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Comparative Evaluation Of Zinc Fertilization Methods On Growth Traits And Yield Of Wheat *Triticum Aestivum*

Article Details

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ABSTRACT

The Zinc nutrient deficiency is widely experienced in field crops specially cereals. The crops responds well to the soil& foliar applied inc. A field research experiment was carried out to investigate the efficacy of Zn fertilizer on growth traits and yield of by soil & foliar application. The objective was to evaluate the economical and appropriate dose and application method to determine influence of Zn on wheat. The treatments were designed in RCBD with three replicates. The Zn deficient soil (0.73 mg/kg) used for this research was textured silty loam, 8.5 pH, and poor in organic matter (0.58%). The $ZnSO_4$ was used as source of fertilizer. There were four treatments T1=Control, T2=Soil applied with 10 kg Zn/ha, T3=Foliar application of 0.5% solution of Zn/ha, T4= T2 + T3 during heading stage/ha and irrigation time. The results revealed that soil and foliar Zn application had significant influence on growth traits and yield of wheat. The height of plants increased from 63.09 to 75.49 cm, tillers increased from 7.71 to 11.86, grains counts from 320 to 456.94, seed index from 49.58 to 52.28, and biological yields from 9085 to 10191 kgha-1. It was concluded that Zn application in T4 foliar application exhibited significant results. It is suggested that Zn application (10 kg of Zn/ha) at time of first irrigation and 0.5% foliar at heading stage can thoroughly be practiced in wheat crop for optimum production.

INTRODUCTION

Wheat is a major and most important staple food crop throughout the world, as economy of our country largely driven by agricultural practices (Sajjad *et al*., 2019). Wheat crop is a leading food grain a major component in national economic returns (Anjum, 2018 and GOP, 2019). The soils of our country is alkaline, calcareous, very low organic matter, elevated pH, and 70% arable soils are deficient in Zn level. Zinc deficiency is a 3rd countable nutritional disorders of our country (Abbas *et al*., 2009), which also trigger the potassium deficiency in crop plants (Zhu, 2001). In saline environments, Zinc exhibit a major function in reduction of Na^+, while increase the K^+ concentration in plants (Saeidnejad and Kafi 2013). Zinc (Zn) is very crucial for metabolism of plants, humans as well as animals. Zinc is widely distributed in plants, animals, and all living cells. This is important for transcription factors and cofactor for over 300 enzymatic actions (Palmgren *et al*., 2008). Zinc is important to maintain a healthy and effective immune system via gene regulation (Prasad, 2010). Like other organisms, plants also need Zn for translation, transcription and regulation of enzymatic activity (White and Broadley, 2011). Dietary insufficiency of Zn affects more than two billion people globally (WHO, 2012), especially victims are women and children due to severe malnutrition. Almost 2 billion people confront the Zn deficiency and almost 30% population face the Fe deficiency in world. In human beings, deficiency of Zn is the fifth chief cause of ailments and/or demises in the world (WHO 2002; White and Broadley 2009). Inadequacy of Zn and Fe along with vitamin A accounts 67% death of the children.

In Pakistan, Zn deficiency is an alarming health problem, as about 20.6% children processes <60 μgL^{-1} level of Zn. Role of Zn in dwarfism is Zn malnutrition in Middle Eastern boys (Prasad *et al*., 1961). A few most prominent diseases associate with Zn malnutrition are scurvy, rickets, anemia, and beriberi (Zhu *et al*., 2007). Lack of Zn is reported to be the cause of retarded sexual development, stunted growth, impaired brain function, DNA damage, dwarfism and even cancer (Gibson, 2006; Prasad, 2007). Deficiency of Zn is a frequent cause of pneumonia and diarrhea in children (Gibson *et al*., 2008; Prasad, 2010). Zn deficiency is particularly important regarding mothers as it causes severe consequences in baby development (King, 2000).

In countries with increased incidences of deficiency of micronutrients, major proportions of dietary intake consist of cereals (Bouis *et al*., 2011). Inherently, cereal crops contain low proportions of Zn in grains. Furthermore, cultivation in Zn deficient soils further decreases the zinc concentration in grains (Cakmak *et al.*, 2010). Keeping in view of this, the application of Fe and Zn containing fertilizers (agronomic bio-fortification) is an effective and time-saving solution. This represents an alternating approach in plant breeding systems. Bio-fortification of Zn in cereal crops is a cost-effective strategy to overcome the Zn-deficiency in human beings (Bouis *et al.*, 2011). The application of these nutrients has been useful in case when low Zn available to the plants also correlates their deficiency in human beings (Alloway, 2009). Furthermore, a lot of information and research studies are prevailing regarding less Zn in crops (wheat) as well as its interactive influence on soil elements. In light of above information an experiment was conducted to evaluate the effect and application efficiency of zinc on wheat crop with following objective: To apply an optimum quantity of Zn in soil and foliar Zn spay technique by different doses of application for growth traits and wheat yields.

MATERIALS AND METHODS

EXPERIMENTAL AREA AND SETUP

The research trials were under taken in plot field of Institute of Salinity Control and Reclamation, Agriculture Research Sindh. The latitude 25º 25' 40. 21 N, longitude 6831.40 E, and altitude 26 m during the season of Kharif. The experiment was designed with four treatments viz., T_1=Control, T_2=Soil applied with 10 kg Zn/ha, T_3=Foliar application of 0.5% solution of Zn/ha, T_4= T_2 + T_3 during heading (fruit formation) stage and irrigation time. The $ZnSO_4$ was used as source of fertilizer applied in four replicates via RCBD. The total area of field plot of 150 m^2 was farther divided into 16 plots of 9 m^2 (3×3). The rest of area was allocated for water channels and paths. Wheat crop variety called Sindhu was chosen for this research work and wheat seed was collected from Chemistry Section, ARS Tandojam. All designed sub plots uniformly received NP at rate of 168 kg N Urea fertilizer & 82 kg P_20_5 DAP fertilizer, respectively. Urea and Zinc Sulfate (Zengro 33%) was applied at first irrigation in three equal splits.

SOIL SAMPLING AND PROCESSING

The experimental plot subdivided into 4 distinct blocks before sowing. The soil samples were collected (0-15 and 15-30 cm) from soil depth with Soil auger from each field of experimental representative block. Around four samples from each depth were chosen and collected from various depths. These four samples were mixed to make one composite sample for every block. Soil ssamples were placed in plastic wrappers and shifted into laboratory for further process and analysis. The soil samples were then processed in the laboratory for detailed analysis. Soil samples were air dried crushed and sieved using 2 mm dia. sieve of the lab. The sieved samples were kept in anaerobic conditions for subsequent lab analysis.

SOIL ANALYSIS

The four samples mixed composite soil was analyzed for EC (dS m^{-1}) by EC meter, pH by pH meter, soil textural class by Boyouocos method, soil organic matter by Walkley-Black, Lime content using NaOH titration, Nitrogen by calculated from organic matter levels, available P by Olsen, Potassium (K) by NH_4 AOC, Ca^{2+} and Mg^{2+} by titration of EDTA and chlorides using Mohr's method of titration.

AGRONOMIC OBSERVATIONS

At time of harvest, five healthy plants were chosen from sub plot for each treatment and replicates. The agronomic observations included plant height (the height was measured manually from top to bottom with scale and tillers). The spike length was also observed. Manual threshing was performed for threshing and separation of straw and grains. The grains in every plant were counted manually for all the representative plots.

PLANT ANALYSIS

WET DIGESTION

The 0.5 g of root and shoot samples were taken in 100 mL conical flasks. Then 15 mL mixture of di-acid ($HClO_4$ and HNO_3) with ratio of 1:2 was added in each flask. After adding the di-acid, kept the samples for overnight. Then, the samples were shifted on hot plate, temperature adjusted at 150 °C for 20 min and finally at 250 °C for 30 min until brown colour of nitric acid fumes were observed, when the colour of fumes became transparent, the hot plate turned off. The samples were removed and left for cooling. The cooled samples were filtered and volume of samples made up to 50 mL (Gargari *et al.*, 2007).

DETERMINATION OF ZN

Concentration of Zn in plant shoots was determined by atomic absorption spectrophotometer (FAAS; Model Thermo S-Series, Thermo Electron Corporation, Cambridge, UK) (Norhaizan and Ain, 2009). A series of standards were run and then a calibration curve was drawn. The supernatant liquid was decanted and Zn concentrations determined in the aliquots. The following formula was used to calculate the Zn in supernatant liquid concentrations according to the calibration curve.

$$\text{Calculation} = \text{ppm of Zn (from calibration curve)} \times V/Wt$$

Where: V = Total volume of the plant digest (mL), Wt = Weight of dry plant (g)

STATISTICAL DATA ANALYSIS

The soil and plant data was subjected to ANOVA using Minitab 17 software. The difference among treatments was assessed by Tukey's test at 0.05 *P* value.

RESULTS

PHYSICO-CHEMICAL PROPERTIES OF SOIL

The physico-chemical characteristics of the experimental site, before sowing of wheat, indicated that the soil from both depths (0-15 and 30 cm) was silty loam in texture, non-saline, moderate to strong alkaline in reaction, low organic matter, and deficient in Zn concentration (Table 1).

AGRONOMICAL OBSERVATIONS OF CHARACTERS

The results indicated by ANOVA that treatments affected the plant height significantly while blocks effected the plant height non-significantly. The plant height of wheat in response to zinc application and block presented in table 2. The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the plant height by 11.1% and 14.2% as compared to control. Comparison tests of plant height for treatments showed that each treatment was significantly different from each other. The results regarding Number of tillers $plant^{-1}$ as affected by Zn application methods. The results indicated that treatments affected the number of tillers $plant^{-1}$ significantly, while non-significantly blocks effected the number of tillers $plant^{-1}$. The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the plant height by 11.1% and 14.2% as compared to control. The results regarding Number of grains $plant^{-1}$ as affected by Zn application methods are described (Table 2). It was indicated by results that treatments affected the number of grains significantly while blocks effected the number of grains non-significantly. The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the plant height by 11.1% and 14.2% as compared to control..

SEED INDEX

In this study, the results regarding1000-grains weight were affected by Zn application methods (Table 2). The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced by 16.2 % and 23.2%, respectively as compared to control. The results indicated that treatments affected the 1000-grains weight significantly, whereas non-significantly blocks effected the weight of 1000-grains.

BIOLOGICAL YIELD (KG HA^{-1})

The results regarding biological yield as affected by Zn application methods are described in this work. This study indicated by results that treatments affected the biological yield significantly while blocks affected the yield non-significantly. The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the biological yield by 4.5% and 7.0%, respectively as compared to control.

GRAINS YIELD (KG HA^{-1})

The results regarding grains yield also affected by Zn application methods (Table 2). The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the grains yield by 6.0% and 9.1%, respectively as compared to control. The results indicated that treatments affected the grains yield significantly, though blocks affected grain yield non-significantly.

HARVEST INDEX (%)

The harvest index also affected by Zn application methods (Table 2). This study indicated by results that treatments significantly affected the harvest index, whereas blocks affected the harvest index non-significantly. The supplementation of Soil Zn (10 kg ha^{-1}) at 1st irrigation + Foliar Zn (0.5%) at heading stage enhanced the harvest index by 1.6% and 3.6%, respectively

DISCUSSION

From our research experiment, it was evident that Zn application by soil applied and folair application has significant influences on growth traits of wheat. Zinc is an essential micronutrients for many crops revealed by Sommer and Lipman (1926). It was depicted from results of this research trials (Table 1 and 2) and previous published studies (Arya and Singh 2001; Aziz *et al.*, 2018) revealed that Zn deficiency induced many implications in wheat and other cereal crops. Further, it was reported that glaring Zinc deficiency brought severe decrease in growth traits, vegetative development, yield of wheat, and yield components.

This is necessity and essentiality of zinc fertilizer needed by crop especially wheat. However, various research studies are prevailing on fertilizer zinc and crop of wheat. The significant effects on local wheat crop variety (Sindhu) to Zn fertilizer is poor in response. Further present research was conducted to investigate the response of Sindhu wheat variety to soil applied and foliar zinc fertilizer. Four (0, 10, 0.5%, 10 kg and 0.5% $ha^{-1)}$ doses of zinc fertilizer were included in the current work. It was clear from the results obtained that enhancing rate of zinc application significantly improved the morpho-physiological parameters like height (11.1, 14.2 % %), numbers of tiller (12.5, 26%), grains yield (20.6, 31%), weight of 1000-grains (16.2, 23.2%) and yields of wheat grain (6.0, 9.2%). The authentically endorsement for this cause for increase brought about by Zn in traits of growth, development and production and wheat yield components may be inference of prompt biochemical bioreactions brought by fertilizer zinc in wheat plant metabolism and crop as whole (Hafeez *et al.*, 2013). Similar results revealed by Ashraf *et al.* (2017) that Zn fertilizer pro activated the various enzymes, activated the growth hormones, and over all starch production. Further affirms the integrity of cellular membrane and helps to join the proteins in crops. The biosynthesis of auxin and increase in pollen production also observed by other workers (Qadir *et al.*, 2017).

It is clear that soil application with Zn enhances the growth parameters and production of crops by improving yield and process of photosynthesis in crop plants (Tabasum *et al.*, 2013). The increase in growth and yield parameters might be due to role of Zinc in biosynthesis of indole acetic acid (IAA), commencement of primordial reproductive parts, and partitioning of photosynthesis in response of appropriate flowering and fruiting (Himanshu *et al.*,2013). The improvement in plant height may be subjected to sufficient application of Zinc, which can counter Zn requirement for optimum application of Zn fertilizer. Previously many researchers depicted that plant height was elevated significantly with proper supply of Zn fertilizer (Islam *et al.*, 1999; Genc *et al.*, 2006; Jain and Dahama, 2006). Flintham *et al.* (1997). The application of zinc enhanced the height of plant and significantly improve the wheat grains. The supplement of Zn fertilizer had significantly enhanced growth traits and wheat production.

In current study it was observed that application rates of Zn positively effects the overall production of wheat crop by methods of soil and foliar Zn application. The findings of our research are in agreement with Oad et al. (2007), wherein values of entire crop growth traits and wheat grains parameters were lower, where there was no Zn. The circumstances reported that experimental soil was deficient in Zn and after its supplement, production and traits improved clearly. This suggested that Zn application in wheat fields is necessary to improve the Zn content in soil in order to harvest an improved grain yield. Similar findings were achieved by Islam et al (1999), they explained that in soil application of zinc has significant effect on effective tillers and other agronomic wheat crop parameters. Zinc fertilizer also effective in improvement of dry matter grain production in wheat crop (Imtiaz *et al.* 2003). The research finding significantly correlated with Genc et al. (2006), they revealed in study that supplementation of zinc has a positive impact on grains wheat plant^{-1}. Various findings revealed that zinc is a reducing factor for growth traits of wheat crop in zinc deficient soils. Its deficiency can be related by zinc biofortification (Khan *et al*., 2008). In conformity with Soylu *et al*., (2005), Guenis *et al*., *(2003*) and Hussian *et al*., (2002) depicted maximum improvement in weight of 1000-grains wheat by application of foliar micronutrients. Hussain et al. (2002) revealed that application of zinc fertilizer has significant effect on grains and biological traits production. The findings of this research depicted that, plots received Zn yielded higher biological production with respect to Zn deficient soil.

Asad et al. (2000) also suggested that application of micronutrients significantly improved the physiological processes in crops, e.g., increased growth parameters and dry matter production. Abid *et al*. (2019) reported that grains of wheat were maximum by application of foliar Zn. Data after statistical analysis depicted that Zn application yielded higher yield (5966.67 kg ha-1) whereas lowest production (4921.3kg ha-1) observed without Zn spray. Fertilizer Zinc played a major role in maximum yield of wheat as zinc fertilizer participated in many physiological processes and chlorophyll parts. This was similar to harvest index (31.30) from plots sprayed with combination of zinc (Arif *et al*., 2006). Foliar application of zinc positively influenced index of harvest of wheat crop.

CONCLUSION

From this research work it was concluded that foliar application of Zn @ 0.5% and 10 kg ha^{-1} in soil should be practiced in field of wheat crop to increase Zn nutrition of wheat and economic yield in Sindh. Further research is needed to investigate the effects of various dozes of Zn biofortifiaction on wheat crop.

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Table 1. Physico-chemical properties of soil sowing of wheat

Parameters		Soil depths	
		0-15 cm	**15-30 cm**
pH		8.3 ± 0.05	8.7 ± 0.03
EC (dS m^{-1})		1.66± 0.04	1.71 ± 0.4
Organic matter (%)		0.55 ± 0.02	0.62 ± 0.04
Available Zn (mg kg^{-1})		15.4 ± 0.01	16.4 ± 0.02
Texture	Sand%	21.0	21.0
	Silt%	74.0	74.0
	Clay%	5.0	5.0
Textural class		Silty loam	Silty loam

Each value in column is mean± SE (*n*=4)

Table 2. Effects of Zn application methods on agronomic characters of wheat

Treatments	Plant height (cm)	% increase over control	Number of tillers $plant^{-1}$	% increase over control	Number of grains $plant^{-1}$	% increase over control	Seed index (1000 grains weight g)	% increase over control	Biological yield (kg ha^{-1})	% increase over control	Grain Yield (kg ha^{-1})	% increase over control	Harvest index (%)	% increase over control
Control	63.093 ± 0.05D	--	7.80 ± 0.02C	--	300.33 ± 0.05C	--	43.543 ± 0.05 C	--	9085.44 ± 0.06C	--	4504.5 ± 0.05 D	--	49.580 ± 0.04C	--
Soil Zn (10 kg ha^{-1})	70.387 ± 0.05C	11.5 %	9.40 ± 0.04B	20.5	362.00 ± 0.03B	20.6	50.667 ± 0.03 B	16.3	9502.20 ± 0.5B	4.5 %	4774.8 ± 0.04C	6 %	50.240 ± 0.07B	1.4 %
Foliar Zn (@ 0.5% of Zn	73.100 ± 0.06B	16%	10.27 ± 0.03B	31.6	395.00 ± 0.05B	31.6	53.753 ± 0.04 B	23.4	9722.30 ± 0.03B	7 %	4941.9 ± 0.04 B	9.7 %	50.840 ± 0.06B	2.6 %
Soil Zn (10 kg ha^{-1} + Foliar Zn (@ 0.5% of Zn)	75.493 ± 0.07A	19.6%	11.87 ± 0.04A	52.1	456.67 ± 0.04A	52.2	57.113 ± 0.07 A	31.2	10191.63 ± 0.06A	12%	5337.2 ± 0.03 A	18.4 %	52.283 ± 0.04A	5.6 %

*Each value is a mean ± SE (*n*=4); Means followed by different capital letters are significantly different from each other (*P*< 0.05) as a function of Zn application methods.