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Micronutrient Dynamics of Zinc and Iron in Soil and Foliar Applications for Wheat Biofortification

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Abstract

Foliar or soil spray-on provision of micronutrients, or agronomic biofortification, is a viable means of increasing wheat grain concentrations of iron (Fe) and zinc (Zn) and potentially having effects on grain quality and the research question of the current paper was as follows: What were the effects of various combinations of soil application, zinc and iron at recommended dose of fertilizer, and foliar sprays of oxide s of zinc and iron (ZnSO4) and iron (FeSO4) on a wheat development, their yield and contents of iron and zinc in a grain. Combinations of RDF (T1), RDF (T2), RDF + water spray (T3), RDF + ZnSO4 soil application (T4), RDF + ZnSO4 foliar spray at tillering (T5), combined soil + foliar Zn (T6), RDF + FeSO4 soil application (T7), RDF + FeSO4 foliar spray (T8), combined soil + foliar Fe (T9) and RDF + combined soil Zn + Fe (T10) and RDF + foliar Zn + Fe (T11) yield. Three replications and randomized block design were used by the design of the experiment. Noticeable observations were traits such as plant height, tiller density, biomass, grain yield, harvest index, grain protein contents and contents of Iron and Zinc. In statistical testing, ANOVA and the respective mean separation-tests were adopted. Expectations: RDF can only hope to improve the pre-existing yield, but (T6, T9, T10, T11) the combination of soil + foliar integrated Zn/Fe treatments with RDF has the potential to bring about the greatest enhancementin grain Fe and Zn concentration and possibly lead to an enhancement in the yield parameters. The research was giving recommendations on cost effective agronomic measures of improving wheat nutritive value.

Keywords: Agronomic biofortification, zinc, iron, wheat, yield, grain quality, foliar spray, soil application

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Introduction

Wheat, the most significant cereal crop in the world, has an area under cultivation of 222.93m hectares and a production of 791.21m tons; India is in the top position with regard to area under cultivation and second with regard to production [1]. Punjab and Haryana have the best yields in India but as a nation, which is a large producer with an average yield of 3555 kg ha^{-1}, is below those of other countries [2]. In spite of wheat being an important source of protein and dietary energy, its iron (38–40 mg kg^{-1}) and zinc (33–35 mg kg^{-1}) contents are inadequate to provide nutritional requirements to humans [3, 4]. An estimated 60 percent of the world population requires iron and 30 percent are deficient in zinc, especially in peasant developing countries [5]. Micronutrient deficiency in soils especially zinc and iron has increased due to high cultivation and the absence of organic substances [6]. Zinc is required in enzyme activity, nitrogen metabolism, photosynthesis, auxin synthesis and stress resistance, and iron in the synthesis of chlorophyll and RNA metabolism. Enriching through wholesomeness growth or foliar application shows a viable option to improve uniformity in production and food value of grains. Investigation of the role of foliar sprays in enhancing productivity and grain fortification is badly needed as these are particularly effective, with combined effects of zinc and iron on wheat quality poorly understood

Material and Methods

The experiment was conducted during the Kharif season at the Research Farm of Vivekananda Global University, Jaipur. The region falls under the semi-arid climate with average annual rainfall of ~550 mm, predominantly received during July–September. The experimental soil was sandy loam, low in available nitrogen, medium in phosphorus, and high in potassium, with a pH of 7.5. The variety of wheat that was utilized was Raj. 3077. In accordance with standard agronomic procedures, the crop was sown at 20× 20 cm spacing with a seed rate of 100 kg ha^{-1}. The study was laid out in a randomized block design (RBD) with 11 treatments and three replications. The treatment details are presented below:

Treatment details

Table 1 Treatments and their symbols

S. No.	Treatments	Symbols
1	Absolute Control (No fertilizer + no spray)	T1
2	RDF (120 kg N ha-1, 60 kg P2O5 ha-1, 40 kg K2O ha-1)	T2
3	RDF + Water Spray	T3
4	RDF + ZnSO4 @ 25 kg ha-1 (Soil application)	T4
5	RDF + ZnSO4 @ 0.5% foliar application at tillering stage (45 DAS)	T5
6	RDF + ZnSO4 @ 25 kg ha-1 (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T6
7	RDF + FeSO4 @ 50 kg ha-1 (Soil application)	T7
8	RDF + FeSO4 @ 0.5 % Foliar application at tillering stage (40-45 DAS)	T8
9	RDF + FeSO4 @ 50 kg ha-1 (soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	T9
10	RDF + ZnSO4 @ 25 kg ha-1 + FeSO4 @ 50 kg ha-1 (soil application)	T10
11	RDF + foliar application of ZnSO4 and FeSO4 @ 0.5% at tillering stage (40-45 DAS)	T11

Data collected

The plant height was recorded at different growth stages, namely 30, 45, and 90 days after sowing (DAS), as well as at harvest, to assess the influence of treatments on crop growth. Along with this, dry matter accumulation (g m^{-2}) was also measured at corresponding intervals to evaluate the biomass production and distribution pattern throughout the crop growth period.

Result and Discussions

Plant Height (cm)

The different treatments of nutrients could greatly alter plant height at all growth stages (30 DAS, 60 DAS, 90 DAS and harvest) which was confirmed by the CD at 5% and CV.

- **Best Performers:** Decreasure (maximum plant height at every stage followed by the harvest value, T10 50% RDF + PM 2.5 t/ha + PSB) was the highest plant height (97.31 cm). T6 (50% RDF + PM @ 2.5 t/ha) and T4 (PM +2.5 t/ha - 94.46 cm) also performed well with the highest performance of 95.49 cm and 94.46 cm respectively [7].
- **Moderate Performance:** FYM that was used in combination with RDF and biofertilizers (T5, T7, T9, T11) produced a height of about 81 to 84 cm, it is fairer than the control but lower compared to the PM treatments.
- **Lowest Performance:** T1(Control) allowed the short plant height of 59.98 cm and displayed a poor growth with no nutrient application. T12 values were very low (3.71 cm at harvest) probably because of an experiment erroneousness or plant death, and cannot be used in comparative conclusions.
- **Interpretation:** The findings demonstrate that poultry manure (PM) is superior to FYM as far as increasing the plant height is concerned. The greatest synergistic effect was reaped upon a combination of 50% RDF with PM and PSB (T10) resulting to enhanced vegetative growth [7, 8].

Dry Matter Accumulation (g/meter row length)

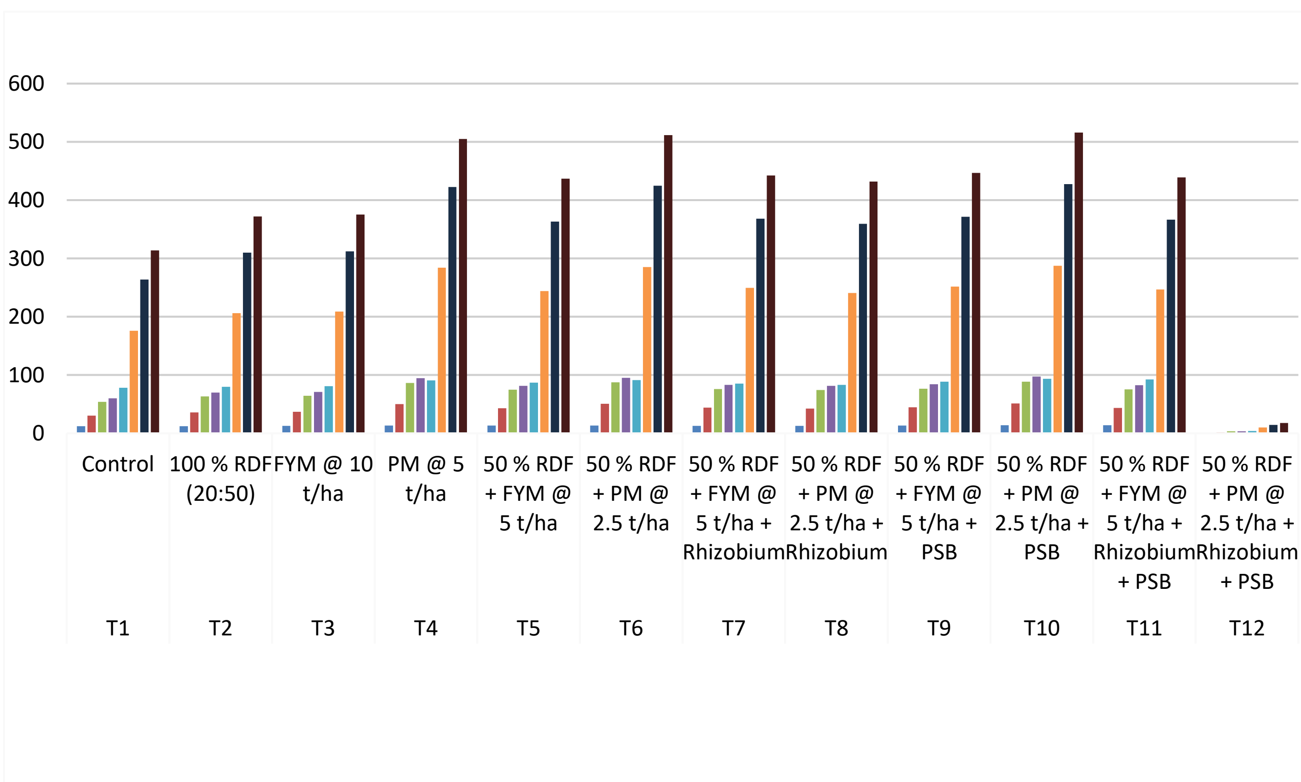
An identical trend was followed in the accumulation of dry matter between 30 DAS and harvest in both treatments; it was increasing consistently as was the case with the plant height.

- **Best Performers:** The maximum dry matter in the harvest was recorded once again at T10 (515.99 g/m row), then: T6 with 511.4 g T4 with 504.99 g These treatments were found to be superior to others throughout all of the growth stages meaning that there was enhanced uptake of the nutrient which was then transferred to biomass. [9]
- **Moderate Performance:** Combination foods using 1/14 FYM (T5, T7, T9, T11) displayed moderate dry matter growth (~436447 g at harvest) that remains well above that of an untreated control.

- **Lowest Performance:** T1 (Control) recorded the lowest valid dry matter (313.76 g), which was deprived of nutrient support creating little biomass. T12 had abnormally low values including (17.96 g) that showed discrepancy in data or lack of crop produce.
- **Key Insights:** Additionally, PM by itself or used with RDF and PSB have a significant positive impact on biomass production. Biofertilizers (Rhizobium and PSB) enhance performance in case of the FYM or PM but PM + PSB (T10) was the most effective [10].

Table 1-1 Impact of integrated nutrient management on growth traits of Wheat

S. No.	Treatments	plant height (cm)				Dry matter accumulation per metre row length (g)			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	AT Harvest
T1	Control	12.28	30.68	54	59.98	78.45	176.2	263.89	313.76
T2	100 % RDF (20:50)	12.44	35.95	63.21	69.81	79.63	206.33	310.28	371.99
T3	FYM @ 10 t/ha	12.57	36.83	64.43	71.25	80.95	208.95	312.21	375.59
T4	PM @ 5 t/ha	13.41	50.03	86.44	94.46	90.61	284.21	422.52	504.99
T5	50 % RDF + FYM @ 5 t/ha	13.12	42.83	74.85	81.5	86.99	243.93	363.13	436.99
T6	50 % RDF + PM @ 2.5 t/ha	13.55	50.84	87.32	95.49	91.15	285.47	425.09	511.4
T7	50 % RDF + FYM @ 5 t/ha + Rhizobium	12.94	43.95	76.07	83.14	85.43	249.56	368.04	442.32
T8	50 % RDF + PM @ 2.5 t/ha + Rhizobium	12.78	42.25	74.37	81.37	82.97	241	359.19	431.83
T9	50 % RDF + FYM @ 5 t/ha + PSB	13.27	44.53	76.68	84.25	88.44	252.05	371.41	446.88
T10	50 % RDF + PM @ 2.5 t/ha + PSB	13.86	51.49	88.88	97.31	93.61	287.67	427.6	515.99
T11	50 % RDF + FYM @ 5 t/ha + Rhizobium + PSB	13.68	43.47	75.52	82.36	92.49	246.84	366.43	439.27
	CD (P=0.05)	0.593	1.819	3.519	3.712	3.935	10.079	14.423	17.962
	SEm+	0.2	0.612	1.185	1.249	1.325	3.393	4.855	6.046
	CV (%)	2.644	2.467	2.746	2.642	2.654	2.41	2.318	2.404



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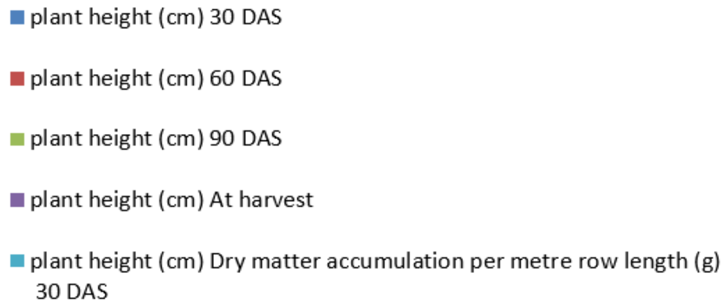

Figure 1 Effect of treatments.

The findings reported by Table and Figure unmistakably show that nutrient management practices played an important contribution in affecting the outcome of the crop in terms of grain yield, straw yield, biological yield, and harvest index. The reproduction error (no fertilizer and no spray) registered the lowest yield of grain (3458 kg ha^{-1}), straw yield (4981 kg ha^{-1}) and biological yield (8439 kg ha^{-1}), which implies the significance of nutrient use to improve productivity. Recommended dose of fertilizers (RDF) was applied which facilitated better yields than control with grain yield of 3962 kg ha^{-1} and biological yield of 9632 kg ha^{-1}. There was also a marginal increase when using RDF + water spray (4033 kg ha^{-1}gain yield) [11, 12].

Table 2 Impacts of iron and zinc on yield and harvest index of wheat

S. No.	Treatment	Yields (kg ha-1)			Harvest index
		Grain	Straw	Biological	
1	Absolute Control (No fertilizer + no spray)	3458	4981	8439	40.97
2	RDF (120 N kg ha-1, 60 P2O5 kg ha-1, 40 kg K2O ha-1)	3962	5670	9632	41.13
3	RDF + Water Spray	4033	5788	9821	41.06
4	RDF + ZnSO4 @ 25 kg ha-1 (Soil application)	5179	7427	12606	41.08
5	RDF + ZnSO4 @ 0.5% foliar application at tillering stage (45 DAS)	4529	6540	11069	40.91
6	RDF + ZnSO4 @ 25 kg ha-1 (Soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	5231	7469	12700	41.18
7	RDF + FeSO4 @ 50 kg ha-1 (Soil application)	4610	6634	11244	40.99
8	RDF + FeSO4 @ 0.5 % Foliar application at tillering stage (40-45 DAS)	4505	6480	10985	41.01
9	RDF + FeSO4 @ 50 kg ha-1 (soil application) + 0.5% foliar application at tillering stage (40-45 DAS)	4645	6699	11344	40.94
10	RDF + ZnSO4 @ 25 kg ha-1 + FeSO4 @ 50 kg ha-1 (soil application)	5291	7534	12825	41.25
11	RDF + foliar application of ZnSO4 and FeSO4 @ 0.5% at tillering stage (40-45 DAS)	4566	6600	11166	40.89
	C.D.	196.773	357.907	474.498	N/A
	SE(m)	66.237	120.476	159.722	0.633
	C.V.	2.523	3.196	2.498	2.671

RDF + $ZnSO_4$ at learn bag hectare plus $FeSO_4$:asta folis at tillering stage at 50 kg ha^{-1} (T10):aha + feis augustis (vaubiasa): presto, r. 5291 kg ha^{-1}) was found to have the highest value in grain yield (5291 kg hectare spencious), straw yield (7534 kg ha^{-1}), and folia cotia (12825 kg ha^{-1}) (T10) closely followed by RDF + ZnSO4 at the Application of $ZnSO_4$ (T4) on soil also did better (5179 kg ha^{-1} grain yield) than the application of $FeSO_4$. This demonstrates that zinc nutrition compared to iron played a greater role in crop production under experimental conditions. Foliar treatments alone ($ZnSO_4$ or $FeSO_4$ @ 0.5) did not lead to comparable yields as compared to soil treatments, nonetheless, they still exceeded the implementation of RDF The integrated nutrient managing effect of the use of soil and foliar treatments (T6, T9, T10) continued to provide a better yield as compared to the use of the treatments singly [12,13].

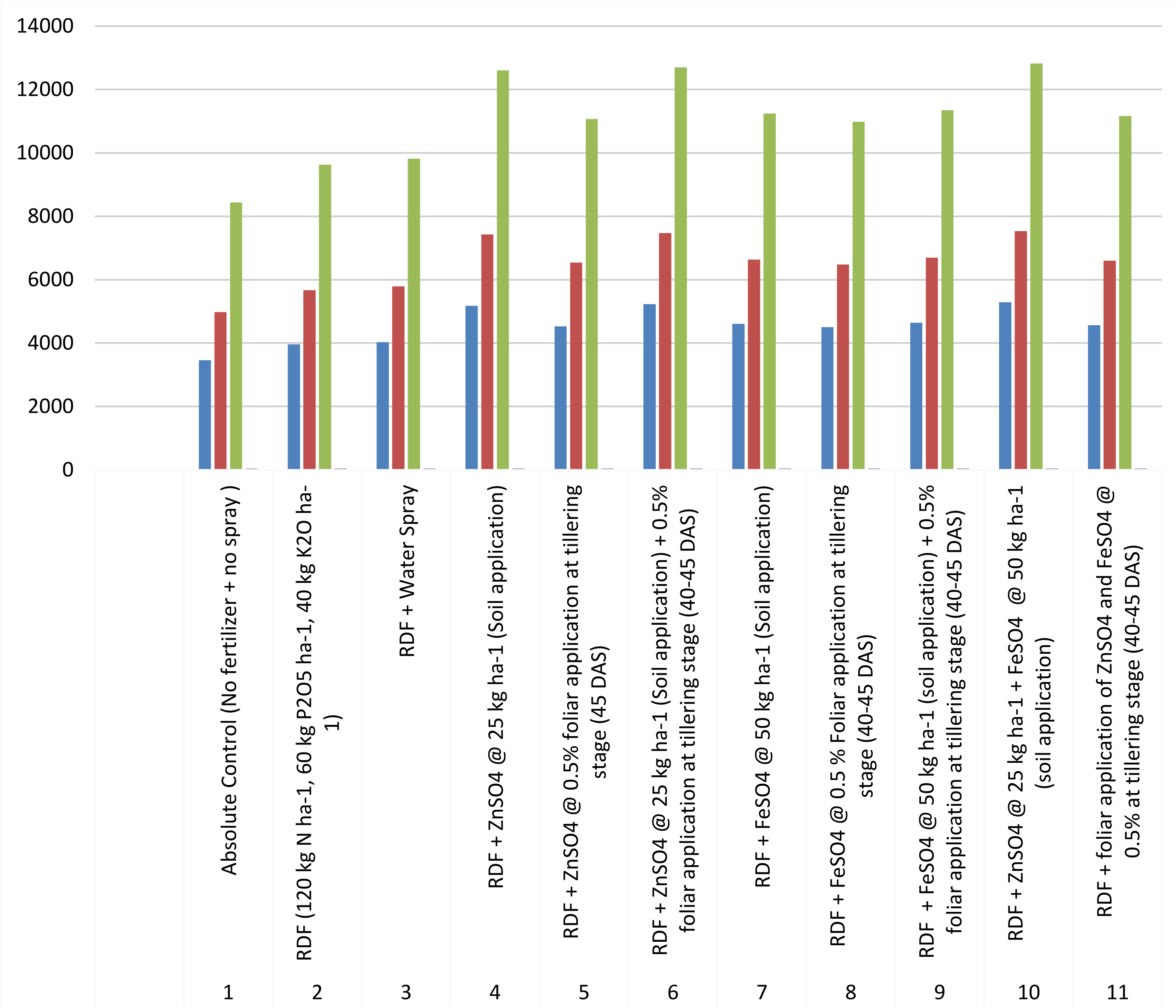

Figure 2 Impacts of iron and zinc on yield and harvest index of wheat

Conclusion

The results showed conclusively that nutrient management practices were very significant in the growth of wheat and yield performance as well. Application of poultry manure (PM) both alone or accompanied by the use of RDF and biofertilisers was observed to be superior to FYM at the utmost level of enhancements in the height and heavy crop of the plants and the levels of dry matter at the two phases of development. In the comparative analysis, RDF + PM 0.5 t/ha + PSB (T10) showed the greatest result in plant height (97.31 cm) and maximum dry matter run-up (515.99 g/m row), showing the effect of synergism between organic application, biofertilizer application, and chemical fertilizer application. Contrary to this, lack of poor growth and biomass was recorded in the control treatment since there was no nutrient support. Using the same zinc and iron micronutrient control enhanced the yields significantly as compared to the application of RDF. ZnSO4 25 kg ha^{-1}+ FeSO4 50 kg ha^{-1}at combination, T10, gave the largest grain yield of 5291 kg ha^{-1} and biological yield of 12825 kg $ha^{-1}$and closely matched the Zn soil + foliar combinations. Higher yields were attributed to enhancement of biomass production but the harvest index was relatively constant (~41 5) across treatments. Overall, one can say that the most tested program to substantially improve the growth of wheat, the development of biomass, and the flour yield is an organized system of using inorganic fertilizers (with the addition of poultry manure), biofertilizers, and micronutrients (Zn and Fe).

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