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Effect of zinc application on quality of wheat grain (*Triticum aestivum* L.)

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Abstract

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. 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 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. A pot culture study entitled "Agronomic fortification of wheat as influenced by graded levels of zinc" was conducted during rabi 2017-2018 at Department of Soil Science and Agricultural Chemistry. Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola. The significantly highest test weight, carbohydrates and protein content were observed in the treatment of soil application of RDF + ZnSO₄ @ 30 kg ha⁻¹. It is concluded that the soil application of ZnSO₄ @ 30 Kg ha⁻¹ + RDF (80:40:40 kg ha⁻¹ N, P₂O₅, K₂O) at the time of sowing recorded highest wheat grain quality viz test weight, carbohydrates and protein content.

Keywords: Agronomic fortification, quality, wheat, zinc

Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop, source of food and thus the most important crop in food security prospective. 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 aestivum* L.) and represents a main dietary source of calories, proteins and micronutrients for the majority of world 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. In plants, zinc plays a vital role as a catalytical, structural and regulatory co-factor of many enzyme reactions. The importance of nutrients (micro and macro) for the normal growth of crop plants is universally recognized. In under-developed and developing countries however, plant nutrition is not being used in optimal and balanced levels and as a consequence the production potential of soils is frequently not being exploited and the application of only major plant nutrients (N, P and K) is not adequate to achieve full potential yield of crops in many agricultural systems. Zinc is an important essential element present in plant enzymatic systems. Genc *et al.* (2006) reported that zinc has vast numbers of functions in plant metabolism and consequently zinc deficiency has a multitude of effects on plant growth. 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 dicotyledons). 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 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, rice and maize, in these countries. An important approach to preventing zinc deficiency in humans is zinc biofortification.

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, showed good behaviour in increasing their concentration in wheat grain. However, little is known about the effect of combined Zn on the quality of this wheat grain. Therefore, this study was conducted to closely assess the effect of Zn applied as foliar fertilizer at different growth stages of winter wheat on grain quality.

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 T₁ treatment only RDF was applied, T₂ treatment RDF + ZnSO₄ was applied @ 10 kg ha⁻¹, T₃ treatment RDF + ZnSO₄ was applied @ 20 kg ha⁻¹, T₄ treatment RDF + ZnSO₄ was applied @ 30 kg ha⁻¹, T₅ treatment RDF + ZnSO₄ was applied @ 40 kg ha⁻¹. Foliar treatments were applied according to the treatments such as T₆ treatment was applied through ZnSO₄ two foliar sprays @ 0.5% first at pre-flowering and second at milk stage. T₇ treatment was applied through ZnSO₄ 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.

Quality analysis

- 1. The weight:** The weight of 1000 seeds of wheat from each pot was recorded and designated as seed index.
- 2. Protein content:** It was determined by multiplying the nitrogen per cent in grain sample by constant factor 5.73 for wheat as described by AOAC (1965) [2].
- 3. Carbohydrate content:** The total carbohydrate content was estimated by the method of Hedge and Hofreiter (1962) [4].



Fig 1: Effect of zinc application on grain quality

Results and Discussion

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

Effect of zinc application on quality parameters of wheat

Effect of zinc application on test weight of wheat

The weight of grain is an important yield component and made major contribution towards grain yield of wheat. Higher 1000 grains weight of a crop depicts its efficacy to store more and more photosynthesis in the seed. It was seen that seed weight was higher (39.83 g) in the treatment of RDF + ZnSO₄

@ 30 kg ha⁻¹ (T₄) and it also contributed to the grain yield of wheat. This treatment was higher than RDF which indicates that application of zinc increased the grain weight but was significantly at par with all treatments except RDF 80:40:40 NPK kg ha⁻¹ (T₁). The lowest test weight (35.33 g) was seen in the treatment RDF 80:40:40 NPK kg ha⁻¹ (T₁) because the soil was deficient in most of the nutrients.

Present result was supported by Abbas *et al.* (2009) [1]. Similarly, Khan *et al.* (2007) [6] in an experiment on wheat and rice using different level of zinc reported an increase in the 1000 grain weight of wheat significantly over control.

Table 1: Effect of zinc application on test weight in wheat grains

Treatments	Test weight (g)
T ₁ Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha ⁻¹	35.33
T ₂ RDF + ZnSO ₄ @ 10 kg ha ⁻¹	37.46
T ₃ RDF + ZnSO ₄ @ 20 kg ha ⁻¹	38.33
T ₄ RDF + ZnSO ₄ @ 30 kg ha ⁻¹	39.83
T ₅ RDF + ZnSO ₄ @ 40 kg ha ⁻¹	38.85
T ₆ RDF + ZnSO ₄ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	38.88
T ₇ RDF + ZnSO ₄ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	39.41
SE (m)±	0.519
CD at 5%	1.575

Effect of zinc application on carbohydrates content in wheat

Carbohydrates are the polyhydroxy organic compounds made up of carbon, hydrogen and oxygen in which the ratio of hydrogen and oxygen is 2:1. The main sources of carbohydrates in plants are starch (storage forms are carbohydrate) for chlorophyll containing plants e.g. cereals, potatoes, legumes, millets etc.

It is observed from the table 20 that carbohydrates content show significant variation due to various micronutrient levels. Maximum carbohydrate content (64.38%) was recorded by application of RDF + ZnSO₄ @ 30 kg ha⁻¹ (T₄). It was seen that all the treatments except (RDF) 80:40:40 NPK kg ha⁻¹ (T₁) were statistically on par with each other and the lowest

carbohydrates content (56.55%) was reported on treatment (RDF) 80:40:40 NPK kg ha⁻¹ (T₁).

This results were shown due to the application of zinc with RDF is required for the carbohydrates metabolism; most enzymes that play a role in carbohydrates metabolism are activated by zinc. Carbonic anhydrase, fructose-1, 6 biphosphate and aldolase enzymes are activated by zinc. These enzymes are active in the chloroplast. The activity of these enzymes decreased zinc deficiency condition, in resulting carbohydrates accumulated in plant leaves.

These results were supported by the results obtained by Keram *et al.* (2014) [5] and suggested that application of ZnSO₄ with RDF will increase the carbohydrate content in wheat.

Table 2: Effect of zinc application on carbohydrate in wheat grains

Treatments	Carbohydrates content (%)
T ₁ Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha ⁻¹	56.55
T ₂ RDF + ZnSO ₄ @ 10 kg ha ⁻¹	59.01
T ₃ RDF + ZnSO ₄ @ 20 kg ha ⁻¹	60.32
T ₄ RDF + ZnSO ₄ @ 30 kg ha ⁻¹	64.38
T ₅ RDF + ZnSO ₄ @ 40 kg ha ⁻¹	62.24
T ₆ RDF + ZnSO ₄ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	63.31
T ₇ RDF + ZnSO ₄ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	63.67
SE (m)±	0.809
CD at 5%	2.455

Effect of zinc application on protein content in wheat

Proteins are the complex organic compounds which are macromolecules or biomolecules composed of amino acid linked by peptide bond. Protein is having relation with N content. Protein content (12.83%) was shown maximum in the treatment RDF + ZnSO₄ @ 30 kg ha⁻¹ (T₄) which was due to higher nitrogen content in grain. But the treatments did not get significant results. It was observed that there was an increase in Protein content higher than treatment (RDF) 80:40:40 NPK kg ha⁻¹ (T₁) and the lowest protein content

(12.31%) was reported on treatment (RDF) 80:40:40 NPK kg ha⁻¹ (T₁).

Yassen *et al.* (2010) [7] observed that the increased protein content with application of zinc and also these result were supported by the Zeidan *et al.* (2010) [8].

This might be due to zinc is essential element in enzyme structure involved in amino acid biosynthesis and because zinc is the main composition of ribosome and is essential for their development.

Table 3: Effect of zinc application on protein content in wheat grains

	Treatments	Protein content (%)
T ₁	Recommended dose of fertilizer (RDF) 80:40:40 NPK kg ha ⁻¹	12.31
T ₂	RDF + ZnSO ₄ @ 10 kg ha ⁻¹	12.49
T ₃	RDF + ZnSO ₄ @ 20 kg ha ⁻¹	12.60
T ₄	RDF + ZnSO ₄ @ 30 kg ha ⁻¹	12.83
T ₅	RDF + ZnSO ₄ @ 40 kg ha ⁻¹	12.66
T ₆	RDF + ZnSO ₄ Two foliar sprays @ (0.5%) First at pre flowering and second at milk stage	12.72
T ₇	RDF + ZnSO ₄ Two foliar sprays @ (1.0%) First at pre flowering and second at milk stage	12.77
	SE (m)±	1.069
	CD at 5%	NS

Conclusion

From the present investigation it is concluded that the application of ZnSO₄ @ 30 kg ha⁻¹ along with recommended dose of fertilizer at the time of sowing is significantly increased the test weight and carbohydrate content in wheat grain.

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