Current Agriculture Updates 9(4) 85-94(October, 2025)
www.currentagriculture.com

RESEARCH ARTICLE

Impact of different levels of fertilizers and foliar application of ferrous and zinc sulphate on growth, yield and of wheat

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Manuscript received: August 30,2025; Decision on manuscript: September 8,2025; Manuscript accepted: October 5, 2025

Abstract

An experiment was conducted during the winter *rabi* season of 2024-25 to assess the impact of different levels of fertilizers and foliar application of ferrous and zinc sulphate on growth and yield of wheat (*Triticum aestivum* L.) An experiment was layout in split plot design and treatment consist two factors Factor A consist optimum doses of fertilizers through soil application S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF, S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF, S_3 - 100% RDF and factor B consist foliar application of $ZnSO_4$ and $FeSO_4$ F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS), F_2 - 0.5% ZnSO4 + 0.5% $FeSO_4$ (at 25 & 45 DAS), F_3 – Water spray at (25 and 45 DAS). While recommended doses of fertilizers 120:60:60 NPK Kg per ha was applied as per treatments by using Urea, SSP and MOP fertilizers. Highest growth attributes plant height cm plant^{-1}, number of tillers plant^{-1}, number of functional leaves plant^{-1}, leaf area cm^2 SPAD reading which was higher with treatment application S_3 - 100% RDF and F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS). Highest yield attributes and yield test weight, length of panicle (cm), weight of single panicle (g), yield (g) plant^{-1}, and yield (qn ha^{-1}) was recorded due to treatment application of S_3 - 100% RDF and F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS).

Keyword: Fertilizer levels, zinc, ferrous sulphate, wheat, yield

Introduction

Around the globe, two billion people face micronutrient deficiency and acute malnutrition, mainly pregnant women, and children under the age of five (White and Broadley, 2009; WHO, 2012). More people are affected by the lack of micronutrients than the issue of low energy intake and poor dietary quality (Christian and Stewart *et al.,* 2010). The deficiency of zinc, iron and iodine causes the death of around 20% of children under the age of five (Prentice *et al.,* 2008). Cereal-based foods represent the major dietary habit of micronutrient-deficient populations (Cakmak, 2010; Bouis *et al.,* 2011; Ibrahim and Jadoon, 2021).

Globally, major human health issues that affected a major portion of the world's population have been found to be associated with micronutrient deficiencies (Manjeru *et al.*, (2019). Major Iron and Zn deficiency has been recognized as one of the key factors to the global burden of diseases, particularly in developing countries. Its deficiency mainly results in anemia, leading to functional impairments of the human body (Cappellini *et al.*, 2020). The deficiency in the human body is mainly associated with the consumption of food that is low in nutrient content. In the past few decades, Fe deficiency chlorosis has been identified as a chief nutritional disorder among the crops grown in calcareous soils, which leads to suppression in yield and quality losses of crops (Chen *et al.*, 1982 and Pal *et al.*, 2019). Wheat (*Triticum aestivum* L.) is an important grain crop in India. It is one of the world's major staple food crops, wheat is consumed by 35% of the human population, contributing almost 20% of dietary energy and protein to the diets of developing countries. Due to its significant role in ensuring food security, wheat is an ideal candidate for biofortification. Because of the increase in the rate of population growth and the decrease of areas of arable land, improving the grain yield is the way to meet food demand. Grain yield of cereals is the product of the following components: the number of spikes per unit area, the number of kernels per spike and thousand kernel weight (Bulman and Hunt, 1988). It can be increased due to the use of improved cultivars and nutrient management. Optimal fertilizer management is necessary to maintain sustainable yields, improve nutrient use efficiency of fertilizers, and save fertilizer resources (Chuan *et al.*, 2016). Agriculture playing important role for providing the food to growing human population worldwide, which has also led to growing reliance on pesticides and Fertilizers (Santos *et al.*, 2012). Indiscriminate and unbalanced use of fertilizers, especially urea and phosphorus along with other agrochemical and reduction in supply of organic manure has led to considerable for degradation in soil health. The exploitation of nitrogen and phosphorus fertilizers causes air and ground water pollution which leads eutrophication of water bodies (Youssef and Eissa, 2014). This circumstances the urgent need for introduction of harmless inputs like biofertilizer. Biofertilizers play significant role in maintaining long term soil fertility and sustainability by fixation of atmospheric nitrogen, helps for solubilize phosphorus and helps for mobilizing potash which is locked in soil with various reaction as well as indirectly its helps for increasing availability of macro and micro nutrients for plants and increases their efficiency (Venkatashwarlu, 2008). Biofertilizers keep the soil environment rich in all kinds of macro- and micro-nutrients via fixation of nitrogen, phosphate and potassium, mineralization or solubilization, production of antibiotics, release of plant growth regulating substances and biodegradation of organic matter in the soil (Sinha *et al.*, 2014; Kedir,*et al.*, 2023). Biofertilizers have tremendous potential for supplying nutrient especially for nitrogen and Phosphorus. . They are eco-friendly and low cost inputs and can reduce chemical fertilizer dose by 25 to 50 % (Rana *et al.*, 2012). Besides, due to use of uncontrolled and unbalanced fertilization, and degradation of soil quality have impacted the quality of crop based food available to poor people, worldwide. Increase the use of subsidies fertilizers in India ex. Urea and DAP and due to heavy use of nitrogenous fertilizers increase nitrate concentration in water bodies and ultimately in drinking water which may induce carcinogenic problems in human beings therefore need to uses optimum fertilizers. Therefore, its need to Zinc and Fe biofortification of wheat for increase its nutritive values through agronomic biofortification and reduce the uses of uncontrolled use of fertilizers and their adverse effect on soil heath.

In view of above consideration the present investigation was studied and entitled as "impact of different levels of fertilizers and foliar application of ferrous and zinc sulphate on growth, yield and of wheat".

Materials and methods

An experiment was conducted during *rabi* 2024-25 at Research farm, School of Agriculture, G.H. Raisoni University, Saikheda, Madhya Pradesh, India. Soil of research plot was sandy loam with having soil pH 7.44 with low nitrogen and with high phosphorus and Potassium. Field trials was layout in Split Plot design and treatment consist two factors i.e. factor A consist optimum doses of fertilizers through soil application S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF, S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF, S_3 - 100% RDF and factor B consist foliar application of $ZnSO_4$ and $FeSO_4$ F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS), F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS), F_3 – Water spray at (25 and 45 DAS). While recommended doses of fertilizers 120:60:60 NPK Kg per ha was applied as per treatments by using Urea, SSP and MOP fertilizers. A basal dose and top dressing 50% Nitrogen fertilizer was applied as per treatment at the time of sowing to wheat. Irrigation was given as per crop need. The recommended package of practices was followed. The grain and straw yields were recorded from net plot area at maturity stage of the crop. For recording biometric observations five plants were randomly selected from the plot and were marked.

Results and discussion

The results shown for optimum doses of fertilizers and foliar application of $ZnSO_4$ and $FeSO_4$ influenced on wheat plant growth parameters during the study viz., plant height, number of functional leaves, leaf area of plant, number of tillers, SPAD reading for asses the chlorophyll in plant and dry matter accumulation during the experiment.

Plant height (cm) plant^{-1}

Due to application of optimum doses of fertilizers highest plant was recorded due to application of S3 - 100% RDF (67.82 cm) followed by (67.72 cm) was recorded with treatment application S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF which is at par with S_3. This might be due to 100 % RDF is adequate supply of nutrients during periods of crop demand leading to better absorption of nutrients promotes higher growth this might be due to better cell division and cell elongation, formation of nucleotides and co-enzymes, energy transfer resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates which reflects higher plant growth this finding match with Panday *et al.*, (2004).While with application of Zn and Fe sulphate with S_2 produce maximum plant height this might be due to increase the plant height was due to increase in protein synthesis and cell growth. Iron has a structural in chlorophyll, energy transfer within the plant and enters in to the root cells also zinc increased the plant height via increasing internode distance. This finding lines with by Ananda and Patil (2010), Kadam *et al.,* (2018), Kandoliya *et al.,* (2018).

Number of functional leaves plant^{-1}

Significantly maximum number of functional leaves per plant-1 was recoded with highest amount of fertilizer application which was S_3 - 100% RDF at all growth stages which was at par with S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF at all growth stages during the experiment.

While lowest number of functional leaves was recorded with treatment application S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF This might be due to improvement in growth parameters with application of 100% RDF might have resulted in better and timely availability of primary nutrients for their utilization by crop plant Similar finding was recorded by Patil *et al.,* (2017) in maize crop. While number of functional leaves per plant^{-1} influenced significantly due to foliar application of $ZnSO_4$ and $FeSO_4$ at all growth stages. The maximum number of functional leaves plant^{-1} was recoded with application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS).

Leaf area

Leaf area was increased with increase RDF of wheat crop at all growth stages. Significantly highest leaf area was recorded with treatment application of S_3 - 100% RDF at all growth stages and which was at par with treatment S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF at 60, 90 DAS and at harvest while at 30 DAS treatment S_3 - 100% RDF was found significantly superior over rest of all treatments and Significant impact of foliar application of $ZnSO_4$ and $FeSO_4$ on leaf area are noticed during all growth stages mentioned in table 1. Treatment application of F_2 - 0.5% ZnSO4 + 0.5% $FeSO_4$ (at 25 and 45 DAS) produced significantly highest leaf area cm2 over rest of all treatments while followed by highest leaf area cm2 was noticed with F1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS). This results might be due to zinc application increase growth hormone responsible for plant growth, resulted in increased plant growth. It was also observed in the higher amount of chlorophyll content in a treatment of zinc and iron similar finding lines with Kandoliya *et al.,* (2018).

Number of tillers

Significantly influence of number of tiller per plant due to application of optimum doses of fertilizer application at all growth stages. Highest number of tillers per plant (4.67) was recorded due to application of S_3 - 100% RDF which was at par with S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF (4.64). While lowest number of tillers per plant was notice with application of S_1 – NPK microbial consortia @ 2.5 liter per ha + 50% RDF. This might be due to application of sufficient amount of nutrients at proper stage of crop growth stages which helps for increase maximum number of tillers per plant while with factor B Significantly highest number of tillers per plant was recorded due to application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was 4.74 per plant which was significantly superior over rest of all treatments followed by F_2 highest number of tillers per plant was recorded with F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS) and F_3 – Water spray at (25 and 45 DAS) subsequently. Combine application of Zn and Fe helps for increase number of tillers per hill. Hafeez *et al.,* (2021) reported that application of Zn and Fe through soil incorporation has a positive influence on tillers, and more tillers were attained by the combination applied of Zn and Fe.

SPAD reading

SPAD reading influenced significantly due to application of optimum levels of fertilizer application at all growth stages. It was increase with increase RDF for wheat crop. Highest SPAD reading was noticed due application of S_3 - 100% RDF which was at par with S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF while lowest SPAD reading was recorded with S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF subsequently.

Table. 1: Effect of optimum doses of fertilizers and foliar application of $ZnSO_4$ and $FeSO_4$ on differ traits of wheat

Factor- A (Soil application- Optimum doses of fertilizers)	**Plant height (cm) plant^{-1}**	**Number of functional leaves plant^{-1}**	**Leaf area (cm^2) plant^{-1}**	**Number of tillers plant^{-1}**	**SPAD reading**	**Dry matter accumulation (g) plant^{-1}**
S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF	62.0	15.0	14.4	3.3	41.3	76.4
S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF	67.7	16.8	14.4	4.6	43.8	85.9
S_3 - 100% RDF	67.8	17.0	16.3	4.6	45.5	89.7
SE m	0.5	0.2	0.3	0.0	0.6	1.1
C.D. at 5%	2.3	1.0	1.3	0.2	2.6	4.5
Factor- B (Foliar application of $ZnSO_4$ and $FeSO_4$)						
F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS)	65.4	15.8	14.5	4.0	43.2	81.7
F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS)	66.2	17.1	16.4	4.7	45.3	89.8
F_3 – Water spray at (25 and 45 DAS)	65.8	15.8	14.1	3.8	42.2	80.5
SE m	0.9	0.3	0.3	0.1	0.6	1.6
C.D. at 5%	NS	0.9	1.0	0.3	2.0	5.1
Interaction (S x F)						
SE m	1.68	0.56	0.60	0.21	1.14	2.91
C.D. at 5%	NS	NS	NS	0.64	3.50	8.96
General mean	**65.85**	**16.31**	**15.08**	**4.23**	**43.58**	**84.03**

With foliar application of $ZnSO_4$ and FeSO4 SPAD reading significantly influenced at all Growth stages except at harvesting stage. Highest values for SPAD reading was noticed due to application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was 45.32 which was at higher side at all growth stages. F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS) was found at par with application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) while lowest SPAD values recorded with F_3 - Water spray at (25 and 45 DAS) Highest Chlorophyll was recorded with maximum application of Zn and Fe this might be due to application of zinc significantly increase in the biosynthesis of IAA, an important growth hormone responsible for plant growth, resulted in increased plant growth. It was also observed in the higher amount of chlorophyll content in a treatment of zinc and iron this results lines with Jat *et al.,* (2018).

Dry matter accumulation

We observed that significant increase in dry matter accumulation (g) per plant with increase age of plant due to development of plant parts and at final stage due to formation panicle and later stage seed grain formation. Highest dry matter accumulation (g) per plant (89.73) was recorded with 100% RDF application with S_3 100% RDF which was at par and very closer S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF which was 85.93 (g). Due to the foliar application of $ZnSO_4$ and $FeSO_4$ both the dry matter of plant influenced significantly and can be seen.

Higher the dry matter accumulation (g) plant^{-1} was recorded due to the application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) at all growth stages which was 89.87 (g) per plant which was significantly superior over rest all foliar application treatment. Followed by highest dry matter accumulation was recorded with treatment application F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS).

Yield and yield attributes

Results and discussion for yield and yield attributes of wheat influenced due to treatment application of Optimum doses of fertilizers and foliar application $ZnSO_4$ and $FeSO_4$ which is summaries under this heading- test weight, length of spike, Number of seed grain per panicle, grain yield (kg) ha^{-1}, Straw yield kg ha^{-1} and biological yield (kg ha^{-1}).

Test weight

Test weight of wheat data mentioned in table 2 which was significantly influenced due to application of optimum doses of fertilizers. Highest test weight (43.17) was recorded with treatment application S_3 - 100% RDF which was found at par with S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF (42.71) while lowest (40.82) was recorded with S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF this might be due to insufficient of plant nutrient to attain maximum weight of each seed grain while significantly influenced test weight of wheat due to foliar application of $ZnSO_4$ and $FeSO_4$. Highest test weight (43.56) for wheat was recoded with F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was significantly superior over rest of all treatments followed by maximum test weight (41.88) was recorded due to treatment application S_3 - 100% RDF. While lowest test weight (41.25) was recorded due to treatment application of F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS). This finding match with Habib (2009) he reported that obtained significant increase in 1000 kernels weight when Zn and Zn + Fe supplied on foliage at grain filling period of wheat without affecting grain numbers per spike.

Length of spike

Signifincalty influenced length of spike (cm) of wheat due to application of optimum doses of fertilizers. Highest length of panicle 12.34 cm was recorded with F_3- 100 % RDF which was found at par with S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF which produce 11.54 cm length of panicle. While lowest panicle length 10.55 cm was recorded with S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF this might be due to lesser supply of primary nutrient rest of all treatments as well as length of spike influenced significantly due to foliar application of $ZnSO_4$ and $FeSO_4$ maximum length of panicle (11.97 cm) was recorded due to application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was superior over rest of all treatments while F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS) recorded (11.32 cm) length of panicle was recorded and lowest length of panicle (11.14 cm) was recorded due to application of F_3 – Water spray at (25 and 45 DAS).

For improve the components of yield of wheat crop might be due to involvement of Zn and Fe and their critical role in biochemical process including photosynthesis which altimately helps for increase plant yield attributes like spike length and similar findings agreement with Niyigaba *et al.*, (2019).

Number of seed grain per panicle

Significantly influenced number of seed grain per panicle due to application of optimum doses of fertilizers data for same noted in table 2. Maximum number of seed grain per panicle (32.18) was recorded with treatment application S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF while it was found at par with S_3 - 100% RDF (32.13). While lowest number of seed grain per panicle (29.68) recorded with S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF this might be due to lowest doses of application then the actual require for wheat crop. While due to treatment application of $ZnSO_4$ and $FeSO_4$ influenced number of seed grain per panicle maximum number of seed grain per panicle was recorded due to F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was (34.18) which was significantly superior over rest of all foliar application treatments which was 15.04 % more over F_3. F_2 followed by maximum number of seed grain per panicle was recorded with F_1 - 0.5% ZnSO4 + 0.5% $FeSO_4$ (at 25 DAS) which was (30.20) while lowest number of grain per panicle (29.71) noticed with F_3 - Water spray at (25 and 45 DAS).

Table 2: Effect of optimum doses of fertilizers and foliar application of $ZnSO_4$ and $FeSO_4$ on different traits of wheat

Factor- A (Soil application- Optimum doses of fertilizers)	**Test weight (g)**	**Length of panicle (cm)**	**Number of seed grain per panicle**	**Grain yield (kg ha^{-1})**	**Straw yield (kg ha^{-1})**	**Biological yield (kg ha^{-1})**
S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF	40.8	10.5	29.6	22761	42493	65254
S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF	42.7	11.5	32.2	26866	47067	73932
S_3 - 100% RDF	43.1	12.3	32.1	28793	49671	78464
SE m	0.4	0.2	0.1	271	750	749
C.D. at 5%	1.6	1.0	0.7	1062	2945	2942
Factor- B (Foliar application of $ZnSO_4$ and $FeSO_4$)						
F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS)	41.2	11.3	30.2	25698	46182	71880
F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS)	43.5	11.9	34.1	27209	47944	75153
F_3 – Water spray at (25 and 45 DAS)	41.88	11.14	29.71	25512	45104	70617
SE m	0.29	0.19	0.36	228	492	576
C.D. at 5%	0.88	0.59	1.11	703	1516	1774
Interaction (S x F)						
SE m	0.50	0.33	0.62	395	852	997.29
C.D. at 5%	NS	NS	NS	1218	NS	NS

Grain yield

Significantly highest seed grain yield 28793 kg ha^{-1} was recorded due to application of S_3 - 100% RDF which was significantly superior over rest of all treatments and 10.14 per cent more over average yield. Followed by maximum seed grain yield 26866 kg ha^{-1} was recorded with treatment application S_2 - NPK microbial consortia @ 2.5 liter per ha + 75% RDF while lowest yield 22761 kg ha^{-1} recorded with S_1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF. Since yield is the result of additive and complementary effect of plant growth and yield-attributing parameters and the yield-attributing characters had better expression at higher fertility level due to adequate quantity and balanced proportion of plant nutrient supply during the crop growth period which ultimately led towards an increase in grain yield similar findings was recorded with Panday *et al.*, (2004). Due to foliar application of $ZnSO_4$ and $FeSO_4$. Highest seed grain yield 27209 kg ha^{-1} was produced with treatment application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was significantly superior over rest of all treatments while, lowest seed grain yield was recorded with F_3 – Water spray at (25 and 45 DAS) which was 25512 kg ha^{-1} which is at par with F_1 This might be due to Foliar application with micronutrients (Fe, B and Zn) play crucial role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus their importance in achieving higher yields (Salih, 2013).

Biological yield

Biological yield increased with increased rate of NPK fertilizer application. Significantly highest biological yield 78464 kg ha^{-1} was produced due to application of S^3 - 100% RDF which was significantly superior over rest of all treatments and lowest biological yield (65225 kg ha^{-1}) produced due to application of S^1 - NPK microbial consortia @ 2.5 liter per ha + 50% RDF this might be due to reduction of 50% RDF and which was not compensate due to additional application of NPK microbial consortia @ 2.5 liter per ha. With application of $ZnSO_4$ and $FeSO_4$ significantly highest biological yield (75153 kg ha^{-1}) was produced due to application of F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) which was 6.42 per cent more over F_3 and significantly superior over rest of all treatments While, lowest biological yield 70617 kg ha-1 was produced due to F_3 - Water spray at (25 and 45 DAS) which was at par with treatment F_1 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 DAS).

Hence in conclusion from the results it can be concluded that application of S_3 - 100% RDF and F_2 - 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ (at 25 and 45 DAS) produce significant maximum crop growth parameters viz. plant height, Number of leaves, leaf area, SPDA reading, dry matter accumulation (g) per plant and as well as produce maximum wheat yield (kg ha-1) along with all yield attributes.

References

1. Ananda, N. and Patil, B.N. 2010. Effect of micronutrients (Zn and Fe) and time of nitrogen application on growth and yield of Durum Wheat. Karnataka J. Agri. Sci., 18(3).
2. Bouis E Howarth, Hotz Christine, Mc Clafferty Bonnie, Meenakshi J. V., and H. Pfeiffer Wolfgang 2011. Food and Nutrition Bulletin, 32 (1) (supplement), The United Nations University.

3. Cakmak, I., Pfeiffer, W. H. and McClafferty, B. 2010. Biofortification of durum wheat with zinc and iron. Cereal Chem., 87(1): 10–20.
4. Cappellini, M.K.; Musallam, K.M.; Taher, A.T 2020. Iron deficiency anemia revisited. J. Intern. Med. 287, 153–170.
5. Chen, Y.and Barak, P. 1982. Iron nutrition of plants in calcareous soils. Advances in Agronomy, 217–240.
6. Parul, C., and Christine, S. P. 2010. Maternal micronutrient deficiency, fetal development, and the risk of chronic disease. The J. Nutriti. Critical Review. 427-145.
7. Habib, M. 2009. Effect of foliar application of Zn and Fe on wheat yield and quality. African J. Biotech., 8(24): 6795–6798.
8. Hafeez M.B., Ramzan, Y., Khan, S., Ibrar, D., Bashir, S., Zahra, N., Rashid, N., Nadeem, M., Rahman Ha.Su., Shair ,H., Ahmad, J., Hussain, M., Irshad, S., Al-Hashimi, A., Alfagham, A. and Diao, Z-H. 2021. Application of zinc and iron-based fertilizers improves the growth attributes, productivity, and grain quality of two wheat (*Triticum aestivum*) Cultivars. Front. Nutr. 8:779595. doi: 10.3389/ fnut. 2021.779595
9. Ibrahim, M. and Jadoon, S.A. 2021. Estimation of heritability for production traits in bread wheat under rainfed condition. J. Gent. Genom. Plant Breed., 5(4):115-123.
10. Jat, R.C., Sharma, Y., Jakhar, R.K. and Sharma, K. 2018. Effect of phosphorus, zinc and iron on yield and quality of wheat in western Rajasthan, India. Int. J. Curr. Microbiol. App. Sci., 7(3): 2055-2062.
11. Kadam, S.R., Bhale, V.M., Chorey, A.B. and Deshmukh, M.R. 2018. Influence of zinc and iron fortification on yield and post-harvest studies of different rice cultivars (*Oryza sativa* L.). Int. J. Curr. Microbial. App. Sci., 7(1): 1878-1888.
12. Kandoliya, R.U., Talaviya, B.P. and Kunjadia, B.B. 2018. Effect soil and foliar application of zinc and iron on growth of wheat plant in calcareous soil of Saurashtra region. European J. Biotechno. Biosci., 86-90.
13. Kedir, A. , Alemu, S., Tesfaye, Y., Asefa, K. and Tashoma, G. 2023. Evaluation of the newly released Adola-01 bread wheat (*Triticum aestivum* L.) variety for stability testing in Ethiopia. J. Gent. Genom. Plant Breed., 7(3): 68-73.
14. Etienne, N., Twizerimana, A., Mugenzi, I., Ngnadong, W. A., Ye, Y. P., Wuand, B. M. and BoHai, J. 2019. Winter wheat grain quality, zinc and iron concentration acted by a combined foliar spray of zinc and iron fertilizers agronomy. 9, 250; doi:10.3390/agronomy9050250
15. Pal, V., Singh, G., Dhaliwal, S.S. 2019. Yield enhancement and biofortification of chickpea (*Cicer arietinum* L.) grain with iron and zinc through foliar application of ferrous sulfate and urea. J. Plant Nutr. 42, 1789–1802.
16. Panday, I.B., Bharti, V., Bharti, R:C. and Misra S.S. 2004. Effect of fertilizer levels and seed rates on growth and yield of surface-seeded wheat (*Triticum aestivum*) under lowland rice ecosystem of north Bihar Indian J. Agrono., 49 (1) : 43-45.
17. Patil A.S., Dabhi B.M. and Shitap, M.S., 2017. Effect of Wheat Residue Management and Fertilizer Levels on Growth and Yield of Fodder Maize (*Zea mays* L.) Int. J. Current Microbiolo. Applied Sci., 6 (10): 25-29.
18. Rana, A., Joshi, M., Prasanna, R., Shivay, Y.S. and Nain, L. 2012. Biofortification of wheat through inoculation of plant growth promoting rhizobacteria and cyanobacteria. European J. Soil Bio., 50:118-126.
19. Salih, H.O. 2013. Effect of Foliar Fertilization of Fe, B and Zn on nutrient concentration and seed protein of Cowpea *Vigna unguiculata*. IOSR J. Agric. Veterinary Sci., 6(3): 42-46.

20. White, P. J. and Broadley, M. R. 2009. Biofortification of crops with seven mineral elements often lacking in human diets - iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytol., 182, 49–84.

21. World health organization 2022. https://www.who.int/news/item/20-05-2022-world-health-statistics-2022.

22. Youssef, M.M.A. and Eissa, M.F.M. 2014. Biofertilizers and their role in management of plant parasitic nematodes. A review, J. Biotechn. Pharmaceutical Res., 5:1-6.

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