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Zinc sulphate a potential micronutrient for wheat growth: A review

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Abstract
Wheat is a major cereal and staple food crop of India. The productivity of wheat in India varies among the states. The highest productivity of wheat is in Punjab. The productivity of wheat varies with soils, genotypes, and input management like irrigation and the use of fertilizers. There is stagnation in the yield of wheat in various states of India over some time; however, by identifying sub-optimal conditions it is necessary to apply efficient scientific management that can improve the production of wheat to meet the future demand of food grain for food security in the country. Zinc is one of the important micronutrients essential for higher yields in cereals in spite of major nutrients like N, P and K. The sub-optimal applications of nutrients along with judicious irrigation are the two important parameters for higher yields considering plant protection measures. Among the literature surveyed it has been observed that monohydrate and heptahydrate zinc sulphateare important sources of zinc that have increased the yield of wheat grain and zinc content in grain and fodder. Zinc is generally recommended by the scientist in the form of $ZnSO_4.H_2O$ and $ZnSO_4.7H_2O$ to the wheat grower based on the zinc status of the soil.

Keywords: Fertilizer, production, yield, zinc

Introduction
Wheat (*Triticum aestivum*) is the second most important food crop after rice in the country, which contributes nearly one-third of total food grain production. It is consumed in the form of chapati, wheat straw used for cattle feed. Wheat contains more protein than other cereals and high in niacin and thymine. Wheat protein is called gluten which is essential for bakery products. Zinc is an essential element for the production of crop and optimal size of fruit, also required in the carbonic enzyme which presents in all photosynthetic tissues, and required for chlorophyll biosynthesis (Ali *et al.*, 2008; Graham *et al.*, 2000) [2, 13]. Most of the soils are deficient in micronutrients mainly in zinc due to mining of nutrients in continuous cropping, increasing demand of zinc by crops, geogenic low status of zinc in soil, etc., which results in poor crop yield and causes the problem in human health due to its deficiency. Zinc deficiency is related to soil pH and its value is very low in calcareous soils with high pH (Alam *et al.*, 2010; Alloway, 2008) [1, 3]. In wheat, zinc can be applied by foliar application, soil application, and seed treatment. Zinc can also be applied in chelated form. Zinc has its important role in the production of growth regulators for the vegetative and reproductive growth of plants. Zinc sulphate heptahydrate and monohydrate are the sources of zinc that decrease the cost of production with an increase in yield due to its low price as compared to other sources. The balanced use of major nutrients and recommended doses of zinc are responsible for higher productivity of wheat.

Zinc potential micronutrient
Zinc is a transition metal also known as heavy metal of atomic number 30 and 23rd abundant element on earth. It is important for auxin synthesis in plants. It synthesizes protein by activating some enzymes. It is also important in chlorophyll formation and carbohydrate metabolism. It helps in the growth of stems through elongation. Zinc helps to increases wheat yield by improving protein content. Zinc deficiency can reduce yield through leaf chlorosis leaf necrosis, leaf bronzing, stunting of plants, etc. Zinc deficiency in soilcan is corrected by application of zinc in soils, seed treatment, and foliar sprays. Zinc sulphate is available in various forms like Zinc sulphate monohydrate ($ZnSo_4.H_2O$)-33% Zn, Zinc sulphate heptahydrate ($ZnSo4.7H_2O$)-21% Zn, Chelated zinc (Zn EDTA)-9% Zn, Zinc coted urea (Zn urea)-2% Zn, Zinc oxide (ZnO)-60-80% Zn, Zinc carbonate ($ZnCO_3$)-52-56% Zn, Zinc chloride ($ZnCl_3$)-48-50% Zn, Zinc applied in small quantities i.e. 15-55 ppm on an average required to plant.

Effect of zinc sulphate on growth and yield of wheat

A series of recent studies have indicated that Indian soils are highly deficient in zinc. Due to zinc deficiency plant growth is inhibited and ultimately yields are reduced. Zinc deficiency in soils leads to low zinc content in wheat grain and straw.

Sharma *et al*., (2000) [24] conducted an experiment to determine the effect of N at 0, 40, 80, 120, and 160 kg ha^{-1} and Zn at 0, 5, and 10 kg ha^{-1} on wheat and observed that wheat responded only to 5 kg Zn ha^{-1}, and Zn at this rate resulted in 13.62% and 6.14% higher grain yield compared to the control and 10 kg Zn ha^{-1}, respectively. Also Sundar *et al*., (2003) [26] observed that grains per ear, test weight, grain, and straw yields increased significantly only up to 10 kg Zn ha^{-1}; beyond this level, adverse effects on the yield were observed. Grains per ear, test weight, grain, and straw yields were influenced by the soils and were highest with the application of 10 kg Zn ha^{-1}. Atak *et al*., (2004) [5] experimented on the effects of Zinc on the yield and yield components of wheat cv. Kiziltan-91 and they observed zinc application increased the grain yield, number of seeds spike-1, and seed weight spike-1 of the wheat crop. Chandrakumar *et al*., (2004) [7] found that combined application of RDF + FYM @10 t ha-1 + Soil application of ZnSO4 @10 kg ha-1 accumulated significantly higher dry matter in leaves, stem, and spikes and also recorded significantly higher dry matter production (297.10 g m-1 row length) and grain yield of wheat crop (38.65 q ha-1). According to Dewal and Pareek (2004) [8] The soil application of 10 kg Zn ha^{-1} exhibited higher plant height (89.5 cm), higher dry matter accumulation (242.4 g m^{-1} row), more number of effective tillers (94.2 m^{-1} row), maximum test weight (35.2 g), higher grain yield (37.2 q ha^{-1}) and straw yield (49.06 q ha^{-1}). Singh (2004) [25] was carried out a field experiment on wheat during the *rabi* season of 1998-2000 and observed the application of 5.0 kg Zn ha^{-1} significantly increased the growth and yield of wheat over the control, while it was at par with 6.25 and 7.5 kg Zn ha^{-1}. The highest ICBR 1:5.72 was estimated with 5.0 kg Zn ha^{-1}.A field experiment was carried out by Mahendra and Yadav (2006) [20] observed maximum growth and yield parameters of wheat were recorded with the application of 40 kg $ZnSO_4$ ha^{-1}. However, it was statistically at par with 30 kg $ZnSO_4$ ha^{-1}. Ranjbar and Bahmaniar (2007) [23] experimented to investigate the effects of soil and foliar application of Zn Fertilizer on Yield and Growth Characteristics of Bread Wheat (*Triticum aestivum* L.) and found that Zn had increasing effects on total dry matter, grain yield, 1000-grain weight, number of tillers, grain Zn content, flag leaf Zn content, plant height, number of nodes, protein content, and grain Fe content. Habib (2009) [15] conducted a field experiment on clay-loam soil to investigate the effect of foliar application of zinc and iron on wheat and the results showed that the foliar application of Zn and Fe increased seed yield and its quality compared with control. Among treatments, the application of (Fe + Zn) obtained the highest seed yield and quality. Hussain *et al*., (2010) [16] reported that the zinc content of wheat inherently low when it is grown on zinc deficit calcarious soils therefore to enrich wheat grain at the farmer field is the best solution against human zinc deficiency. Soil and foliar application of zinc to wheat in zinc deficient soils enhance both grain yield and grain zinc content. Gul *et al*. (2011) [14] conducted an experiment on the foliar spray of zinc in wheat and observed that the number of plants emerged m^{-2}, number of tillers m^{-2}, and plant height (cm) were significantly affected while the number of days to anthesis was not affected significantly by foliar spray. Dhaliwal *et al*. (2012) [9] conducted an experiment at Ludhiana and Hoshiarpur in sandy loam and loamy sand soils and they concluded that various plant parameters of wheat variety PBW 550 such as plant height, no of tillers m^{-2} increased with soil application of $ZnSO_4.7H_2O$ was applied @ 62.5 kg ha^{-1}. Zoz *et al*., (2012) [29] observed that the foliar application of zinc increased the number of fertile tillers and yield of wheat, however, have little effect on the agronomic characteristics of the no-tilled crop with high nutrient content in the soil. Keram *et al*., (2013) [17] concluded that the grain and straw yield, as well as harvest index, increased with the increasing levels of Zn as compared to N:P: K alone. Mathpal *et al*., (2015) [21] showed a marked difference in Zn accumulation and grain Zn content. Khattak *et al*. (2015) [19] observed that foliar application of zinc at 1.0% $ZnSO_4$ solution and 5 Kg $ZnSO_4$/ha soil application increased the yield and they also concluded that the zinc application increased the protein content in grains. Bhutto *et al*. (2016) [6] reported that the application of N:P: K 168:84:60 kg ha^{-1} with Zn 2.0 kg ha^{-1} as a foliar spray with the standard dose statically showed significant effect with an increasing number of tillers m^{-2}, plant height, spike length, number of grains $spike^{-1}$, seed index and grain yield. Khattab *et al*., 2016 [18] stated that dry matter of wheat increased by increasing rates of Zn above the optimum rate, the higher rates of Zn application decreased the dry weight of crop plants from the control had lower Zn concentrations. Ahmadi and David (2016) observed that the treatment combination (120 kg Nitrogen ha^{-1} + @ 30 kg Zinc ha^{-1}) gave the best results with respect to plant height, yield straw yield and test weight. Arif *et al*., (2017) [4] stated that the application of potassium fertilizer (375 $kgha^{-1}$) and zinc (15 $kgha^{-1}$) significantly improved the plant height, number of fertile tillers per unit area, spike length, number of spikelet's per spike, number of grains per spike, 1000-grain weight, biological yield, grain yield, and harvest index. Dahshowri *et al*., (2017) [10] concluded that Zn foliar application treatments significantly increased grain yield and its components of the two wheat cultivars as well as plant nutritional status and grain protein, Zn and Fe content. The highest Zn concentration and uptake in grain, and Zn use efficiencies were recorded with the application of 1.25 kg Zn/ha through Zn-EDTA as soil application + 0.5% foliar spray at maximum tillering and booting stage. Ghasal *et al*., (2017) [12].

Firdous *et al*., (2018) [11] showed that the effect of Zn application was significant on the grain yield (q/ha), straw yield (q/ha), and sterility percentage but had no effect on spike length, test weight, and Harvest index. Tao *et al*., (2018) [27] showed that HTS and zinc fertilizer had greater impacts on the strong gluten cultivar compared to the medium gluten cultivar. Vora *et al*., (2019) [28] reported that in sandy soils $ZnSO_4$ @20Kg ha^{-1} as a basal dose along with two sprays of $ZnSO_4$ @0.5% (50gm L^{-1} water) at heading and milking stages with RDF 120:60:60 NPK Kg/ha recorded higher yield as compared to other treatments like only RDF, $ZnSO_4$ @ 15 Kg ha^{-1} and $ZnSO_4$ 20 Kg ha^{-1}only through soil application. Paramesh *et al*., (2020) [22] suggested that 50% recommended dose of P (RDP) through phospho-enriched compost (PEC) + 50% RDP through fertilizer and soil application of 12.5 kg $ZnSO_4.7H_2O$ ha^{-1} + one foliar spray of 0.5% $ZnSO_4.7H_2O$ recorded significantly higher grain yield, straw yield and protein content.

Conclusion

From the overall review, it can be concluded that the deficiency of zinc varies from soil to soil due to various factors like mono-cropping of cereals, cereal after cereals, double cropping, multiple cropping patterns in agriculture no use or sub-optimal use of organics, calcarious soils, imbalanced use of fertilizer, etc. Therefore it is necessary to know the zinc deficiency in soil and the use of zinc fertilizer along with organic to maintain the sufficient level of zinc in soil from the various experimentation. It is concluded that zinc is very important for normal and luxurious physiological and reproductive crop growth to get improvement in qualitative and quantitative wheat yield.

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