Original Research Article

Effect of foliar application of zinc on growth and yield of wheat (*Triticum aestivum*)

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 S~~s~~chool of A~~a~~griculture, 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 replications were T_1- Absolute Control, T_2- RDF (Chemical Control) 120:60:40 NPK, T_3- RDF 120:60:40 NPK + Zinc~~INC~~ (~~-~~Spray @ 15 DAYS 0.5%), T_4- 75% RDF + Zinc~~INC~~ (~~-~~Spray @ 15 DAYS 0.5%), T_5- RDF 120:60:40 NPK + Zinc~~INC~~ (~~-~~Spray @ 15 DAYS 0.5% + 30 DAYS 0.5%), T_6- 75% RDF + Zinc~~INC~~ (~~-~~Spray @ 15 DAYS 0.5% + 30 DAYS 0.5%), T_7- RDF 120:60:40 NPK + Zinc~~INC~~ (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, ~~-~~effective tillers per m^2, Chlorophyll by SPAD value, spike length, ~~,~~ awn length, grains per spike, test weight, biological yield, g~~G~~rain yield, and straw yield. Whereas at harvest, the highest values of growth parameters like plant height (cm) was 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).
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. Along with this, it has also been found that foliar application of zinc should be done ~~after~~ at 15 days intervals at crucial stages of crop so that maximum absorption of nutrient ~~should~~ takes place by the crop, which ultimately affects the yield.

Keywords: Zinc, deficiency, foliar application, maize???, wheat, spray and yield

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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 one the principle food grain eaten by people all over the world and is known of 35 percent of the aggregate population depends on it, as it contribute more enhancements particularly basic body need like amino acids than some other cereal crop. It is the staple food which is never affected by the changes of the costs for fooding and utilization (Bancel, *et al.,* 2015).

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 soil across all over 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 (Sadana *et al.,* 2010). The soils of the south-western districts of the State are more prone to Zn deficiency compared to central and sub-mountainous districts. Further, soils that are coarse in texture, low in organic matter and high in pH and $CaCO_3$ are more prone to Zn deficiency (Sadana and Takkar, 1983). 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.

Since zinc is a co-factor carbonic anhydrase and aldolase,. tTherefore, 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 (Lee, 2018). 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 (Rehman *et al.,* 2012). Micronutrients are mostly applied in readily available forms and out of all, the foliar spray is considered to be better for faster uptake. Hence, it could be easy and cheaper way of agronomical biofortification of crop.

2. MATERIAL 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 experi-mental 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 $ZnSO_4.7H_2O$.

Table No. 1: Chemical properties of the soil

Particulars	**values**	**Method used**
Electrical conductivity (ds m^{-1})	0.812	Conductivity meter method (Sparks, 1996)

Soil pH	6.55	Glass electrode pH meter (Piper,1967)
Organic carbon	1.6	Walkley and Black rapid titration method (Jackson, 1934)
Available nitrogen (kg ha^{-1})	365.7	Alkaline permanganate method (Subbiah, 1965)
Available Phosphorus (kg ha^{-1})	104.4	0.5 N $NaHCO_3$ extractable Olsen method (Olsen *et al.,* 1954)
Available Potassium (kg ha^{-1})	23.8	1N Neutral ammonium acetate (Black, 1965)

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 + ZincINC (Spray @ 15 DAYS), T5- RDF + ZincINC (Spray @ 15 DAYS + 30 DAYS), T6- 75% RDF + ZincINC (Spray @ 15 DAYS + 30 DAYS), T7- RDF + ZincINC (Spray @ 15 DAYS + 30 DAYS + 60 DAYS and T8- 75% RDF + ZincINC (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 in two 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.

Plant height (cm):

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

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 from the randomly selected plants.

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.

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.

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 (1984) was followed to determine the specific differences between pairs of means.

Figure 1 : Preparation of field

Figure 2: Crop at 90 days after sowing

3. RESULTS AND DISCUSSION

The results of plant height of crop are summarized in table 2 which shows that 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 sowing (75%RDF-+Zinc (Spray @ 15 + 30 + 60 DAS). In the previous studies also it has been observed that the 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 (Shaheen *et al*., 2007). 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 (El-Habbasha *et al*., 2015).

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	$18.20^{ab}\pm0.58$	$39.47^{c}\pm2.74$	$72.87^{bc}\pm3.61$	$79.00^{bc}\pm3.35$
T2- RDF (Chemical control)	$18.33^{ab}\pm0.58$	$42.07^{bc}\pm2.54$	$77.17^{bc}\pm3.51$	$84.80^{bc}\pm2.95$
T3- RDF + Zinc (Spray @ 15 days)	$17.90^{b}\pm0.40$	$42.90^{bc}\pm2.43$	$85.33^{ab}\pm2.86$	$89.57^{ab}\pm4.09$
T4- 75% RDF + Zinc (Spray @ 15 days)	$18.23^{ab}\pm0.46$	$43.40^{ab}\pm2.36$	$85.47^{ab}\pm7.21$	$92.30^{ab}\pm6.26$
T5- RDF + Zinc (Spray @ 15 days + 30 days)	$18.46^{a}\pm0.43$	$43.93^{ab}\pm3.50$	$86.00^{ab}\pm3.61$	$92.67^{a}\pm3.00$
T6- 75% RDF + Zinc (Spray @ 15 days + 30 days)	$18^{ab}\pm0.17$	$41.30^{bc}\pm1.00$	$85.13^{ab}\pm6.96$	$91.50^{ab}\pm4.16$
T7- RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	$18.26^{b}\pm0.06$	$45.20^{a}\pm2.96$	$90.67^{a}\pm3.89$	$97.07^{a}\pm2.54$
T8- 75% RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	$17.83^{b}\pm0.40$	$44.00^{a}\pm3.42$	$88.23^{a}\pm2.65$	$95.97^{a}\pm3.13$
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.

Number of leaves per plant

The results (figure 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 drieds up and feall, so there was no significant effect of foliar application 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 conclude that 4 and 6 mM zinc sulphate could be effective in leaf growth and development (Noreen and Kamran, 2019).

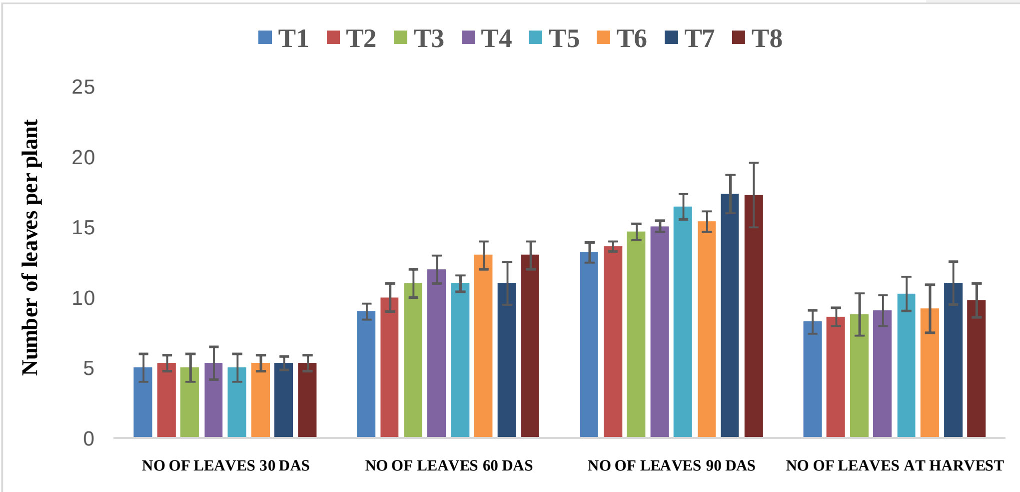

Figure 3: Effect of foliar application of zinc on number of leaves per plant.

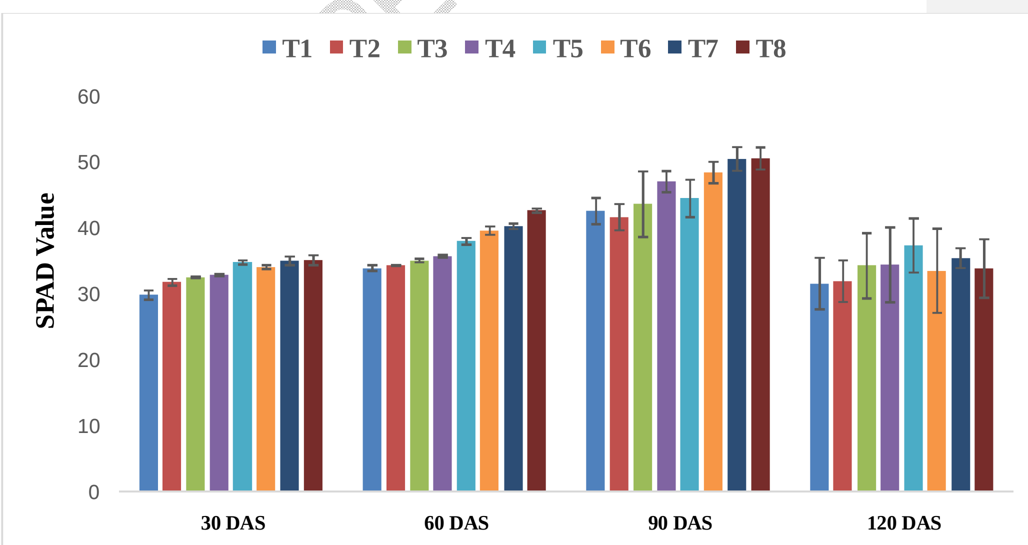

Figure 4: Effect of foliar application of zinc on plant chlorophyll in wheat crop.

Chlorophyll Content by SPAD meter

The effect of zinc on Chlorophyll by SPAD value 30, 60, 90, and 120 DAS is summarized in figure 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 untreated. 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 (El-Metwally *et al.,* 2015).

Grain Yield (q/ha)

The effect of zinc on gGrain yYield (q/ha) at harvest is summarized in table 3., The results indicate that the foliar application of Zinc had a significant effect on gGrain yYield at harvest. The results showed that significantly higher gGrain yYield (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 spike-lets spike^{-1}, the spike length, the thousand grain weight, the grain, straw, and biological yield (Mannan *et al*., 2022). Similar improvement in biological yield as well as grain yield of wheat was observed on zinc application (Modaihsh, 1997). 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 (Metwally *et al.,* 2012), amongst all, the foliar zinc fertilizer is effective to improve grain yield (Bameri *et al.,* 2012). The foliar application of Zn had positive significant effect on wheat grain yield and its components as well as quality of grains (El-Habbasha *et al.,* 2015; Esfandiari *et al.,* 2016).

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

TREATMENTS	GRAIN YIELD
T1- Absolute control	$51.07^{c}\pm3.35$
T2- RDF (Chemical control)	$54.10^{bc}\pm4.85$
T3- RDF + Zinc (Spray @ 15 days)	$57.80^{ab}\pm2.97$
T4- 75% RDF + Zinc (Spray @ 15 days)	$57.40^{ab}\pm1.06$
T5- RDF + Zinc (Spray @ 15 days + 30 days)	$60.47^{a}\pm3.62$
T6- 75% RDF + Zinc (Spray @ 15 days + 30 days)	$58.53^{ab}\pm1.90$
T7- RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	$61.70^{a}\pm2.83$
T8- 75% RDF + Zinc (Spray @ 15 days + 30 days + 60 days)	$60.70^{a}\pm2.24$
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 (Dun-can's Multiple Range Test) for separation of means.

4. CONCLUSION

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 as well as helps in increasing the yield of the crop. 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 ~~should~~ takes place by the crop, which ultimately affects the yield.

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