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Influenced of zinc application on macro and micro nutrients content at different growth stages of wheat (*Triticum aestivum* L.)

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Abstract
Zinc deficiency is major problem in cereal crops. Therefore, zinc agronomic fortification of wheat and other cereal crops is being urgently addressed and highly prioritized as a research topic. Increasing the zinc content of food crop resulting in better crop production is an important global challenge. An investigation was carried out to find out the influenced of zinc application on content of macro and micro nutrients in wheat (*Triticum aestivum* L.). There were seven treatments of different levels of zinc was applied in this experiment generated using completely randomized design. The significantly highest macro and micro nutrients content were observed in the treatment of soil application of RDF + $ZnSO_4$ @ 30 kg ha^{-1} at the time of sowing. It is concluded that the soil application of $ZnSO_4$ @ 30 Kg ha^{-1} + RDF (80:40:40 kg ha^{-1} N, P_2O_5, K_2O) at the time of sowing recorded highest wheat macro and micro nutrients content.

Keywords: Agronomic fortification, wheat, zinc deficiency, macro, micro, nutrients content

Introduction
Wheat (*Triticum aestivum L.*) is an important cereal crop, source of food and thus the most important crop in food security prospective. In plants, zinc plays a vital role as a catalytical, structural and regulatory co-factor of many enzyme reactions. Zinc is necessary for the metabolism of carbohydrates, protein synthesis, the biosynthesis of growth hormones, in particular of indole acetic acid and the maintenance of the integrity of cell membranes. Plants suffering from acute zinc deficiency exhibit stunted growth, chlorosis of leaves, shortened internodes and petioles, and clustering of small malformed leaves at the top of the plant (classic rosette symptom of di-cotyledons). The deficiency symptoms first appears on young leaves as zinc is an immobile nutrient in plants. Zinc deficient leaves remains small with extended necrotic spots and interveinal chlorosis on the upper leaf surfaces. Zinc is one of the abundant trace element in human bodies. In humans zinc is a component of a large number of enzymes (>300) and participates in various metabolic processes such as synthesis and degradation of carbohydrates, proteins, and nucleic acids. Zinc plays a vital role in the functioning of the nervous, reproductive, and immune systems and is important in the physical growth and cognitive development of children. Numerous health problems such as retarded growth, skeletal abnormalities, delayed wound healing increased abortion risk and diarrhea are formed due to zinc deficiency. Approximately one-third of the world's population is suffering from zinc deficiency. The situation is even more adverse in developing countries where more than half of the children and pregnant women are suffering from iron and zinc deficiencies. This situation is largely attributed to the high consumption of cereal based foods viz., wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.) and maize (*Zea mays* L.), in these countries. An important approach to preventing zinc deficiency in humans is zinc biofortification.

Cereals are the major source of zinc for the world's population, especially for the poor people living in rural areas. However, zinc contents of cereal-based foods are quite inadequate to meet human demands. The problem is especially acute for wheat consumers, as wheat (*Triticum astivum* L.) and represents a main dietary source of calories, proteins and micronutrients for the majority of words population.

Wheat is responsible up to 70% of daily calorie intake of the population living in rural regions and an important source of zinc for human beings living in developing world.

Materials and methods

A pot culture experiment was conducted during rabi season of 2017-18 at Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola. The soil for filling the pots where collected from long term fertilizer experiment unit, Dr. PDKV, Akola which was deficient in zinc. The experimental soil which was collected from LTFE unit was slightly alkaline in reaction, medium in organic carbon, moderately calcareous in nature, low in available N, medium in available P, very high in available K, marginal in available S, and sufficient in micronutrients but deficient in zinc. The certified seed of wheat (AKAW-4627) were sown in rabi season by drilling method at rate of 150 kg ha^{-1} (20 seeds per pot). Basal dose of nitrogen, phosphorous and potassium was applied through urea, single super phosphate and murate of potash. For T_1 treatment only RDF was applied, T_2 treatment RDF + $ZnSO_4$ was applied @ 10 kg ha^{-1},T_3 treatment RDF + $ZnSO_4$ was applied @ 20 kg ha^{-1},T_4 treatment RDF + $ZnSO_4$ was applied @ 30 kg ha^{-1}, T_5 treatment RDF + $ZnSO_4$ was applied @ 40 kg ha^{-1}. Foliar treatments were applied according to the treatments such as T_6 treatment was applied through $ZnSO_4$ two foliar sprays @ 0.5% first at pre-flowering and second at milk stage. T_7 treatment was applied through $ZnSO_4$ two foliar sprays of @ 1.0% first at pre flowering and second at milk stage. Double quantities of fertilizers (Urea, SSP, MOP) were applied in the pot culture experiment as the nutrients would become less available to the plants.

Macro and micro nutrients content at different growth stages and at the time of harvesting in the plant was determined by using drying the samples in hot air oven at 60°C ± 2°C till a constant dry weight obtained. N content in sample was analysed by using Kjeldahl's apparatus and express as percentage. The P content was determined by using Vanado-molybdo-phosphoric acid yellow colour method. The K content was determined by using the flame photometer and was expressed in percentage. The Zn content in dry matter of wheat at different growth stages, straw and grain were determined using Atomic Absorption Spectrophotometry (AAS). The experiment was laid out in a Complete Randomize Design and replicated in thrice.

Results and discussion

The results obtained from the present investigation have been presented under following heads.

Macronutrient content

Effect of zinc application on nitrogen content at different growth stages of wheat

The results in relation to nitrogen content in wheat at different growth stages are reported in Table 1.

At 30 DAS the highest nitrogen content (0.76%) in wheat was recorded in RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) as the soil application of zinc as $ZnSO_4$ helped to increase in availability of nitrogen for wheat plant. It was seen that nitrogen content in other treatments except recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1) had no much differences as they all were applied only with RDF at this stage and in the RDF (T_1) treatment nitrogen content (0.70%) was least observed. But the treatments were seen non-significant at this stage.

The similar results were also observed at the 60 DAS straw content of wheat. But the nitrogen content was more than 30 DAS samples. It may be because; there was an increase in metabolic activity and absorption of nitrogen at this grand growth period. Maximum nitrogen content (0.85%) was observed at RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and minimum nitrogen content (0.76%) was observed in (RDF) 80:40:40 NPK kg ha^{-1} (T_1) treatment. But the treatments was non-significant at this stage.

At harvest stage nitrogen content in grain was significantly maximum (2.24%) RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4). The lowest nitrogen contain (2.15%) in wheat grains was observed in (RDF) 80:40:40 NPK kg ha^{-1} (T_1). There was significant effect of zinc application on nitrogen content in grains. Nitrogen content in grains was much higher than straw.

There was a significant effect of zinc application on nitrogen content in straw at harvest stage of wheat. It was observed that soil application RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) got the highest value of nitrogen content (0.72%) in straw. But this treatment was statistically at par with other treatments such as RDF + $ZnSO_4$ two foliar sprays @ (1.0%) first at pre flowering and second at milk stage (T_7), RDF + $ZnSO_4$ two foliar sprays @ (0.5%) first at pre flowering and second at milk stage (T_6), RDF + $ZnSO_4$ @ 40 kg ha^{-1} (T_5) and RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3). The lowest nitrogen content (0.63%) in straw was observed in recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1) treatment due to the low availability of nutrients in the soil.

Dwivedi *et al.* (2002) [4] reported that application of zinc enhanced the nitrogen content in plants. The results were in agreement with the findings reported by Shivay *et al.* (2008) [12], Abbas *et al.* (2009) [1] and Cakmak *et al.* (2010) [3].

Table 1: Effect of zinc application on nitrogen content in wheat

	Treatments	At 30 DAS (Straw) (%)	At 60 DAS (Straw) (%)	At harvest Grain (%)	At harvest Straw (%)
T_1	Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1}	0.70	0.76	2.15	0.63
T_2	RDF + $ZnSO_4$ @ 10 kg ha^{-1}	0.73	0.78	2.18	0.64
T_3	RDF + $ZnSO_4$ @ 20 kg ha^{-1}	0.74	0.78	2.20	0.68
T_4	RDF + $ZnSO_4$ @ 30 kg ha^{-1}	0.76	0.85	2.24	0.72
T_5	RDF + $ZnSO_4$ @ 40 kg ha^{-1}	0.75	0.78	2.21	0.69
T_6	RDF + $ZnSO_4$ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	0.71	0.79	2.22	0.70
T_7	RDF + $ZnSO_4$ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	0.71	0.80	2.23	0.71
	SE (m)±	0.087	0.112	0.011	0.011
	CD at 5%	NS	NS	0.036	0.035

Effect of zinc application on phosphorous content at different growth stages of wheat

The data in respect of content of P in wheat at different stages were presented in Table 2.

At 30 DAS the phosphorous content were significantly influenced by various treatments and were found to vary from 0.21 to 0.25 per cent in straw. Phosphorous content of wheat at 30 DAS in straw was highest (0.25%) in treatment of RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3), RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and it was at par with the treatments (T_2), (T_5), (T_6) and (T_7). The lowest phosphorous content (0.21%) was found in the treatment (T_1).

The similar results were also observed at 60 DAS phosphorus content in wheat and they were found to vary from 0.22 to 0.27 per cent in straw content. Phosphorous content in straw at 60 DAS was highest (0.27%) in the treatment RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3), RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and lowest phosphorous content (0.22%) was observed in (T_1). In this case the treatments (T_2), (T_5), (T_6) and (T_7) were found at par with each other. The phosphorous content at 60 DAS was in increment with the phosphorous content at 30 DAS which states that phosphorous content is absorbed more at grand growth stage due to higher metabolic activities.

Table 2: Effect of zinc application on phosphorous content in wheat

	Treatments	At 30 DAS (Straw) (%)	At 60 DAS (Straw) (%)	At harvest	
				Grain (%)	Straw (%)
T_1	Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1}	0.21	0.22	0.23	0.16
T_2	RDF + $ZnSO_4$ @ 10 kg ha^{-1}	0.24	0.26	0.24	0.17
T_3	RDF + $ZnSO_4$ @ 20 kg ha^{-1}	0.25	0.27	0.25	0.18
T_4	RDF + $ZnSO_4$ @ 30 kg ha^{-1}	0.25	0.27	0.25	0.18
T_5	RDF + $ZnSO_4$ @ 40 kg ha^{-1}	0.23	0.25	0.23	0.16
T_6	RDF + $ZnSO_4$ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	0.23	0.24	0.23	0.16
T_7	RDF + $ZnSO_4$ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	0.23	0.25	0.23	0.16
	SE (m)±	0.009	0.009	0.034	0.022
	CD at 5%	0.028	0.029	NS	NS

At harvesting stage phosphorus content in grain of wheat did not show any significant result. The phosphorus content in wheat grain ranges from 0.23 to 0.25 per cent in which the maximum phosphorous content (0.25%) was observed in treatment RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3), RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and the lowest phosphorous content (0.23%) was observed in the treatments (T_1), (T_5), (T_6) and (T_7). Phosphorous content in wheat straw at harvest stage was ranged from 0.16 to 0.18 per cent and maximum phosphorous content (0.18%) in wheat straw was observed in the RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3), RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) treatment and lowest phosphorous content (0.16%) was observed in treatment (T_2), (T_5), (T_6) and (T_7).

Singh M. V. (1999) [13] observed antagonistic effect of phosphorous to the zinc application which was also observed in the present data. Soil application of zinc did not affect the decrease in phosphorous content as much as foliar treatments. This may be the reason of higher grain and straw yield on treatment of soil application of RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4). Similar results were also observed by Alam *et al.* (2000) [2].

Effect of zinc application on potassium content at different growth stages of wheat

The data pertaining to the content of potassium in wheat at different growth stages are reported in Table 3.

The significantly potassium content in wheat straw at 30 DAS stage was noticed highest (2.62%) in treatment RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4). But this value were found to be statistically at par with treatments such as RDF + $ZnSO_4$ @ 40 kg ha^{-1} (T_5), RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3). The lower potassium content (2.54%) was found in the RDF 80: 40:40 NPK kg ha^{-1} (T_1) treatment.

Table 3: Effect of zinc application on potassium content in wheat

	Treatments	At 30 DAS (Straw) (%)	At 60 DAS (Straw) (%)	At harvest	
				Grain (%)	Straw (%)
T_1	Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1}	2.54	2.67	0.37	2.22
T_2	RDF + $ZnSO_4$ @ 10 kg ha^{-1}	2.56	2.70	0.40	2.25
T_3	RDF + $ZnSO_4$ @ 20 kg ha^{-1}	2.57	2.72	0.43	2.26
T_4	RDF + $ZnSO_4$ @ 30 kg ha^{-1}	2.62	2.75	0.48	2.32
T_5	RDF + $ZnSO_4$ @ 40 kg ha^{-1}	2.58	2.70	0.44	2.27
T_6	RDF + $ZnSO_4$ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	2.55	2.70	0.46	2.30
T_7	RDF + $ZnSO_4$ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	2.55	2.71	0.47	2.31
	SE (m)±	0.010	0.011	0.008	0.008
	CD at 5%	0.031	0.034	0.027	0.024

The significantly increase in potassium content in wheat straw at 60 DAS as compared to the potassium content at 30 DAS. Similar trend was observed as that of potassium content at 30 DAS which was due to the soil application of zinc as $ZnSO_4$ was only applied at this stages and foliar application was yet to be applied. The maximum potassium content (2.75%) was observed in treatment RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and lowest potassium content (2.67%) was observed in RDF 80:40:40 NPK kg ha^{-1} (T_1) treatment.

At harvest stage potassium content in grain was highest (0.48%) in the treatment RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) which was higher than all other treatments, but statistically found at par with treatment such as RDF + $ZnSO_4$ two foliar sprays @ (1.0%) first at pre flowering and second at milk stage (T_7), RDF + $ZnSO_4$ two foliar sprays @ (0.5%) first at pre flowering and second at milk stage (T_6), RDF + $ZnSO_4$ @ 40 kg ha^{-1} (T_5) and RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3). The lowest potassium content (0.37%) in grain was observed in recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1).

The potassium content in wheat straw at harvest stage was decreased from potassium content at 60 DAS due to reduction in dry matter content at harvest stage than grand growth stage. It was also observed that the treatment were significant to the potassium content in wheat straw. The highest potassium content (2.32%) in wheat straw was observed in treatment RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and the lowest potassium content (2.22%) was observed in recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1).

Increase in potassium content in grain and straw might be due to the Zinc application and soil application of zinc got highest potassium content in grain and straw at every growth stages of wheat. Results were in agreement with the finding in respect of potassium content by Ghasal *et al.* (2017) [5].

Micronutrient Concentration

Effect of zinc application on zinc content at different growth stages of wheat

The data in respect of zinc content at different growth stages in wheat are presented in Table 12. Data indicated that zinc content in grain and straw at different growth stages was found to be significantly influenced with application of various levels of zinc.

The zinc content in wheat straw at 30 DAS samples were significantly affected by zinc application treatments. The highest zinc content (45.60 mg kg^{-1}) was observed by treatment of soil application of RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4), and was followed by (43.45 mg kg^{-1}) RDF + $ZnSO_4$ @ 40 kg ha^{-1}(T_5) and the lowest zinc content (38.63 mg kg^{-1}) was observed in recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1).

The similar results were observed at 60 DAS zinc content in straw. But there was an increase in zinc concentration than 30 DAS straw zinc content, which may be due to the higher metabolic activity of plant at grand growth stage and higher absorption of zinc. The highest zinc content (46.90 mg kg^{-1}) was observed in treatment of RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) which is higher than (RDF) 80:40:40 NPK kg ha^{-1} (T_1) and was followed by (45.27 mg kg^{-1}) treatment such as RDF + $ZnSO_4$ two foliar sprays @ (1.0%) first at pre flowering and second at milk stage (T_7), but the treatments were significantly at par with each other except the recommended dose of fertilizer mg kg^{-1} which contains the lowest zinc content (39.24 mg kg^{-1}) among the treatments.

Table 4: Effect of zinc application on zinc content in wheat

	Treatments	At 30 DAS (Straw) (mg kg^{-1})	At 60 DAS (Straw) (mg kg^{-1})	At harvest Grain (mg kg^{-1})	At harvest Straw (mg kg^{-1})
T_1	Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1}	38.63	39.24	19.75	37.50
T_2	RDF + $ZnSO_4$ @ 10 kg ha^{-1}	42.20	43.80	21.09	40.11
T_3	RDF + $ZnSO_4$ @ 20 kg ha^{-1}	43.12	44.64	24.40	41.25
T_4	RDF + $ZnSO_4$ @ 30 kg ha^{-1}	45.60	46.90	27.83	44.37
T_5	RDF + $ZnSO_4$ @ 40 kg ha^{-1}	43.45	44.55	25.24	42.88
T_6	RDF + $ZnSO_4$ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	38.72	45.17	26.70	43.15
T_7	RDF + $ZnSO_4$ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	38.78	45.27	27.60	43.75
	SE (m)±	0.451	0.620	0.106	0.447
	CD at 5%	1.369	1.882	0.324	1.356

The highest zinc content (27.83, 44.37 mg kg^{-1}) in wheat grain and straw was observed in treatment of RDF + $ZnSO_4$ @ 30 kg ha^{-1} (T_4) and it was followed by treatment such as RDF + $ZnSO_4$ two foliar sprays @ (1.0%) first at pre flowering and second at milk stage (T_7), RDF + $ZnSO_4$ two foliar sprays @ (0.5%) first at pre flowering and second at milk stage (T_6), RDF + $ZnSO_4$ @ 40 kg ha^{-1} (T_5) and RDF + $ZnSO_4$ @ 20 kg ha^{-1} (T_3) which is zinc content 27.60, 26.70, 25.24, 24.40 mg kg^{-1} respectively in grain and 43.75, 43.15, 42.88, 41.25 mg kg^{-1} respectively in wheat straw. The lowest zinc concentration (19.75, 37.50 mg kg^{-1}) in grain and straw was observed in recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha^{-1} (T_1). All treatments except (T_1) were statistically similar with each other.

Role of micronutrient in crop production has significantly increased in the recent years due to availability of better analysis techniques and better understanding of their functions in crop plants reported by Singh *et al.* (2014) [14]. Since sufficient experimental data case with lacking in conducting the effects of micronutrients effect on concentration, uptake and utilization of other essential plant nutrients, the present investigation was undertaken to find out the effect of Zn fertilization or fortification on concentration and uptake are increases. The present findings support the results of Kanwal *et al.* (2010) [8]. Sharma and Bapat (2000) [11] also observed concentration of zinc in grain and straw increased significantly with application of grain and straw increased significantly with application of zinc over control.

Conclusion

From the present investigation it is concluded that the application of $ZnSO_4$ @ 30 kg ha^{-1} along with recommended dose of fertilizer at the time of sowing is significantly increased the macro and micro nutrients content in wheat.

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