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EFFECT OF ZINC APPLICATION ON BIOFORTIFICATION IN WHEAT

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ABSTRACT

Zn biofortification is a technique in which the inherent Zn status of the edible portion of plants is improved by simply spraying a Zn solution onto the crop or through a soil application at a predetermined stage and a proper dose. The concentration of Zn within a wheat grain is genotype-dependent and interacts with the environment, inducing variation in a grain's concentration of micronutrients. A pot experiment was conducted in net house during 2019 with wheat in alluvial soil. The experiment was conducted in pots in net house with 12 treatments having first 6 treatments (T_1-0,T_2-10,T_3-20,T_4-30,T_5-40,T_6-50) kg Zn / ha+ soil application alone at 6 levels and last 6 treatments (T_7-0 ,T_8-10,T_9-20,T_{10}-30,T_{11}-40,T_{12}-50) kg Zn/ ha+ soil +0.5% Foliar Spray(FS) and among the zinc levels, maximum zinc content recorded with30 kg+ 0.5% FS as 43.47ppm and minimum zinc content recorded with control as 0 kgZn/ha as 28.38ppm.

KEYWORDS: Zinc, Biofortification, Wheat

In India, wheat is the second most important staple cultivated food crop after rice and consumed by nearly 65% of the population (Mishra *et al.*, 2005) and ranks first in dietary shares in northern India represented by Gangetic plains (Joshi *et al.*,2007). Zinc plays a significant role in various enzymatic and physiological activities and performs many catalytic functions in plants besides transformation of carbohydrates, chlorophyll, nitrogen metabolism, protein synthesis (Alloway, 2008) and synthesis of tryptophan, which is precursor of indole acetic acid (Tsui, 1988). Zinc is essential for all humans, animals (Broadley *et al.*, 2007) and plants (Prasad, 2008). It is vital for the proper functioning of the immune system and crucial for healthy growth, physical and mental development of children.

Biofortification focuses on enhancing the Zn nutritional qualities of crops at source, which encompasses processes that increase both Zn levels and their bioavailability inthe edible part of staple crops. So now biofortification (breeding, biotechnology and agronomic practices) of food crops with micronutrients is receiving attention (Bouis and Welch, 2010). Fertilization of food crops with Zn represents a short term and complementary strategy, which is necessary to build the Zn pool for uptake or translocation (Cakmak, 2008). The soil and foliar Zn application *i.e.* keeping sufficient amount of available Zn in soil solution (by soil application of Zn) and in leaf tissues (by foliar application of Zn) which greatly contributes to maintenance of adequate root Zn uptake and transport of Zn from leaf tissue to the seeds during reproductive growth stage (Cakmak, 2012). Therefore a experiment was conducted to study the effect of soil and foliar application on biofortification of wheat in alluvial soil.

METHODS AND MATERIALS

A pot experiment was conducted with 12 treatments with wheat in alluvial soil during 2019. Treatments are ;first 6 zinc levels (0,10,20,30,40,50 kg Zn/ha) as soil application and last 6 levels of zinc (0+FS,10+FS,20+FS,30+FS,40+FS,50+FS kgZn/ha) as soil application + 0.5 % foliar application.

Soil moisture was maintained the field capacity by regular weighing the pots. Irrigation was given throughout the experiment period to keep the soil moist. At maturity, clean plants were harvested by cutting at above the soil surface by using a stainless steel scissors and grain samples were separated from wheat plant. The dried grain and straw samples were then finely ground in a grinder for laboratory analysis. Total N was determined by semi micro-kjeldhal method and zinc content was determined by using AAS in diacid digest of plant samples (Jackson, 1973).

RESULTS

The application of $ZnSO_4$with various combinations of 12 treatments having first 6 treatments only with soil application and last 6 treatments with soil+ 0.5% foliar application. It has been applied in the wheat crop to find the effect of this treatment on yield. The completely randomized design has been obtained to find out the effect of zinc on grain and straw yield and zinc content in grain. It have been described in the present study. The separate analysis has been carried out for the

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wheat grain and straw yield and zinc content in grain. Effect of various treatments has been shown in the Table 1 and 2.

Grain Yield (mg/kg)

The analysis of data in Table 1 showed that zinc levels had significant effect on grain yield of wheat. Maximum grain yield 34.50mg/kg was recorded with 30 kg + 0.5%FS which was significantly higher than 20kg+0.5% FS as 33.70mg/kg, 10 kg + 0.5% FS as 27.87mg/kg, 30 kg as 31.97mg/kg and minimum grain yield 25.37mg/kg was recorded with 0 kg.

Foliar application of zinc with and without basal dose significantly increased in grain yield but application of 40 kg and 50kg zinc sulphate kg/ ha failed to increase grain yield. Application of 30 kg + 0.5% FS significantly increased the grain yield as compared to 20 kg + 0.5%FS, 10 kg + 0.5%FS and control 0 kg respectively. Yield is a function of complex inter-relationships of its components, which are determined from the growth rhythms in vegetative phase and its subsequent reflection in reproduction phase of the plant. The significant improvement in the growth characters and yield components ultimately resulted in higher grain. The favorable influence of soil and foliar applied zinc on grain yield, straw yield and biological yield is attributed to its catalytic or stimulatory effect on most of the physiological and metabolic process of plants (Mandal *et al*., 2009 and Dhaliwal *et al*., 2009). Participation of Zn in biosynthesis of indole acetic acid (IAA) and its role in initiation of primordial reproductive parts and partitioning of photosynthates towards sink are responsible for increased yields. These results are in agreement with finding of Gopal and Nautiyal (2012), Zou *et al*. (2012), by Bharti *et al*. (2014), Gomez-Coronado *et al*. (2016).

Grain yield was significantly superior grain yield under the levels of zinc. The response of crop to different levels of zinc application, in terms of grain yield seems to be positive. (Boorboori *et al*., 2012) expressed that foliar application of zinc increased grain wheat yield. The increase in the grain yield is attributable to the improved physiology of plants with the added Zn consequently correcting the efficiency of chlorophyll content and improvement in nitrate conversion to ammonia in plant leading to higher yield (Hacisalihoglu *et al.*, 2003; Abbas *et al.*, 2009). Ranjbar and Bahmaniar (2007) reported that soil and foliar application of Zn fertilizer alone were not as effective as soil along with foliar applications to increase yield (Firdous *et al.*, 2018).

Straw Yield (mg/kg)

Zinc levels had significant effect on straw yield of crops. Among zinc levels, higher straw yield 50.43mg/kg was achieved with 30 kg + 0.5% FS and followed by 20 kg + 0.5% FS as50.03mg/kg, 10kg + 0.5% FS as 41.10mg/kg and lower straw yield recorded with control 0kg as 39.15mg/kg.

The significant improvement in the growth characters and yield components ultimately resulted in straw yields.

Soil application of 5 mg/kg soil along with foliar application of 0.5% zinc sulphate solution increased the grain yield, straw yield and total dry matter as compared to soil application of 5 mg/kg soil alone whereas the increment was in comparison to foliar spray of 0.5% zinc sulphate solution. (Mathpal *et al*., 2015; Keram *et al*., 2013) also reported that the straw yield of wheat was significantly increased with the application of zinc.

The grain and straw yield of wheat increased significantly with the increase in the applied zinc level from 0 to 30 kg. The maximum grain and straw yield was obtained with the application of 30 kg and minimum with no zinc. This increased yield due to Zn may be attributed to its function as catalyst or stimulant in most of the physiological and metabolic processes and metal activator of enzyme, resulting in increased growth and development of plant, which ultimately gave higher grain and straw yields of wheat (Pandey and Chauhan 2016).

Zinc Content in Grain (ppm)

The critical assessment of data in Table-2 reflected that zinc content in grain was influenced significantly with zinc levels .Among the zinc levels, maximum zinc content recorded with 30 kg + 0.5%FS as 43.47ppm followed by 20 kg + 0.5%FS as 40.87ppm, 10 kg + 0.5%FS as 33.90ppm and minimum zinc content recorded with control 0 kg as 28.38ppm.

Among the tested varieties of wheat, higher Zn concentration was found in grain as compared to straw. The higher Zn concentration in wheat grain than straw showed that Zn is easily mobilized to sink, i.e. grain. Similar findings have been reported by Prasad *et al.* (2012). Foliar Zn spray is an effective way for biofortification of wheat grains with Zn. A synergistic external foliar supply Zn source is more effective than Zn-only spray in increasing grain Zn concentration and bioavailability (Xia *et al*. 2018).

Application of Zn as $ZnSO_4$ to soil or foliar application is an effective way to increase grain Zn concentration with remarkable yield increase. Applying Zn with macronutrient fertilizers or at higher rates will give optimum yield and higher grain Zn concentration. Similarly, applying Zn for ≈ 100% relative grain yield will greatly increase grain Zn concentration (Hussain *et al*.,2010). There was 83.5 % increase in grain Zn concentration by foliar Zn application alone, while soil Zn application was less effective .Such marked increases in grain Zn by foliar Zn application would have important contributions to improving dietary intake of Zn by human beings. Application of foliar Zn fertilizers represents a short-term solution to the problem, while plant breeding is rather long-term solution (Bouis and Welch 2010). In contrast to foliar Zn applications, soil Zn application was not effective in increasing grain Zn by more than 10 mg kg^{-1}. Liu *et al*. (2014) highlighted that increase in protein content and grain zinc content is mostly parallel to each other. Abdoli *et al*., (2014) reported that zinc foliar application increased grain zinc concentration. Kutman *et al*. (2011) and Zhang *et al*. (2012) described that accumulation of zinc in vegetative tissue had a positive correlation with increase in grain zinc concentration up to 30 mg kg^{-1}. Abdoli et *al*. (2014) and Jiang *et al*. (2008) also noticed a three-fold increase in grain zinc content in comparison with control from 18.7 to 50 mg kg^{-1}. Up to 83.5% increase in grain zinc content was reported by Zou *et al.* (2012) who recorded almost consistent results over a wide range of 23 locations in seven different countries with their local cultivars and agronomic practices. Waters *et al.* (2009) and Liu *et al.* (2014) discussed the source and sink limitations in grain zinc accumulation. They emphasized that zinc translocation towards grains was not proved to be the limiting factor. Thus grains could accumulate quite high amounts of zinc by increasing its supply. Zhao (2011) also recommended that foliar application of zinc was preferable as it could increase yield attributes and grain zinc content up to 80%. Karim *et al.*, (2012) reported a simultaneous increase in yield and grain zinc content in wheat. Cakmak *et al*. (2010b) reported that 10 mg kg^{-1} increase in grain zinc concentration was sufficient to combat zinc deficiency while foliar application increased grain zinc up to 20 mg kg^{-1}. This was helpful in achieving targeted levels of zinc in cereal grains (Noreen *et al.* 2018).

The results revealed that Zn content in grains increased significantly according to levels of Zn application in soil. The control treatment, i.e. no Zn application had lower Zn content in grain. The treatment receiving foliar spray of 0.1% Zn showed maximum increase in Zn grain content (39.8 mg kg^{-1}). This increase in grain Zn was 84.8 % over the control (no Zn application). Many studies on wheat crop indicated that movement of Zn from vegetative parts to the developing grains presents the phloem involvement in Zn transport. It was reported that in field situations the Zn content in grain increased up to many folds with the application of Zn fertilizers. It was reported that there is significant increase in Zn content of wheat grain and also in its yield by applying Zn fertilizers or Zn coated fertilizers to the soil (Saleem *et al*. 2015).

Table 1: Effect of zinc levels on grain yieldmg/kg and straw yield mg/kg of wheat

Treatments	Grain yield mg/kg	Straw yield mg/kg
T_1	25.37	39.15
T_2	26.83	39.85
T_3	31.10	46.08
T_4	31.97	47.45
T_5	29.53	43.30
T_6	28.77	42.32
T_7	26.60	39.50
T_8	27.87	41.10
T_9	33.70	50.03
T_{10}	34.50	50.43
T_{11}	33.13	49.12
T_{12}	32.50	47.82
SEm±	1.02	1.69
CD (at 5%)	2.11	3.49

Table 2: Effect of zinc levels on total zinc content (ppm) in wheat grain

Treatment	Zinc content (ppm)
	2019
T_1	28.38
T_2	30.15
T_3	36.63
T_4	38.33
T_5	36.73
T_6	35.67
T_7	32.47
T_8	33.90
T_9	40.87
T_{10}	43.47
T_{11}	42.20
T_{12}	41.20
SEm±	1.49
CD (at 5%)	3.07

Application of Zn to soils and/or foliage represents a very useful and rapid approach in enrichment with Zn of wheat grains. Grain Zn concentration increased from28.38 mg kg^{-1} to 35.67 mg kg^{-1} with soil Zn application and to 43.47 mg kg^{-1} with combined application of $ZnSO_4$ to soil and foliar. An increase in grain Zn concentration by application of foliar Zn fertilizers was more pronounced when Zn was applied as basal dose.

REFERENCES

Abdoli M., Esfandiari E., Mousavi S.B. and Sadeghzadeh B., 2014. Effects of foliar application of zinc sulfate at different phonological stages on yield formation and grain zinc content of bread wheat (cv. Kohdasht). Azarian J. Agric., **1**(1):11–6.

Alloway B.J., 2008. Zinc in soils and crop nutrition. 2nd editios. International Zinc Association and International Fertilizer Association, Brussels, Belgium and Paris, France, pp.223- 225.

Bouis H.E. and Welch R.M., 2010. Biofortification a sustainable agricultural strategy for reducing micronutrient malnutrition in the global south. Crop Science, **50**: S20- S32.

Broadley M.R., White P.J., Hammond J.P., Zelko I. and Lux A., 2007. Zinc in plants. New Phytologist, **173**(4): 677-702.

Cakmak I., 2008. Enrichment of cereal grains with zinc: agronomic or genetic bio-fortifications. Plant and Soil, **302**: 1-17.

Cakmak I., 2012. Harvest Plus zinc fertilizer project: Harvest Zinc. Better Crops with Plant Food, **96** (2), 17-19.

Joshi A.K., Mishra B., Chatrath R., Ortiz Ferrara G. and Singh R.P., 2007. Wheat improvement in India: present status, emerging challenges and future prospects. Euphytica, **157**: 431-446.

Mishra B., Shorean J., Chatrath R., Sharma A.K., Gupta R.K., Sharma R.K., Singh R., Rane J. and Kumar A., 2005. Cost effective and sustainable wheat production technology. Directorate of wheat research, Karnal, Technical Bulletin, **8**: 1.

Prasad A.S., 2008. Zinc in human health: effect of zinc on immune cells. Molecular Medicine- Cambridge Ma then New York, **14**(5-6): 353-357.

Saleem I., Javid S., Ehsan S., Niaz A., Bibi F. and Ahmed Z.A., 2015. Improvement of Wheat Grain Zinc and Zinc Daily Intake by Biofortification with Zinc. International Journal of Plant & Soil Science, **8**(5): 1-6, Article no.IJPSS.19739ISSN: 2320-7035.

Tsui C., 1988. The effect of zinc on water relation and osmotic pressure of the plant. American Journal of Botany, **35**: 309-311.

Xia H., Xue Y., Kong W., Tang Y., Li J., and Li D., 2018. Effects of source/sink manipulation on grain zinc accumulation by winter wheat genotypes. Chilean Journal of Agricultural Research; doi: 10.4067/S0718-58392018000100117.

Abbas G., Khan M.Q., Jamil M., Tahir M. and Hussain F., 2009. Nutrient uptake, growth and yield of wheat (*Triticum aestivum*) as affected by zinc application rates. Int. J. Agric. Biol., **11**: 389-396.

Bharti K., Pandey N., Shankhdhar D., Srivastava P.C. and Shankhdhar S., 2014. Effect of different zinc levels on activity of superoxide dismutases and acid phosphatases and organic acid exudation on wheat genotypes. Physiology and Molecular Biology of Plants, **20**(1): 41-48.

Boorboori M.R., Eradatmand A.D. and Tehrani M., 2012. The Effect of Dose and Different Methods of Iron, Zinc, Manganese and Copper Application on Yield Components, Morphological Traits and Grain Protein Percentage of Barley Plant (*Hordeum vulgare* L.) in Greenhouse Conditions. J. Advances in Environmental Biology, **6**(2): 740.

Cakmak I., Kalayci M., Kaya Y., Torun A.A., Aydin N., Wang Y., Arisoy Z., Erdem H., Yazici A., Gokmen O., Ozturk L. and Horst W.J., 2010b. Biofortification and localization of zinc in wheat grain. J. Agric. Food Chem., **58**: 9092-9102.

Dhaliwal S.S., Sadana U.S., Manchanda J.S. and Dhadli H.S., 2009. Biofortification of wheat grains with zinc and iron in typic ustochrept soils of Punjab. Indian Journal of Fertilsers, **5**(11), 13-16.

Firdous S., Agarwal B.K. and Chhabra V. (2018)." Zinc-fertilization effects on wheat yield and yield components". Journal of Pharmacognosy and Phytochemistry, 7(2): 3497-3499.

Gomez-Coronado F., Poblaciones M.J., Almeida, Ana S. and Cakmak I., 2016. Zinc concentration of bread wheat grown under Mediterranean conditions as affected by genotype and soil/foliar Zn application. Plant and Soil, **401**(1-2): 331-346.

Gopal R. and Nautiyal N., 2012. Variability in response to zinc application in 10 high-yielding wheat varieties. Communications in Soil Science and Plant Analysis, **43**:1930–1937.

Hacisalihoglu G., Hart J.J., Wang Y.H., Cakmak I. and Kochian L.V., 2003. Zinc efficiency is correlated with enhanced expression and activity of zinc-requiring enzymes in wheat. Plant Physiology, **131**: 595-602.

Hussain S., Maqsood A. M. and Rahmatullah, 2010. Increasing grain zinc and yield of wheat for the developing world. Emir. J. Food Agric., **22**(5): 326-339.

Karim M. R., Zhang Y.Q., Zhao R.R., Chen X.P., Zhang F.S and Zou C.Q., 2012. Alleviation of drought stress in winter wheat by laten foliar application of zinc, boron, and manganese. Journal of Plant Nutrition and Soil Science, **175**: 142-151.

Keram K.S., Sharma B.L., Sharma G.D. and Thakur R.K.D., 2013. Impact of zinc application on its translocation into various plant parts of wheat and its effect on chemical composition and quality of grain. Scientific Research and Essays, **8**(45): 2218-2226.

Jiang W., Struik P.C., Keulen H.V., Zhao M., Jin L.N. and Stomph T.J., 2008. Does increased zinc uptake enhance grain zinc mass concentration in rice?. Annals of Applied Biology, **153**:135-147.

Kutman U.B., Yildiz B. and Cakmak I., 2011." Effect of nitrogen on uptake, remobilization and partitioning of zinc and iron throughout the development of durum wheat. Plant Soil, **342**: 149-164.

Liu N., Zhang Y., Wang B., Xue Y., Yu P., Zhang Q. and Wang Z., 2014. Is grain zinc concentration in wheat limited by source? Australian Journal of Crop Science, **8**(11): 1534-1541.

Mandal L., Maiti D. and Bandyopathyay P., 2009. Response of zinc in transplanted rice under integrated nutrient management in new alluvival zone of west Bengal. Oryza, **46**(2): 113-115.

Pandey M. and Chauhan M., 2016. Effect of sulphur and zinc on yield, quality and uptake of nutrients in barley. Annals of Plant and Soil Research, **16**(1): 74-78.

Prasad R., Shivay Y.S. and Kumar D., 2012. Biofortification/ fertifortification of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) for ameliorating zinc malnutrition for humans and animals in India. Indian Journal of Agronomy, **57** (3rd IAC Special Issue): 195–8.

Ranjbar G.A. and Bahmaniar M.A., 2007. Effects of soil and foliar application of Zn fertilizer on yield and growth characteristics of bread wheat (*Triticum aestivum*L.) cultivars. Asian Journal of Plant Sciences, **6**(6): 1000-1005.

Waters B.M., Uauy C., Dubcovsky J. and Grusak M.A., 2009. Wheat (*Triticum aestivum*) NAM proteins regulate the translocation of iron, zinc, and nitrogen compounds from vegetative tissues to grain. Journal of experimental botany, **60**:4263-4274.

Xia H., Xue Y., Kong W., Tang Y., Li J. and Li D., 2018. Effects of source/sink manipulation on grain zinc accumulation by winter wheat genotypes. Chilean Journal of Agricultural Research, doi: 10.4067/S0718-58392018000100117.

Zhang Y.Q., Deng Y., Chen R.Y., Cui Z.L., Chen X.P., Yost R., Zhang F.S. and Zou C.Q., 2012. The reduction in zinc concentration of wheat grain upon increased phosphorus-fertilization and its mitigation by foliar zinc application. Plant and Soil, **361**(1–2):143–52.

Zhao A., Lu X., Chen Z. and Yang X., 2011. Zinc Fertilization Methods on Zinc Absorption and Translocation in Wheat. Journal of Agricultural Science, **3**(1): 28-35.

Zou C.Q., Zhang Y.Q., Rashid A., Ram H., Savasli E., Arisoy R.Z., Ortiz-MonasterioI.,Simunji S., Wang Z.H., Sohu V., Hassan M., Kaya Y., Onder O., Lungu O., Mujahid M.Y., Joshi A.K., Zelenskiy Y., Zhang F.S. and Cakmak I., 2012. Biofortification of wheat with zinc through zinc fertilization in seven countries. Plant and Soil, **361**: 119-130.