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Pramod Lawate
Assistant Professor, RGSC, Barkachha, BHU, Mirzapur, Uttar Pradesh, India

Virendra Chavan
Research Associate, MPKV, Rahuri, MH, India

Pratik Sanodiya
Assistant Professor, FVAS, RGSC, Barkachha, BHU, Mirzapur, Uttar Pradesh, India

SK Prasad
Assistant Professor, Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India

Prabhat Tiwari
Teaching Associate, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, India

Savita Dewangan
Assistant Professor, Department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi, Uttar Pradesh, India

Correspondence
Pramod Lawate
Assistant Professor, RGSC, Barkachha, BHU, Mirzapur, Uttar Pradesh, India

Zinc Biofortification in Wheat: Boon for alleviating disorders in crops and human

Pramod Lawate, Virendra Chavan, Pratik Sanodiya, SK Prasad, Prabhat Tiwari and Savita Dewangan

Abstract
Wheat is a staple food of world, especially of developing countries, which lacks mechanism of zinc absorption, compared to pulses, more intention is therefore necessary to be given for the same. Micronutrient, zinc, deficiency affects one third population of world. Although it is not integral part like nitrogen, phosphorus and potash but recent arised deficiencies in soil, plants and of course in human beings ranged a bell of danger. Improper and imbalanced application of fertilizers, especially of N, P, and K lack of awareness among farmers about zinc and its application and prospects, are some major primary factors that prevent its application. Besides, this, it is also important for growth and development of plant and animals. Application of zinc is therefore necessary in wheat through different sources that are compatible for particular soil, management and its availability.

Keywords: Wheat, deficiency, growth and development, zinc

Introduction
Zinc (Zn) is an essential trace element for the growth and development of humans (Salgueiro *et al*; 2000; Brown *et al*; 2001) animals and plants (Broadley *et al*; 2007) and recent estimates shows that over two billion of the world population is affected by Zn deficiency (Cakmak *et al;* 2010a).

Wheat is one of the most grown and consumed worldwide crop and plays a crucial role in food security. It is growing under 220 Mha of area with 729 MT of production throughout the world. India, ranks first in area (30.5 Mha.) and second in production (95.9 MT), which is 24.5 Mha 157 MT respectively, in case of China (FAOSTAT, 2016). Development of short statured wheat varieties, adoption of intensive irrigation practices and heavy application of nitrogenous fertilizers which were directly responsible for green revolution era at 1965-67. During same time, most of the micro nutrients were neglected especially, Rice- Wheat grown area, by most of farmers as they were not directly responsible for yield expansion and zinc was one of them. Cereals, wheat, which is an integral part of human diet, lacks the mechanism of zinc absorption as compared legume thus realized deficiency of zinc in plants meanwhile in human as well as in soils also.

Besides to plants, Zn is also an essential nutrient for human beings and is estimated that 1/3 of the world population is affected by Zn deficiency that is associated with low dietary intake (Boonchuay, 2013). Zinc deficiency causes serious adverse impacts on human heath, especially in children, like impairments in physical growth, immune system, and learning ability, and causing DNA damage and cancer development (Keen and Gershwin 1990; Ho *et al;* 2003; Black *et al*; 2008) therefore; increasing Zn concentration of stable food crops is, an important humanitarian challenge. Zn deficiency affects, on average, one-third of the world's population, ranging from 4 to 73% in different countries (Hotz and Brown, 2004). Thus, the story of zinc deficiency and intensive research over it, started from here, mostly in of Rice-Wheat and only wheat growing regions in India.

Zinc (Zn) is an essential micronutrient, required for every crop and animals for functioning different physiological processes normally. The major functions played in all living systems by zinc are, maintenance of structural and functional integrity of biological membranes and helps to protein synthesis and gene expression (Alloway, 2008). Zinc deficiency is most widespread and pronounced in soils and ultimately in crops and their products, resulting in human and animals. But this deficiency is more seen in areas where cereals, especially, Rice-Wheat growing regions. This is because of nearly half of the soils on which cereals are grown have levels of available Zn low enough to cause Zn deficiency (Alloway, 2008).Being cereal grains have inherently low Zn concentrations, growing such crops on already Zn deficient soils results further decreases grain Zn concentration (Alloway, 2008). It is, therefore, well-documented Zn deficiency problem in humans founds predominantly in the countries/regions such as India, China, Pakistan and Turkey where soils are low in available Zn, and cereals are the major source of calorie intake (Alloway, 2008). Climate change brought different types of stress on crop. These environmental stress conditions require Zn in large amount to regulate and maintain the expression of genes needed to protect cells from the detrimental effects of stress (Cakmak, 2000).

The major role of zinc in crop production is, carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens (Alloway, 2008). Its deficiency in plants causes, stunting (reduced height), interveinal chlorosis (yellowing of the leaves between the veins), bronzing of chlorotic leaves, small and abnormally shaped leaves and/or stunting and rosetting of leaves (Alloway, 2008).

Biofortification is a process of increasing the bioavailable (the amount of an element in a food constituent or a meal that can be absorbed and used by a person eating the meal) concentrations of an element in edible portions of crop plants through agronomic intervention or genetic selection (Philip *et al;* 2005). In zinc biofortification, the key tools of the biofortification of zinc are fertilization, breeding, and biotechnology. Fortification of zinc by these methods although helps to improve zinc content, but its adoption depends on adaptability and technologies available. In present paper, all information gathered is regarding enriching of zinc in wheat by fertilization, both by foliar and soil application. For this we collected various papers from various journals tried to compile their findings regarding effects of zinc on wheat growth, yield parameters and yield.

Effect of Zinc on Growth, Yield Parameters and Yield of Wheat

Growth of wheat is an important parameter being further development and final yield is mostly depend on well grown wheat if it's not affected by any type of stress, besides its responses to all other growth factors. Under this, the growth parameters are being influenced by various doses of zinc either soil or foliar or both, are described from various research papers.

Application of different forms of zinc, its method of application, type and or variety of crop, stage of crop at which zinc is applied, concentrations of zinc, various soil reactions*etc.* are some factors that differentiate in their wheat yield levels and their different efficiencies. Yilmaz *et al*; (1997) in his experiment applied zinc in wheat by following methods: a) control (no Zn application), b) soil, c) seed, d) leaf, e) soil + leaf, and f) seed + leaf applications and they found, application of Zn significantly increased grain yield in all cultivars irrespective of the method. Significant effects of Zn application methods were also found on the yield components, i.e., spike number·m-^{2}, grain number-spike-^{1}, and thousand kernel weight. Spike number·m-2 was affected most by Zn applications, particularly by soil and soil + leaf applications. Compared to the control, increases in grain yield were about 260% with soil, soil + leaf, and seed + leaf, 204% with seed and 124% with leaf application of Zn. In a similar manner, biomass production (dry weight of above-ground parts) was increased by Zn treatments. Shivay *et al*; (2008) observed that, Zn-enrichment of urea either with $ZnSO_4$ or ZnO was equally effective for increasing the productivity of wheat and increasing Zn concentrations and uptake by the wheat grain with higher recovery of their application. But as concentration of zinc was increased from 0.5 to 2%, the agronomic and crop recovery efficiency of applied Zn was found to be decreased.

Dhar *et al;* (2011), found that soil application of 25 kg $ZnSO_4$ ha^{-1}+ 2 foliar spray at booting after anthesis @ 2.0 kg $ZnSO_4$ ha^{-1}each or 2 foliar spray at boot and after anthesis @ 0.2% $ZnSO_4$ each until all leaves are totally wet gave higher grain yield (4.21q ha^{1}and 4.32 q ha^{-1}respectively) over control (3.94 q ha^{-1}). Shaheen *et al;* (2007),conducted a pot experiment with two rates of zinc zero(0) ppm per pot (Zn_0) and 10 ppm zinc per pot (Zn_{10}) as $ZnS0_4$ were applied in solution in each pot and reported that panicle length(cm), weight of 1000 grains (g), Grain yield (g pot^{-1}) and straw yield (g pot^{-1}) were 9.41, 32.37, 8.62 and 14.85 respectively in 10 ppm Zn per pot over control 8.86, 31.17, 7.27 and 12.98 respectively. Gopal *et al.*2012, conducted apot culture experimentto study the effect of zinc (Zn) on biofortification of wheat (*Triticum aestivum* L.) with a basal dose of 20 mg Zn kg^{-1} and two foliar sprays of zinc sulfate ($ZnSO_4$) 0.5% at the pre flowering stage and 7 days after flowering and hefound that, application of Zn (20 mg Zn kg^{-1}) with two foliar sprays also proved beneficial for maximizing Zn concentrations of grains and other plant parts.

Yang *et al;* (2011) observed that, Zn application in soil have mixed effect in increasing grain Zn concentration in wheat which increased by 21% in some cultivars, while decreased in some cultivars. But, foliar application of Zn increased grain Zn concentration in all wheat cultivars ranging from 26 to 115%. Grain Zn concentration in wheat ranged from 33.3 to 59.7%. Ozturk *et al;* (2006), studied changes in grain concentration of Zn in wheat during the reproductive stage and found that the highest concentration of Zn in grain occurs during the milk stage of the grain development. Cakmak *et al*; (2010) reported that, timing of foliar Zn application is most important for increasing grain Zn in wheat, especially in the endosperm part, which is the predominant grain fraction consumed in many countries and also providing a large pool of Zn in vegetative tissues during the grain filling (e.g., via foliar Zn spray) is an important practice to increase grain Zn and contribute to human nutrition. Zhang *et al;* (2012) conducted field experiment to examine the effects of soil and foliar Zn application (0, 0.2, 0.4 and 0.5%) with or without foliar urea application on Zn nutrition in whole grain and reported that the grain Zn concentration was positively correlated with foliar Zn rates. Khan *et al*; (2007) reported that the number of tillers, spike/m^{2}, spike length, plant height and 1000 grain weight and grain yield of wheat were significantly increased with 5 kg Zn/ha over control. Zeidan *et al;* (2010) reported that highest number of spikes/m^{2}, number of grains/spike and the highest grain and straw yields (kg/4200 m^{2}) were obtained with 0.5% Zn foliar application.

From above discussions, it is concluded that, Zinc is an equally important as major nutrients. Its deficiency is reflected through plant, animals and soils. Deficiency of zinc micronutrients, a key barrier in augmenting crop productivity and human health. Zinc deficiency ranks first along with Vitamin A. Organic intervention –increase use efficiency & arrest the tendency of emergence of its deficiency. Biofortification of wheat is required to address the problem of micronutrients deficiency in human. Zinc in fertilizers can significantly enhance the quality and yield of crops. It's necessary to increase the zinc content in crops human and animals, particularly in the developing countries. For this zinc should be applied on principle of feeding to soil rather than plant and animals for sustained and nutritious food.

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