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Effect of foliar application of Nano zinc on uptake, yield and economics of wheat under zinc deficient and sufficient soils of inceptisol

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Abstract
Zinc deficiency in cereal crops can be solved by the application of Zn through foliar application. Nanotechnology is one of the options to enhance the nutritional value of crops as some engineered nanoparticles (NPs) could be used as a fertilizer. Zinc can be used in the form of zinc oxide (ZnO) NPs. The present study used the soil and foliar application and then evaluated the effect of foliar application of Nano Zinc on yield and economics of wheat (*Triticum aestivum* L.) under zinc deficient and sufficient soils of Inceptisol. The field experiment consisted of soil application and as well as foliar application of bulk Zn sources and Nano Zn source. Results revealed that the application of General Recommended Dose of Fertilizers (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM) along with soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} found beneficial under Zn deficient soil for increase in total uptake of zinc, grain as well as straw yield and B:C ratio of wheat under zinc deficient soil of Inceptisol. However, under zinc sufficient soil, the application of General Recommended Dose of Fertilizers (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM) along with Two foliar sprays of nano zinc @ 0.15% found beneficial for increase in yield, zinc uptake and economics of wheat.

Keywords: Nanoparticles (NPs), zinc uptake, yield, economics

Introduction
Wheat, a cereal grain originating from the Levant region (Feldman *et al*. 2007) [6], is now cultivated globally. It serves as a significant source of carbohydrates (Shewry and Hey, 2015) [25]. Internationally, it stands as the primary supplier of plant-based protein in human diets, containing around 13% protein content. This content is comparatively high among major cereals, yet relatively subpar in supplying essential amino acids for optimal protein quality. When consumed as whole grains, wheat offers diverse nutrients and dietary fiber. However, a subset of the population faces issues due to gluten, the major component of wheat protein. This fraction can trigger ailments such as coeliac disease, non-coeliac gluten sensitivity, gluten ataxia, and dermatitis herpetiformis (Ludvigsson *et al*. 2013) [14]. The cultivation of wheat in India spans approximately 30.5 million hectares, yielding 112.74 million tons with a productivity of 3.5 tons per hectare (Anonymous, 2022) [2].

Wheat holds a crucial role as a staple crop in temperate zones and is increasingly sought after in urbanizing and industrializing nations. Besides being a key source of starch and energy, wheat offers substantial quantities of essential or beneficial components for health, including protein, vitamins (notably B vitamins), dietary fiber, and phytochemicals. Among these, wheat is particularly noteworthy for its dietary fiber content, with bread alone accounting for 20% of the UK's daily intake. This dietary fiber intake has established connections with lowered risks of cardiovascular disease, type 2 diabetes, and certain cancers (notably colorectal cancer). The surging global demand for wheat is driven by its versatility in producing unique food items, aligning with industrialization and westernization trends. The distinct attributes of the gluten protein fraction enable wheat processing for bread, baked goods, noodles, pasta, and functional ingredients, catering to modern lifestyles.

Zinc a crucial element for plant nourishments, plays crucial roles in enzyme activation, enzyme and hormone biosynthesis, and oxidative stress mitigation. Zinc deficiency is prevalent in Indian soils, primarily due to varying soil and climatic conditions affecting its availability. The application of nanoparticles (NPs) for agricultural advancement, a more recent innovation, is currently in development (Gogos *et al*. 2012) [7].

Utilizing nano-added foliar fertilizers enhances element efficiency, reduces soil toxicity, and mitigates negative effects associated with excessive fertilizer use. Farmers employ sulfates and chelated EDTA for soil and foliar applications. However, efficacy remains limited.

Materials and Methods

Experimental details

I) Field experiment

The present research work entitled, “Effect of foliar application of Nano zinc on nutrient uptake, yield and quality of wheat on zinc deficient and sufficient soils of Inceptisol” was conducted at the PGI Research Farm, Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Rabi* season 2022. Two types of soils were selected, one with low available nitrogen, low available phosphorus, very high available potassium, and was deficient in zinc and another was also the same as the first soil type in macronutrients but sufficient in zinc. (Table 1)

Table 1: Initial properties of field experiment soils on Zn deficient soil and Zn sufficient soil

Sr.	Parameter	Value	
		Zn deficient soil	**Zn sufficient soil**
I	**Texture**	**Clay**	**Clay**
II	**Chemical properties**		
1.	pH (1: 2.5)	8.24	8.20
2.	EC (1:2.5) (dSm-1)	0.35	0.38
3.	Organic carbon (g kg^{-1})	4.9	5.4
4.	Calcium carbonate (%)	6.80	7.87
III	**Macronutrients**		
1.	Available N (kg ha^{-1})	159	166
2.	Available P (kg ha^{-1})	10.83	12.78
3.	Available K (kg ha^{-1})	467	490
IV	**DTPA micronutrients (mg kg^{-1})**		
1.	Fe	4.61	4.60
2.	Mn	8.30	9.80
3.	Zn	0.54	0.67
4.	Cu	1.35	1.52

Experiment consisting of eight treatments and three replications in Randomized Block Design (RBD). The treatments comprised of T_1: Absolute control, T_2: General Recommended Dose of Fertilizer (GRDF), T_3: GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}, T_4: GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50%, T_5: GRDF + Two foliar sprays of Nano zinc @ 0.10%, T_6: GRDF + Two foliar sprays of Nano zinc @ 0.15%, T_7: GRDF + Two foliar sprays of chelated zinc @ 0.15% and T_8: GRDF + Two foliar sprays of chelated zinc @ 0.20% were sprayed at 20 and 40 DAS. The variety of Wheat (*Triticum aestivum* L.) Phule Samadhan was sown under general recommended dose of fertilizers (120:60:40 kg ha^{-1} N:P_2O_5:K_2O + 10 t ha^{-1} FYM) was applied urea, diammonium phosphate and muriate of potash, respectively. 50 percent of nitrogen was applied as basal dose. Remaining 50 percent of nitrogen was applied at 21 and 45 days after sowing. Soil application of $ZnSO_4.7H_2O$ (20 kg ha^{-1}) was carried out at the time of sowing. The foliar applications of $ZnSO_4.7H_2O$ @ 0.50%, Nano zinc @ 0.10%, Nano zinc @ 0.15% and chelated zinc @ 0.20% were sprayed at 20 and 40 DAS.

Soil and plant analysis: Soil samples were processed and analyzed for pH and electrical conductivity (1:2.5) using glass electrode pH meter and EC meter, respectively. Organic carbon (g kg^{-1}) was estimated by Wet oxidation method (Nelson and Sommer, 1982) [20], available N by alkaline permanganate method (Subbiah and Asija, 1956) [27], available P by Olsen method (Watanabe and Olsen, 1965) [21] and available K by Neutral normal ammonium acetate method (Jackson, 1973) [9]. For DTPA micronutrients (Fe, Mn, Zn and Cu), soil samples extracted by 0.005 *M* DTPA method (pH-7.3) (Lindsay and Norvell, 1978) [12]. Finely ground grain and straw samples were digested with di-acid mixture (H_2O_2:H_2SO_4 1:1) for total N by Kjeldahl method and total micronutrients (Fe, Mn, Zn and Cu) atomic absorption spectrophotometry (AAS) and for total P and K digested with (HNO_3:$HClO_4$ 9:4) and analyzed by Vanado-Molybdate yellow colour in HNO_3 and Flame photometer, respectively.

Statistical analysis

The data obtained was analyzed as per the methods described by Panse and Sukhatme (1985) [22]

Results and Discussion

Effect of foliar application of different sources of zinc on total uptake of zinc by wheat under zinc deficient and sufficient soil

The data presented in table 2 under zinc deficient soil, the total uptake of zinc was found significantly higher (419 g ha^{-1}) in treatment T_3 (GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}) over T_1, T_2, T_4, T_5, T_7 and T_8 treatment, while treatment T_6 (402 g ha^{-1}) were at par with treatment T_3. Under conditions of zinc deficiency, wheat cultivated in treatment T_3 showed a percent overall uptake in total zinc compared to wheat cultivated in treatment GRDF.

While in the case of zinc sufficient soil, the total uptake of zinc was found significantly higher (455 g ha^{-1}) in treatment T_6 (GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS) over T_1, T_2 and T_3 treatment, while treatments T_4, T_5, T_7 and T_8 (427, 440, 435 and 446 g ha^{-1}, respectively) were at par with treatment T_6. In conditions where zinc was sufficient, wheat cultivated in treatment T_6 displayed an overall increase of 12.62 percent in the uptake of total zinc compared to wheat cultivated in treatment GRDF.

Nano particles of zinc exhibit a remarkable ability to penetrate plant tissues through the leaf cuticle, epidermis, and stomatal openings more effectively than ionic or conventional particles. When applied as a foliar application, nano zinc acts as a site-specific agent and undergoes increased absorption in a sophisticated manner. This mechanism likely contributes to the improved uptake of zinc within the plant system through foliar application of nano zinc. These results are consistent with the findings of Lopez *et al*. (2019) [13], Sadak and Bakri (2020) [24]. The increased uptake of zinc resulting from the application of nano zinc was similarly documented by Moghaddasi *et al*. (2017) [17]. Also, the slow-release pattern of nutrients has been recognized as a contributing factor to enhanced nutrient uptake, as advocated by Manikandan and Subramanian (2016) [17]. Foliar application stands as a rapid and efficient method for addressing plant nutrition. The result of zinc nanoparticles applied topically operate as site-specific agents and are also exposed to sophisticated methods of enhanced absorption, which may have improved zinc uptake in the plant system, Similar results detected by Naik *et al*.

(2007) [19] and Du *et al*. (2011) [5].

Table 2: Effect of foliar application of different sources of zinc on total uptake of zinc by wheat in zinc deficient and sufficient soil

Tr. No	Treatment	Total uptake of Zinc (g ha^{-1})	
		Zn deficient soil	Zn sufficient soil
T_1	Absolute control	85	95
T_2	General Recommended Dose of Fertilizers (GRDF)	364	404
T_3	GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}	419	423
T_4	GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50% at 20 and 40 DAS.	378	427
T_5	GRDF + Two foliar sprays of Nano zinc @ 0.10% at 20 and 40 DAS.	394	440
T_6	GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS.	402	455
T_7	GRDF + Two foliar sprays of chelated zinc @ 0.15% at 20 and 40 DAS.	371	435
T_8	GRDF + Two foliar sprays of chelated zinc @ 0.20% at 20 and 40 DAS.	399	446
	SE m±	7.40	9.99
	CD at 5%	22.22	29.98

Effect of foliar application of different sources of zinc on yield of wheat under zinc deficient and sufficient soil

Grain yield

The application of fertilizers, regardless of the doses and sources of nutrients, led to a significant increase in grain yield compared to scenarios with no nutrient application, as evidenced by the data presented in table 3 under zinc deficient soil. The grain yield of wheat was found significantly higher (42.61 q ha^{-1}) in treatment T_3 (GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}) over T_1, T_2 and T_3 treatments, while treatments T_4, T_5, T_6 and T_8 (40.65, 41.15, 41.56 and 42.07 q ha^{-1}, respectively) were at par with treatment T_3. Overall 9 percent increased grain yield of wheat found in treatment T_3 over GRDF treatment under zinc deficient soil.

Nevertheless, in the context of soil with sufficient zinc content, the grain yield was found significantly higher (44.15 q ha^{-1}) in treatment T_6 (GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS) over T_1 and T_2 treatments, while treatments T_3, T_4, T_5, T_7 and T_8 (41.18, 41.47, 42.76, 42.39 and 43.91 q ha^{-1}, respectively) were at par with treatment T_6. Which indicated that 8.61 percent increase in grain yield of wheat observed in treatment T_6 over T_2 (GRDF) treatment. In general, under Zn deficient soil, the wheat crop responding soil application of zinc. However, under zinc sufficient soil, the crop responding for foliar application of Nano zinc @ 0.15% at 20 and 40 DAS.

Nano fertilizers, characterized by their extensive surface area and smaller particle size compared to the pores of plant roots and leaves, offer the potential to enhance nutrient penetration from the applied surface, thereby improving nutrient uptake and increasing wheat yields. As previously mentioned, nano fertilizers may influence these processes by facilitating the transport of nutrients, both in terms of penetration and movement within the plant. The significant increase in crop yields through the foliar application of nano fertilizers has been supported by research conducted by Tarafdar *et al*. (2012) [28] and Benzon *et al*. (2015) [4]. Also, higher concentration of zinc played prominent significance in synthesis of carbohydrate and their transport to the site for grain production. Better absorption from the zinc treatment's foliar spray led to more efficient translocation to storage organs and, in turn, helped the photosynthetic activity, which may have accelerated the yield, Subbaiah *et al*. (2016) [26] showed similar results.

Table 3: Effect of foliar application of different sources of zinc on grain yield in zinc deficient and sufficient soil under wheat crop

Tr.	Treatment	Grain yield (q ha^{-1})	
		Zn deficient soil	Zn sufficient soil
T_1	Absolute control	9.75	10.27
T_2	General Recommended Dose of Fertilizers (GRDF)	39.09	40.65
T_3	GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}	42.61	41.18
T_4	GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50% at 20 and 40 DAS.	40.65	41.47
T_5	GRDF + Two foliar sprays of Nano zinc @ 0.10% at 20 and 40 DAS.	41.15	42.76
T_6	GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS.	41.56	44.15
T_7	GRDF + Two foliar sprays of chelated zinc @ 0.15% at 20 and 40 DAS.	39.96	42.39
T_8	GRDF + Two foliar sprays of chelated zinc @ 0.20% at 20 and 40 DAS.	42.07	43.91
	SE m±	0.87	1.01
	CD at 5%	2.65	3.04

Straw yield

In the present investigation the straw yield of wheat presented in table 4 under zinc deficient soil, was found significantly higher (60.14 q ha^{-1}) in treatment T_3 (GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}) over T_1, T_2 and T_4 treatments, while treatments T_5, T_6, T_7 and T_8 (57.60, 58.09, 56.11 and 58.66 q ha^{-1}, respectively) were at par with treatment T_3. Overall, 8.60 percent increased straw yield of wheat found in treatment T_3 over GRDF treatment, under zinc deficient soil.

In circumstances where the soil already contained sufficient zinc, the straw yield of wheat was found significantly higher (63.50 q ha^{-1}) in treatment T_6 (GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS) over T_1 and T_2 treatments, while treatments T_3, T_4, T_5, T_7 and T_8 (59.40, 60.12, 61.98, 61.26 and 62.47 q ha^{-1}, respectively) were at par with treatment T_3. Under zinc sufficient soil 9.95 percent increase in straw yield in T_6 treatment over GRDF.

Incorporating nano fertilizers in conjunction with NPK (Nitrogen, Phosphorus, and Potassium) demonstrated a notable enhancement in crop yield compared to their individual application. The combined utilization of these components were found to establish a harmonious synergy in the context of chemical fertilizer application. This synergy facilitated the efficient uptake and translocation of essential nutrients from source to sink within the plant, consequently augmenting both crop productivity and straw yield. Consequently, this approach contributed to the achievement of consistent and sustainable crop yields, emphasizing the significance of judicious chemical fertilizer management. This outcome aligns with earlier findings reported by Gosavi and Bhagat (2009) [8], Rakesh Kumar *et al*. (2015) [23] and Auwal and Amit (2017) [3]. The observed rise in straw yield following the foliar application of Nano zinc fertilizers can be attributed to the rapid uptake of these nano fertilizers by the plant. This increased absorption, in turn, stimulates a higher rate of photosynthesis and greater production of dry matter, ultimately leading to an elevated straw yield. These findings concur with those reported by Benzon *et al.* (2015) [4] in the context of rice cultivation. Supplementing with zinc demonstrated favorable outcomes by promoting the production of Indole-3-acetic acid (IAA) and initiating the development of reproductive structures in plants. This, in turn, facilitated enhanced metabolic responses within the plants. Mohsen *et al*. (2016) [18] similarly documented an increase in barley yield as a result of zinc supplementation.

Table 4: Effect of foliar application of different sources of zinc on straw yield in zinc deficient and sufficient soil under wheat crop

Tr.	Treatment	Straw yield (q ha^{-1})	
		Zn deficient soil	Zn sufficient soil
T_1	Absolute control	13.54	14.22
T_2	General Recommended Dose of Fertilizers (GRDF)	55.38	57.75
T_3	GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}	60.14	59.40
T_4	GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50% at 20 and 40 DAS.	56.25	60.12
T_5	GRDF + Two foliar sprays of Nano zinc @ 0.10% at 20 and 40 DAS.	57.60	61.98
T_6	GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS.	58.09	63.50
T_7	GRDF + Two foliar sprays of chelated zinc @ 0.15% at 20 and 40 DAS.	56.11	61.26
T_8	GRDF + Two foliar sprays of chelated zinc @ 0.20% at 20 and 40 DAS.	58.66	62.47
	SE m±	0.96	1.40
	CD at 5%	2.88	4.22

Effect of Foliar Application of Different Sources of Zinc on Economics of Wheat

The data in respect of cost of cultivation, gross monetary return, net monetary return and B:C ratio are presented in table 5 and 6. Under zinc deficient soil, the lowest cost of cultivation Rs. 35948 /- was observed in T_1 i.e., absolute control followed by treatment T_2 (Rs. 54933/-). The gross monetary return (Rs. 94611/-) was recorded higher in T_3 i.e., GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} followed by treatment T_8 (Rs. 93376 /-). The net monetary return (Rs. 38478 /-) was recorded higher in T_3 i.e., GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} followed by treatment T_8 (32403/-) The percent increase in net monetary returns was 20.66 over GRDF treatment. However, the highest B:C ratio (1.69) was recorded in T_3 treatment followed by treatment T_2 i.e GRDF (1.58).

However, under zinc sufficient soil the lowest cost of cultivation Rs. 35948/- was observed in T_1 i.e., absolute control followed by treatment T_2 (Rs. 54933/-). The gross monetary return (Rs. 98098/-) was recorded higher in T_6 i.e., GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS followed by treatment T_8 (Rs. 97530/-). The net monetary return (Rs. 37255/-) was recorded higher in T_6 i.e., GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS followed by treatment T_8 (36557/-). The B:C ratio (1.64) of wheat crop in zinc sufficient soil was recorded higher in treatment T_2 i.e., General Recommended Dose of Fertilizers (GRDF) followed by treatment T_3 (1.63). There was very slight difference in net returns and B:C ratio in treatment T_3 over T_2. This outcome was made possible by the noteworthy increase in grain yield and the associated fertilizer costs across various treatments. This increase in grain yield at these levels is attributed to higher levels of productivity, resulting in elevated gross returns, net returns, and an improved benefit-to-cost ratio. According to Kumar *et al.* (2020) [11], nano fertilizers have the capacity to enhance crop yields while concurrently reducing fertilizer wastage and minimizing the overall cost of cultivation. Similar results were also observed by Mehdi *et al*. (2012) [16] and Kumar *et al*. (2014) [10].

Table 5: Effect of foliar application of different sources of zinc on economics of wheat in zinc deficient soil under wheat crop

Tr. No	Treatment	Cost of cultivation (Rs ha^{-1})	Gross monetary return (Rs ha^{-1})	Net monetary return (Rs ha^{-1})	B:C ratio
T_1	Absolute control	35948	21640	-14309	0.60
T_2	General Recommended Dose of Fertilizers (GRDF)	54933	86820	31887	1.58
T_3	GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}	56133	94611	38478	1.69
T_4	GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50% at 20 and 40 DAS.	57873	90203	32330	1.56
T_5	GRDF + Two foliar sprays of Nano zinc @ 0.10% at 20 and 40 DAS.	59753	91345	31592	1.53
T_6	GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS.	60843	92259	31416	1.52
T_7	GRDF + Two foliar sprays of chelated zinc @ 0.15% at 20 and 40 DAS.	59273	88720	29447	1.50
T_8	GRDF + Two foliar sprays of chelated zinc @ 0.20% at 20 and 40 DAS.	60973	93376	32403	1.53

Note: FYM- 1.20 Rs. kg^{-1}, N– 11.30 Rs. kg^{-1}, P– 56.25 Rs. kg^{-1}, K- 56.66 Rs. kg^{-1}, Chelated zinc- 170 Rs./100 g, $ZnSO_4.7H_2O$ - 60 Rs. kg^{-1}, Nano zinc- 218 Rs/100 mL, Spraying charges- 40 Rs/15 L pumps Grains-2150 Rs. q-1, Stover- 50 Rs. q-1.

Table 6: Effect of foliar application of different sources of zinc on economics of wheat in zinc sufficient soil under wheat crop

Tr. No	Treatment	Cost of cultivation (Rs ha^{-1})	Gross monetary return (Rs ha^{-1})	Net monetary return (Rs ha^{-1})	B:C ratio
T_1	Absolute control	35948	22792	-13157	0.63
T_2	General Recommended Dose of Fertilizers (GRDF)	54933	90285	35352	1.64
T_3	GRDF + Soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1}	56133	91507	35374	1.63
T_4	GRDF + Two foliar sprays of $ZnSO_4.7H_2O$ @ 0.50% at 20 and 40 DAS.	57873	92167	34294	1.59
T_5	GRDF + Two foliar sprays of Nano zinc @ 0.10% at 20 and 40 DAS.	59753	95033	35280	1.59
T_6	GRDF + Two foliar sprays of Nano zinc @ 0.15% at 20 and 40 DAS.	60843	98098	37255	1.61
T_7	GRDF + Two foliar sprays of chelated zinc @ 0.15% at 20 and 40 DAS.	59273	94202	34929	1.59
T_8	GRDF + Two foliar sprays of chelated zinc @ 0.20% at 20 and 40 DAS.	60973	97530	36557	1.60

Note: FYM- 1.20 Rs. kg^{-1}, N – 11.30 Rs. kg^{-1}, P – 56.25 Rs. kg^{-1}, K- 56.66 Rs. kg^{-1}, Chelated zinc- 170 Rs/100 g, $ZnSO_4.7H_2O$ - 60 Rs. kg^{-1}, Nano zinc- 218 Rs/100 mL, Spraying charges- 40 Rs/15 L pumps Grains-2150 Rs. q-1, Stover- 50 Rs. q-1.

Conclusion

It can be concluded that, the application of General Recommended Dose of Fertilizers (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM) along with soil application of $ZnSO_4.7H_2O$ @ 20 kg ha^{-1} found beneficial under Zn deficient soil for increase in total uptake of zinc as well as yield and B:C ratio of wheat also maintaining the Zn status in zinc deficient soil of Inceptisol. However, under zinc sufficient soil, the treatment of GRDF + Two foliar sprays of nano zinc (0.15%) found at par. Application of General Recommended Dose of Fertilizers (120:60:40 kg ha^{-1} $N:P_2O_5:K_2O$ + 10 t ha^{-1} FYM) along with Two foliar sprays of nano zinc @ 0.15% found beneficial for increase in total uptake of zinc and yield of wheat. However, the treatment of GRDF + Two foliar sprays of nano zinc (0.10%) found at par.

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