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Effect of Foliar Application of Zinc on Growth and Yield of Wheat (*Triticum aestivum*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study was aimed to observe "Effect of foliar application of Zinc on growth and yield of wheat (*Triticum aestivum*)".
Study Design: The experiment was laid out in randomized complete block design (RCBD).
Place and Duration of Study: The field experiment was conducted at the research fields of School of Agriculture, Department of Agronomy, Lovely Professional University, Jalandhar (Punjab) during rabi season in the year 2021-2022.
Methodology: The experiment was conducted with eight treatments and three replicationswere T_1- Absolute Control, T_2- RDF (Chemical Control) 120:60:40 NPK, T_3- RDF 120:60:40 NPK + Zinc (Spray @ 15 DAYS 0.5%), T_4- 75% RDF + Zinc (Spray @ 15 DAYS 0.5%), T_5- RDF 120:60:40 NPK + Zinc (Spray @ 15 DAYS 0.5% + 30 DAYS 0.5%), T_6- 75% RDF + Zinc (Spray @ 15 DAYS 0.5% + 30 DAYS 0.5%), T_7- RDF 120:60:40 NPK + Zinc (Spray @ 15 DAYS 0.5% + 30 DAYS 0.5% + 60 DAYS 0.5%), T_8- 75% RDF + Zinc (Spray @ 15 DAYS 0.5% + 30 DAYS 0.5% + 60 DAYS 0.5%).
Results: The results showed that the foliar application of Zinc at different stages, along with recommended dose of fertilizer had a positive effect on plant height, number of leaves per plant,

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Chlorophyll by SPAD value and grain yield of crop. It was reported that at harvest, the highest values of growth parameters like plant height (cm) were recorded in T_7 (97.07cm), number of leaves per plant was in T_7 (11.03), Chlorophyll by SPAD value was in T_5 (37.37) and grain yield was in T_7 (61.70 q/ha) which were significantly higher over control treatments where we did not applied Zinc.

Conclusion: It can be concluded that along with RDF, foliar application of Zinc has positive effects on growth and development of plant as well as helps in increasing the yield of the crop as compared to the no foliar application Zinc. Along with this, it has also been found that foliar application of Zinc should be done in splits ie. at15 days intervals at crucial stages of crop which helps in maximum absorption of nutrients that ultimately affects the yield of the crop . Since the Zinc fertilizers like Zinc sulfate is a cheap and easily available fertilizer, it could find wider acceptability among farmers.

Keywords: Wheat; zinc; foliar application; micronutrient deficiency and yield.

1. INTRODUCTION

Wheat (*Triticum aestivum*) is the staple food and second most important food crop after rice in the country, which contributes nearly one-third of the total food grains productions. It is consumed mostly in the form of bread as “Chapati”. Wheat straw is used for feeding cattle. Wheat contains more protein than other cereal and has a relatively high content of niacin and thiamine.

It is one of the most consumed cereal crop in the world also, it is cultivated all over the world. The most widely grown is common wheat (*Triticum aestivum*). It is commonly known as the "king of cereal" for a significant life span and it is still holding the pride of place even today.

It is most important staple food of about two billion people (36% of the World population). About 55% of the world population depends on wheat for intake of about 20% of food calories [1].

Most of the people are dependent on cereals and legumes as their primary dietary source of these micronutrients, therefore, biofortification of staple crops is an effective strategy, which ensures the consumption of essential micronutrients in a cost effective manner. Wheat is the major staple food crop of the world, which contributes up to 28% of the world edible dry matter production and up to 60% of daily energy intake in several developing countries [2].

Deficiencies of important nutrients like Zinc, iron etc. directly or indirectly results in poor crop yield and also cause serious health problems in human beings and in livestock also. The soils of Punjab are known to be rich in most of the nutrients and are considered as one of the most fertile soils across India. Although, during the years of intensive farming the nutrient status of soil has depleted at a very great extent and nowadays the deficiency symptoms of major and micro nutrients are more predominant. The available Zinc in Indian soils ranges between 0.08–20.5 ppm, but Punjab have shown that available Zn, Fe, and Mn content of soils ranged from 0.02 to 10.4, 0.5 to 176, and 0.8 to 120 mg/kg soil with mean values of 0.95, 10.7, and 11.3 mg/kg soil, respectively [3]. The soils of the south-western districts of the State are more prone to Zn deficiency compared to central and sub-mountainous districts. It is recommended to apply these nutrients at the time of soil preparation, but most of the farmers avoid such nutrients like Zinc and Sulphur. The availability of zinc is influenced by numerous soil parameters like, soil pH, organic matter content, adsorptive surfaces, and other physical, chemical, and biological conditions in the rhizosphere zone [4].

Since Zinc is a co-factor carbonic anhydrase and aldolase, therefore, it may adversely affect enzyme activities and carried corresponding metabolic reactions when Zinc is deficient in soil. It is also involved in synthesis of protein and tryptophan. It is indicated that Zinc is an essential structural component for normal functioning of super oxide dismutase enzyme [5]. Zinc deficiency also causes poor tillering leading to decreased productivity of crop. Application of Zinc to the crop has been found to boost growth and yield of crops to a greater extent [6]. Micronutrients are mostly applied in readily available forms and out of the all methods, foliar application is considered to be better for faster uptake by the plants. Hence, it could be considered as a easy and cheaper way of agronomical biofortification of crop, which could help in overcoming the most common nutrient

deficiency i.e. Zinc deficiency among the Indian population.

2. MATERIALS AND METHODS

Experiment was conducted at the agricultural experimental field of Lovely Professional University, Kapurthala district during *Rabi* season in the year 2021-2022. The experimental site belongs to the "Trans-Gangetic Plains Region (VI)" ($31^0$22'31.81" N and $75^0$23'03.02" E). The physical and chemical characteristics of the soil are displayed in Table 1. The seeds of Wheat-PBW 803 were from Punjab Agriculture University (PAU), Ludhiana. The Zinc fertilizers used in the experiments was $ZnSO_4.7H_2O$.

2.1 Experimental Design

The experiment was in Randomized complete block design (RCBD) with eight treatments as follows T1- Absolute Control, T2- RDF (Chemical Control), T3- RDF + Zinc (Spray @ 15 DAYS), T4- 75% RDF + Zinc (Spray @ 15 DAYS), T5- RDF + Zinc (Spray @ 15 DAYS + 30 DAYS), T6- 75% RDF + Zinc (Spray @ 15 DAYS + 30 DAYS), T7- RDF + Zinc (Spray @ 15 DAYS + 30 DAYS + 60 DAYS and T8- 75% RDF + Zinc (Spray @ 15 DAYS + 30 DAYS + 60 DAYS). Fertilizer application in RDF plots was 120:60:40 NPK via urea, diammonium phosphate (DAP)and muriate of potash (MOP), where nitrogen was applied intwo equal split doses(at basal and 30-45 days after sowing).The full dose of phosphorus and potassium were applied to the treatments at basal. The foliar application of $ZnSO_4$ (0.5%) was applied @ (15 DAYS), (15 DAYS + 30 DAYS) and (15 DAYS + 30 DAYS + 60 DAYS) according to the mentioned treatments.

2.2 Plant Height (cm)

Plant height was recorded from randomly selected plants and average was done from each plot at 30, 60, 90DAS, and at harvest.

2.3 Number of Leaves per Plant

The total number of leaves on each plant were counted from randomly selected plants at 30, 60, 90 DAS and at harvest.

2.4 Chlorophyll Content by SPAD Meter

The plants were randomly selected from each plot and the SPAD meter readings were recorded for each plant at 30, 60, 90 and 120 DAS.

2.5 Grain Yield q/ha

The harvesting was done from each of the treatment plots by harvesting $1m^2$ at its physiological maturity and was dried in shade and converted into q/ha. Then the crop was threshed and winnowed and kept for future use.

2.6 Statistical Analysis

The data collected for all the parameters were subjected to analysis of variance (ANOVA) and was analyzed statistically. To determine the standard error of the mean (S.Em) and the value of CD (Critical difference) at a 5% level of significance, a methodology stated by Gomez and Gomez [12] was followed to determine the specific differences between pairs of means.

3. RESULTS AND DISCUSSION

The results of plant height of crop are summarized in Table 2 which showsthat plant height at the initial stages of crop stand did not have any significant effect of foliar application of Zinc. However, during the later stages there was a significant effect of foliar spray of Zinc on plant height at 90 days and at harvest of the crop, where highest plant height was observed in the treatment T_7 where we applied recommended RDF along with foliar application of Zinc (0.5%) at 15, 30 and 60 days after

Table 1. Chemical properties of the soil

Particulars	Values	Method used
Electrical conductivity (ds m^{-1})	0.812	Conductivity meter method [7].
Soil pH	6.55	Glass electrode pH meter [8].
Organic carbon	1.6	Walkley and Black rapid titration method [9].
Available nitrogen (kg ha^{-1})	365.7	Alkaline permanganate method (Subbiah &Asija, 1956)
Available Phosphorus (kg ha^{-1})	104.4	0.5 N $NaHCO_3$ extractable Olsen method [10].
Available Potassium (kg ha^{-1})	23.8	1N Neutral ammonium acetate [11].

Fig. 1. Preparation of field for the sowing of wheat crop

Fig. 2. Wheat Crop at 90 days after sowing

sowing (75%RDF+Zinc Spray @ 15 + 30 + 60 DAS). In the previous studies also, it has been observed that wheat crop is affected by foliar spray of two doses of $ZnSO_4$, 0 ppm and 10 ppm pot^{-1}. Their results also showed that with a foliar spray of 10 ppm $ZnSO_4$ is effective in increasing the plant height and number of tillers $hill^{-1}$ than the control [13]. Another study also revealed that $ZnSO_4.7H_2O$ (200 g ha^{-1}) foliar application resulted in the greatest significant increase in plant height (104.02cm), dry material (179.64 g), and chlorophyll content (47.46) in wheat crop when compared to 0 and 100 g $ZnSO_4.7H_2O$ at 60DAS [14].

3.1 Number of Leaves per Plant

The results (Fig. 3) indicate that number of leaves per plant@ 30 DAS was not significantly affected by foliar application of Zinc, but@ 60 DAS and 90 DAS, there was significant effect of foliar application of Zinc. The maximum number of leaves per plant(13.00) was observed in T_8 (75% RDF +Zinc (Spray @ 15 + 30 + 60 DAS) and (17.37) in T_7 (RDF +Zinc Spray @ 15 + 30 + 60 DAS) respectively. Whereas at the maturity the crop proceeds towards maturity and some of the leaves dried up and fell, so there was no significant effect of foliar application

Table 2. Effect of foliar application of Zinc on plant height of wheat at 30DAS, 60DAS, 90DAS and harvest stage

Treatment	Plant height(cm)			
	30DAS	60DAS	90DAS	At Harvest
T1- Absolute control	18.20^{ab}±0.58	39.47^{c}±2.74	72.87^{bc}±3.61	79.00^{bc}±3.35
T2- RDF (Chemical control)	18.33^{ab}±0.58	42.07^{bc}±2.54	77.17^{bc}±3.51	84.80^{bc}±2.95
T3- RDF + Zinc (Spray @ 15 days)	17.90^{b}±0.40	42.90^{bc}±2.43	85.33^{ab}±2.86	89.57^{ab}±4.09
T4- 75% RDF + Zinc (Spray @ 15 days)	18.23^{ab}±0.46	43.40^{ab}±2.36	85.47^{ab}±7.21	92.30^{ab}±6.26
T5- RDF + Zinc (Spray @ 15 days + 30 days)	18.46^{a}±0.43	43.93^{ab}±3.50	86.00^{ab}±3.61	92.67^{a}±3.00
T6- 75% RDF + Zinc (Spray @ 15 days + 30 days)	18^{ab}±0.17	41.30^{bc}±1.00	85.13^{ab}±6.96	91.50^{ab}±4.16
T7- RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	18.26^{b}±0.06	45.20^{a}±2.96	90.67^{a}±3.89	97.07^{a}±2.54
T8- 75% RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	17.83^{b}±0.40	44.00^{a}±3.42	88.23^{a}±2.65	95.97^{a}±3.13
S.Em (±)	0.464	1.256	2.773	2.318
C.D. (5%)	NS	NS	8.494	2.318
CV (%)	7.74	5.09	5.73	4.43
MEAN	23.43	42.78	83.86	90.36

**Though the mean, followed by different letters are significantly different at p<0.05, according to DMRT (Dun can's Multiple Range Test) for separation of means*

of Zinc on leaf number at harvest. Our findings were in accordance with others where it has been found that application of Zinc promotes the growth of leaves like it was reported in a study where maximum increase in leaf length (30.79 cm) was observed in 4 mM and along with it increase in leaf area was also recorded at 4 mM treatment (33.50 cm^2) and it was concluded that 4 and 6 mMZinc sulphate could be effective in leaf growth and development [15].

3.2 Chlorophyll Content by SPAD Meter

The effect of Zinc on Chlorophyll by SPAD value 30,60,90 and120 DAS is summarized in Fig. 4. The results indicate that SPAD value @ 30 DAS, 60 DAS and 90 DAS was significant effect of foliar application of Zinc. Similar finding where foliar Zn application at the rate of 3 g L^{-1} gave the greatest values of SPAD value, flag leaf area and plant height as compared to control

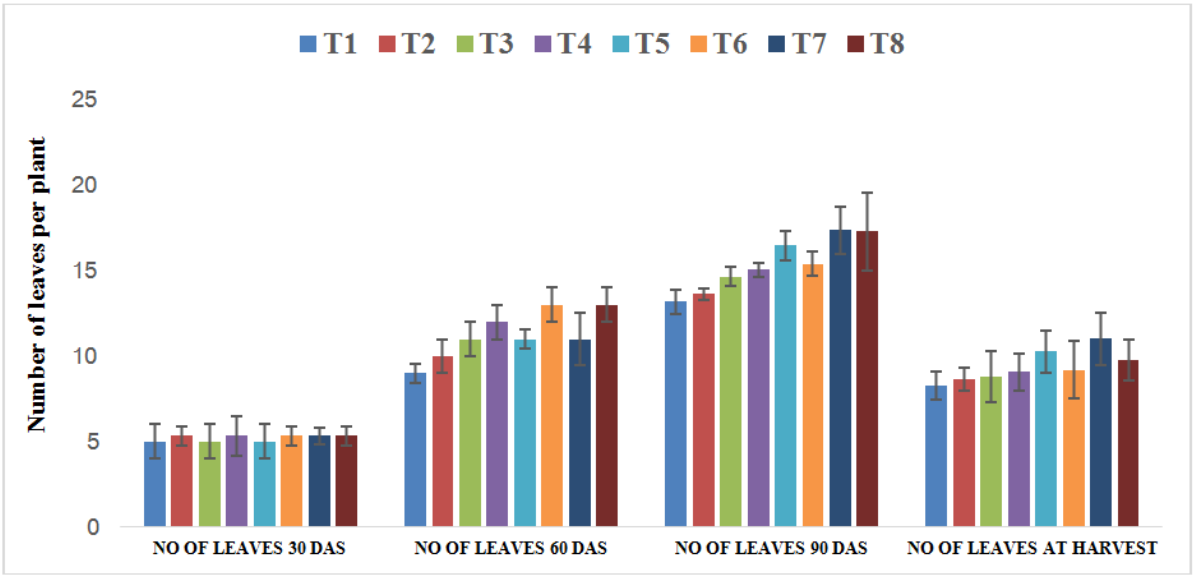

Fig. 3. Effect of foliar application of zinc on number of leaves per plant in wheat crop

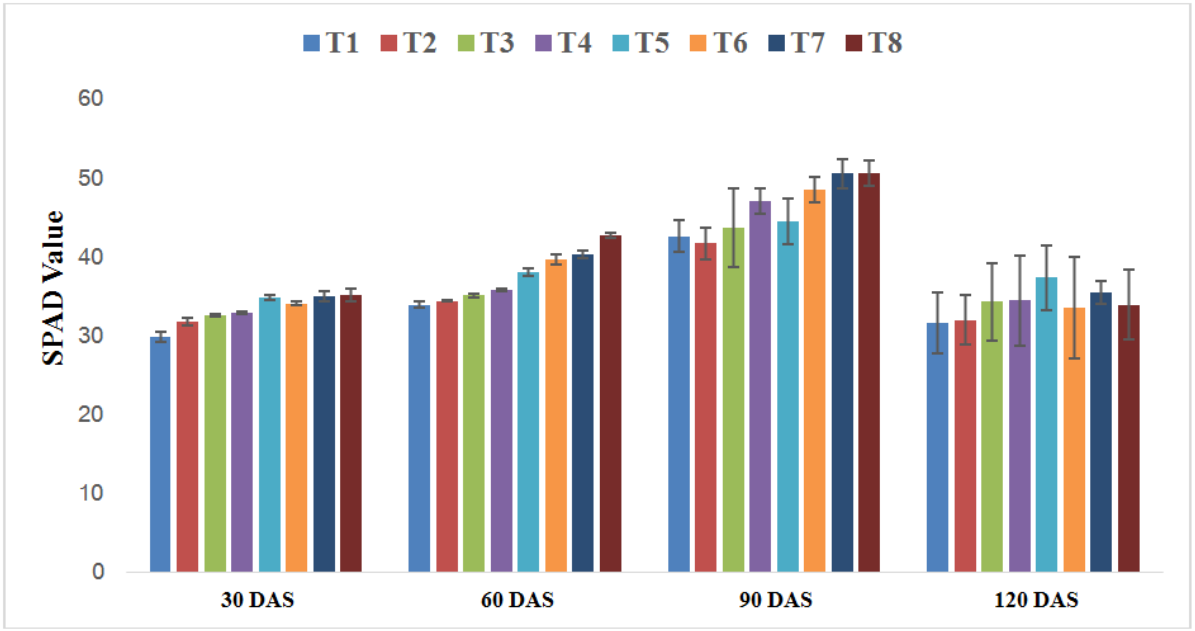

Fig. 4. Effect of foliar application of Zinc on plant chlorophyll by SPAD Value in wheat crop

Table 3. Effect of foliar application of Zinc on grain yield of wheat crop

Treatments	Grain Yield
T1- Absolute control	51.07^{c}±3.35
T2- RDF (Chemical control)	54.10^{bc}±4.85
T3- RDF + Zinc (Spray @ 15 days)	57.80^{ab}±2.97
T4- 75% RDF + Zinc (Spray @ 15 days)	57.40^{ab}±1.06
T5- RDF + Zinc (Spray @ 15 days + 30 days)	60.47^{a}±3.62
T6- 75% RDF + Zinc (Spray @ 15 days + 30 days)	58.53^{ab}±1.90
T7- RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	61.70^{a}±2.83
T8- 75% RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	60.70^{a}±2.24
S.Em (±)	1.878
C.D. (5%)	5.751
CV (%)	5.634
MEAN	57.73

**Though the mean, followed by different letters are significantly different at p<0.05, according to DMRT (Duncan's Multiple Range Test) for separation of means*

treatments where no foliar application of zinc was given. The increment in growth characters due to foliar application of Zn might be due to their critical role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates [16].

3.3 Grain Yield (q/ha)

The effect of Zinc on grain yield (q/ha) at harvest is summarized in Table 3. The results indicate that the foliar application of Zinc had a significant effect on grain yieldat harvest. The results showed that significantly higher grain yield (q/ha)(61.70 q/ha) was observed in T_7 (RDF+Zinc Spray @ 15 + 30 + 60 DAS) as compared to other treatments. Our results are in accordance to other studies where it has been observed that on application of Zinc sulfate ($ZnSO_4 \cdot 7H_2O$) and/or iron sulfate ($FeSO_4 \cdot 7H_2O$) significantly increases total number of fertile tillers m^{-2}, the number of spikelets $spike^{-1}$, the spike length, thousand grain weight, grain, straw, and biological yield [17]. Similar improvement in biological yield as well as grain yield of wheat was observed on Zinc application [18]. However, there are different outcomes for wheat when Zinc fertilizers were applied. Many studies have shown that one of the effective ways to improvement in cereal is application of Zinc fertilizer [16], amongst all, foliar Zinc fertilizer is effective to improve grain yield [19]. The foliar application of Zn had positive significant effect on wheat grain yield and its components as well as quality of grains [14,20].

4. CONCLUSION AND FUTURE PROSPECT

Based on our research, it can be concluded that along with RDF, foliar application of Zinc has positive effects on growth and development of plant viz plant height, no of leaves, chlorophyll content as well as helps in increasing the yield of the crop as compared to the control treatments where no foliar spray of zinc was given [21]. It gives massive indicate that foliar application of zinc at 15, 30 and 60 DAS with RDF helps in increasing yield and other crop growth indicating characters. It has also been found that foliar application of Zinc should be done after 15 days intervals at crucial stages of crop so that maximum absorption of nutrient takes place by the crop, which ultimately affects the yield of the crop. Since the Zinc fertilizers like Zinc sulfate is a cheap and easily available fertilizer, it could find wider acceptability among farmers. The results of our research can provide baseline information that can be utilized for future research, including crop modelling work aimed at developing fertilizer management and application strategies for different soils of India.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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