soil application of  $ZnSO_4 @ 25 \text{ kg ha}^{-1}$  ( $T_4$ ) and RDF + soil application of  $ZnSO_4 @ 25 \text{ kg ha}^{-1} + \text{foliar application of } ZnSO_4 (0.5\%)$  at tillering stage ( $T_6$ ) and significantly higher as compared to  $T_1, T_2, T_3, T_5, T_7, T_8, T_9$  and  $T_{11}$ . The Harvest index of wheat did not influenced due to application of different treatments. The increase in the yield due to zinc and iron application may be attributed to the fact that the initial status of available zinc and iron in the experimental soil was medium. Under such a situation an increase in the yield is quite natural. Further, increased seed yield is the manifestation of increase in yield attributes i.e. spike  $\text{plant}^{-1}$  and number of grain  $\text{spike}^{-1}$ . The significant

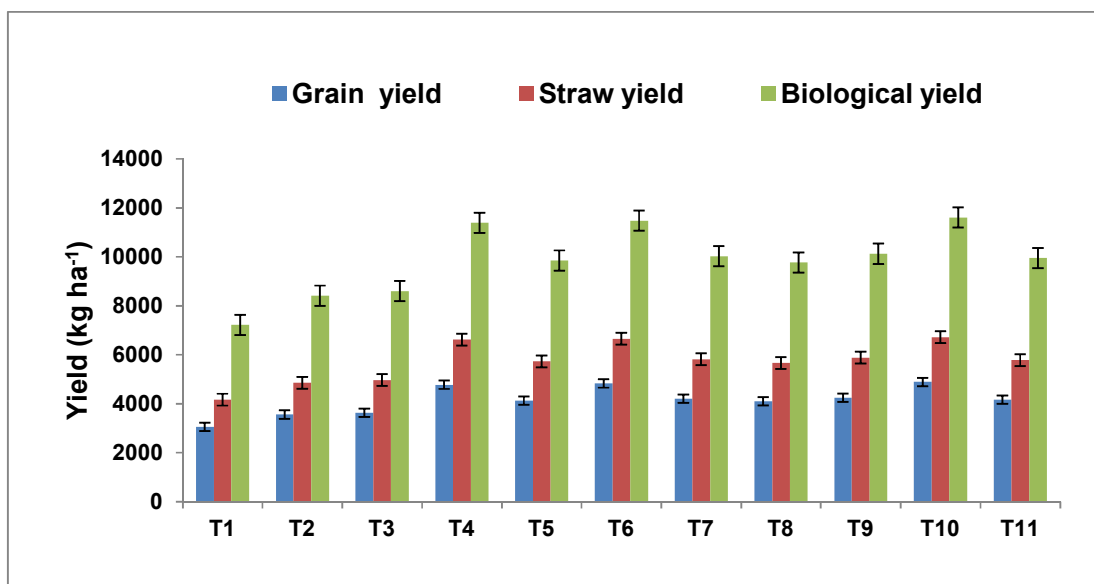


Fig. 1. Effect of iron and zinc on yield of wheat

Table 1. Effect of iron and zinc on yield attributes of wheat

Treatments	Yield attributes				Yields (kg ha <sup>-1</sup> )			Harvest index (%)
	Effective tillers ( m <sup>-2</sup> )	Grains spike <sup>-1</sup>	Spike length (cm)	Test weight (g)	Grain	Straw	Biological	
Absolute Control (No fertilizer + no spray)	229.9	25.03	5.11	36.10	3054	4165	7219	42.18
RDF (120 kg N ha <sup>-1</sup> , 30 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> , 40 kg K <sub>2</sub> O ha <sup>-1</sup> )	268.6	29.37	6.12	36.44	3558	4854	8412	42.31
RDF + Water Spray	271.1	30.27	6.24	36.68	3629	4972	8601	42.26
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> (Soil application)	367.4	40.81	8.64	38.02	4775	6611	11386	41.93
RDF + ZnSO <sub>4</sub> @ 0.5% foliar application at tillering stage (40-45 DAS)	315.4	35.21	7.34	37.24	4125	5724	9849	41.96
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	371.0	41.40	8.72	38.29	4827	6653	11480	42.04
RDF + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application)	320.8	35.80	7.60	37.01	4206	5818	10024	41.95
RDF + FeSO <sub>4</sub> @ 0.5 % Foliar application at tillering stage (40-45 DAS)	311.5	34.55	7.24	36.81	4101	5664	9765	42.00
RDF + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	322.8	36.11	7.69	37.67	4241	5883	10125	41.89
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application)	374.7	42.67	8.85	38.84	4887	6718	11606	42.09
RDF + foliar application of ZnSO <sub>4</sub> + FeSO <sub>4</sub> @ 0.5% at tillering stage (40-45 DAS)	318.2	35.54	7.45	38.56	4162	5784	9946	41.86
SEm+	12.08	1.28	0.29	1.51	182	255	428	0.47
CD (P = 0.05)	35.65	3.77	0.86	NS	536	752	1263	NS

**Table 2. Effect of iron and zinc on economics of wheat**

Treatments	Economics			
	Total cost (₹ ha <sup>-1</sup> )	Gross returns (₹ ha <sup>-1</sup> )	Net returns (₹ ha <sup>-1</sup> )	B: C ratio
Absolute Control (No fertilizer + no spray )	28600	63724	35124	2.23
RDF (120 kg N ha <sup>-1</sup> , 30 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> , 40 kg K <sub>2</sub> O ha <sup>-1</sup> )	32712	74241	41529	2.27
RDF + Water Spray	32862	75744	42882	2.30
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> (Soil application)	35212	99730	64518	2.83
RDF + ZnSO <sub>4</sub> @ 0.5% foliar application at tillering stage (40-45 DAS)	33112	86168	53056	2.60
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	35612	100780	65168	2.83
RDF + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application)	37712	87829	50117	2.33
RDF + FeSO <sub>4</sub> @ 0.5 % Foliar application at tillering stage (40-45 DAS)	33112	85627	52515	2.59
RDF + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	38112	88589	50477	2.32
RDF + ZnSO <sub>4</sub> @ 25 kg ha <sup>-1</sup> + FeSO <sub>4</sub> @ 50 kg ha <sup>-1</sup> (Soil application)	40212	102021	61809	2.54
RDF + foliar application of ZnSO <sub>4</sub> + FeSO <sub>4</sub> @ 0.5% at tillering stage (40-45 DAS)	33612	86937	53325	2.59
SEm±	--	2899	2899	0.09
CD (P = 0.05)	--	8551	8551	0.26

(Common cost of cultivation = ₹ 28600ha<sup>-1</sup>)

increase in straw yield due to micronutrient fertilization could be attributed to the increased plant growth and biomass production, possibly as a result of the uptake of nutrients. While the biological yield is a function of grain and straw yields, thus, increase in biological yield with the application of zinc and iron could be ascribed to increase seed and straw yields. Similar results showing the increase in wheat yield with the application of micronutrient were reported by Jat et al. [11], Gill and Walia [12], Singh et al. [7], Arshad et al. [8], Goyal et al. [9] and Jat et al. [13].

Data also revealed that the net returns and B: C ratio of wheat was significantly influenced by different treatments combinations. The highest net returns (₹65168 ha<sup>-1</sup>) and B: C ratio (2.83) were obtained when wheat crop was supplied with RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + foliar application of ZnSO<sub>4</sub> (0.5%) at tillering stage (T<sub>6</sub>) (Table 2). The increased net returns and BC ratio could be explained on the basis of increased yield and low cost of treatment. These results are in corroborating the findings of Singh [14] and Goyal et al. [9] in wheat.

#### 4. CONCLUSION

From the above study, it can be concluded that application of iron and zinc on wheat brought an additive effect in increasing yield attributes, yield and economics of wheat crop. The highest grain yield (4887 kg ha<sup>-1</sup>) of wheat was recorded with application of RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + FeSO<sub>4</sub> @ 50 kg ha<sup>-1</sup> (T<sub>10</sub>). While, the highest net returns (₹ 65168 ha<sup>-1</sup>) and B: C ratio (2.83) were observed when wheat crop was supplied with RDF + soil application of ZnSO<sub>4</sub> @ 25 kg ha<sup>-1</sup> + foliar application of ZnSO<sub>4</sub> (0.5%) at tillering stage (T<sub>6</sub>).

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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