Effect of Zinc Fortification on Growth, Yield and Economics of Wheat (*Triticum aestivum* L.) Under Irrigated Condition

ABSTRACT

In soil zinc (Zn) deficiency is a serious constraint affecting the yield and nutritional quality of wheat and, in turn, human health. Zn fertilization for enhancing its uptake in grains is a prominent technological solution for the problem. Accordingly, the present field study was undertaken to assess the impacts of different Zn fertilization on growth, yield and economics returns of wheat at Regional Research Sub Center NARP, Saini, Kaushambi, UP during *Rabi* season of 2020-21. Five Zn treatments (control, 5 kg zinc/ha, 7 kg zinc/ha, 10 kg zinc/ha and 5 kg zinc/ha+2 two foliar spray @5%of Zn So_4 at tillering and before flowering) were taken in randomized complete block design with three replication. Results showed that relative effectiveness of different Zn fertilization was varied for the crop attributes studied. Soil + foliar fertilization was superior in increasing grain yield (9.88% over the control). Moreover, for an optimum balance among all the tested attributes including Plant height, crop dry weight, yield attributes, yield, HI and returns and Zn content in grain were significantly higher under soil fertilization combined with foliar Zn fertilization (T5) over other treatments. Therefore, the outcomes of this study can provide a guideline for sustainable and quality wheat production, which will help address the malnutrition challenge.

Key words: *Economics; Protein; Wheat; Yield; Zinc*

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Introduction

Wheat is the leading staple food in the world, particularly in developing countries, which lacks a mechanism of zinc absorption; when compared to pulses, more attention is consequently important to be given to the wheat crop. Micronutrient deficiencies and especially zinc (Zn) deficiency influences one-third of the world population. In addition to this, it is also essential for the growth and development of plants (*Sher et al., 2022*). Zn deficiency in soils of India is widespread and crops grown in these soils suffer from poor yield. A close relationship exists among soils, crops and human health nutrition (*Layek et al., 2017*). According to the World Health Organization, about 8 lakh people die annually due to zinc malnutrition, among which more than 50% are children below five years of age. Cereal grains are inherently low both in concentration and bioavailability of Zn, particularly when grown on potentially Zn-deficient soils. Zinc deficiency has been associated with poor growth, depressed immune function, increased susceptibility to and severity of infection, adverse outcomes of pregnancy, and neurobehavioral abnormalities (*Dhaliwal et al., 2019*). There is a close geographical overlap between global distribution of zinc deficiency in soil and humans which highlights the core linkage among agriculture, food crops and human health (*Kumssa et al., 2015*). 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*). Wheat is responsible up to 70 per cent of daily calorie intake of the population living in rural regions and an important source for zinc for human beings living in the developing world (*Cakmak, 2008 and Cakmak et al., 2010*).

Fortification is the practice of deliberately increasing the content of an essential micronutrient, i.e. vitamins and minerals (including trace elements) in a food, so as to improve the nutritional quality of the food supply and provide a public health with minimal risk to health. There are basically two ways to increase zinc concentration in food grains, namely genetically breeding crop cultivars that absorb and transmit more zinc to grains biofortification or fertilizing crops with zinc ferti-fortification (*Cakmak and Kutman, 2018*). Zinc biofortification is the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding or modern biotechnology. Ferti-fortification is a solution to increase zinc concentration in wheat grains. It involves the application of fertilizers to grain, soil and foliage for maximum yield to increase the uptake of nutrients into the plants and its translocation into grains. So as to increase the zinc concentration in wheat is the best way on agronomic level is ferti-fortification (*Rehman et al., 2018*). Application of zinc fertilizer in soil having low zinc increased the grain yield in wheat up to 6.4-50%. Now-a-days, the requirement is high wheat yield together with high zinc content in wheat grain. So, to accomplish a part of this study, it is proposed to explore the possibility of agronomic biofortification for enhancing the Zn content of wheat through ferti-fortification of wheat crops with Zn at appropriate dose and time during its growth.

METHODOLOGY

A fixed plot field experiment was carried out at Regional Research Sub Center NARP, Saini, Kaushambi, UP during Rabi season of 2020-21. This region comes under subtropical, climate with moderate rainfall. The soil of the experimental site falls under alluvial clay loam in texture, well drained and moderately fertile with good facility of irrigation. The experimental soil are with soil pH (7.58), low in organic carbon and available nitrogen and medium in available phosphorus, potassium and Zn (0.43 ppm). It was laid out in a Randomized Block Design with three replications and four zinc treatments (5 kg zinc/ha, 7 kg zinc/ha, 10 kg zinc/ha and 5 kg zinc/ha+2 two foliar spray @5%of Zn So_4 at tillering and before flowering) were applied along with control. The crop was sown on 12 December 2020 in 5m x 4 m^2 at 22.5 cm row spacing with seed-cum-ferti-drill. The 120+60+40 kg ha^{-1} N, P_2O_5 and K_2O, respectively were applied. As basal, half dose of nitrogen and full dose of phosphorus and potassium were applied in the form of urea, DAP and MOP. Remaining dose of nitrogen in the form of urea was applied in 2 equal split at jointing and before flowering. The zinc was applied as both soil as well as foliar spray as per the treatments. All the dada of growth and yield was recorded at the harvest. Cost incurred for completing experiment and returns was calculated based on the local market price (Grain Rs.18/kg and straw Rs. 2.50/kg). Recorded data was statistically analyzed by standard statistical procedure to draw a valid conclusion.

RESULTS AND DISCUSSION

Crop growth

Improvement in growth characters was observed with increasing the Zn level. The maximum plant height and crop dry matter was recorded with treatment T5 (5 kg zinc/ha+2 two foliar spray @5%of $ZnSO_4$ at tillering and before flowering) in comparison to 5 kg zinc/ha (T2) and 7 kg zinc/ha (T3) and it was statistically at par with (T4)10 kg zinc/ha (Table 1) while, the statistically lowest plant height and crop dry matter was recorded under control (T1), where zinc was not applied. The increase in plant height and crop dry matter was due to more availability and absorption of Zn from soil solution as well as foliar application which results in fastens the auxin metabolism, synthesis of cytochrome and stabilization of ribosomal fractions, faster the cell division and cell elongation and there was also increase in the rate of photosynthesis and chlorophyll formation due to the Zn which led to the increase in plant height (*Layek et al., 2017* and *Dhaliwal et al., 2019*).

Yield attributes

Different wheat yield attributes were significantly influenced by the application of Zn fertilization. The effective tillers, number of grain per spike and 1000 grain weight as affected by different treatments have been summarized (Table 1). The outcome of different soil and soil + foliar applied treatments was found significant. The number effective tillers, grains per spike and 1000 grain weight was recorded significantly maximum under the treatment T_5 (5 kg zinc/ha+2 two foliar spray @5% of $ZnSO_4$ at tillering and before flowering) in comparison to other zinc treatments (T_1, T_2, T_3) and statistically at par with the treatments T_4 (10 kg zinc/ha). This was due to the application of Zinc through soil as well as foliar which results in the reduction of adverse effects of salinity stress at both vegetative and reproductive stages of wheat. Thease results are corroborated with the research results of *Rehman et al. (2018)* and *Sher et al. (2022).*

Yield and harvest index

Agronomic biofortification of wheat grains with Zn through its foliar application is an instant mode to increase the Zn concentration in wheat grains. The grain yield, straw yield, biological yield and harvest index was significantly influenced by the different Zn treatments over control (Table 1). The maximum yield and harvest index was recorded with the application of 5 kg Zn/ha+2 two foliar spray @5% of $ZnSO_4$ at tillering and before flowering over T2 and T3 Zn treatments and it were statistically at par with the treatments T_4 (10 kg Zn/ha). This was due to the application of Zinc through soil as well as foliar which results in the reduction of adverse effects of salinity stress at both vegetative and reproductive stages of wheat. Foliar application of nutrients is an important crop management strategy to maximize crop yields

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(*Dhaliwal et al., 2019*). Foliar application of Zn had a significant positive effect on wheat grain yield and its components, as well as quality of grains (*Esfandiari et al., 2016*).

Zinc and protein content in grains

The maximum protein and zinc content in wheat grain (Table 2) was recorded with the application of 5 kg Zn/ha+2 two foliar spray @5% of $ZnSO_4$ at tillering and before flowering over T2 and T3 Zn treatments and it were statistically at par with the treatments T_4 (10 kg Zn/ha).The results reported that foliar application of Zn was even more effective than application to root environment in providing the Zn for transport to wheat crop indicating that foliar spraying with Zn in field-grown cereal crops can be effective in increasing Zn concentration in grains (*Dhaliwal., 2019*). Significant impact of foliar-applied Zn on wheat protein content and plays an important role in protein synthesis and protein functions was reported by *El-Habbasha et al. (2018).*

Economics

The treatment T_5 observed significantly maximum value of net return and B:C ratio which was closely followed by treatment T_4 (Table 2) However, lowest net returns and B- C ratio was obtained in control. This may be due to the proper growth and development of the crop as well as highest grain and straw yield obtained (T_5) and proportionally higher gross return than that of the cost of cultivation. Another possible reason that can be ascertained to these findings is that this could have happened due to the fact that all treatments associated with zinc fortification were more remunerative than control with regard to net returns.

Conclusion

It may be concluded that the treatment (T_5) 5 kg zinc/ha+2 two foliar spray @5% of $ZnSO_4$ at tillering and before flowering was found to be the best treatment in terms of growth, yield quality parameters of wheat. The application of zinc sulphate has increased the availability of zinc as well as other nutrients especially nitrogen; which enhanced the growth and development of the crop, made the crop more vigorous, improved the grain filling and thus, increased the yield of wheat as well as maintained the economics by increasing the net returns and B-C ratio to the maximum.

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Table 1. Effect of zinc on growth, yield and economics of wheat

Treatments	Plant height (cm)	Crop dry weight/ running meter (g)	Effective tillers/ running meter	Grains/ spike	1000 grain weight	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
T1- 0 kg zinc/ha	87.6	325.5	84.2	39.0	38.9	4150	6521	10771	39.5
T2-5 kg zinc/ha	88.9	340.6	88.9	40.5	39.8	4296	6535	10831	39.7
T3-7 kg zinc/ha	92.6	352.5	92.3	41.0	40.4	4325	6692	11017	39.3
T4-10.00 kg zinc/ha	95.4	362.4	102.4	42.4	42.5	4395	6954	11349	38.7
T5-5 kg zinc/ha+2 two foliar spray @5%of Zn So4 at tillering and before flowering	96.5	364.0	105.6	43.6	43.1	4605	6999	11504	39.2
CD (p=0.05)	2.84	11.5	9.4	1.3	0.62	112.0	45.0	298	NS

Table 2. Effect of zinc application on nutrients uptake, quality and economics of wheat

Treatments	Nutrients uptake				Protein content (%)	Zinc content (mg/kg)	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B-C ratio
	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)						
T1- 0 kg zinc/ha	68.2	12.1	65.8	77.4	10.47	42.2	35149	92803	57654	1.64
T2-5 kg zinc/ha	95.4	12.8	69.9	112.5	10.64	44.9	35499	93666	58167	1.64
T3-7 kg zinc/ha	98.2	13.5	73.3	123.2	10.76	49.8	35639	94580	58941	1.65
T4-10.00 kg zinc/ha	102.0	15.4	79.5	141	10.84	52.8	35849	96495	60646	1.69
T5-5 kg zinc/ha+2 two foliar spray @5%of Zn So4 attillering and before flowering	104.4	17.6	84.3	147	10.87	56.5	36499	98588	62089	1.70
CD (p=0.05)	2.5	2.3	4.9	6.1	0.13	3.8	-	2094	1445	0.02

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