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Response of Crop Production of Wheat (*Triticum aestivum* L.) to Use Different Level of Zinc Sulphate and Urea Fertilizer

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RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Fertilizer management plays an important role for obtaining satisfactory yields and to increase crop productivity. Zinc plays an important role in protein metabolism, gene expression, structural and functional integrity of biological membranes and photosynthetic carbon metabolism. Indiscriminate use of chemical fertilizers to achieve high yield and to compensate for lack of nutrients and consequently the increase of production costs and destruction of soil and water resources have made the specialists interested in healthy and stable crop systems in terms of ecology.

OBJECTIVES: This study was carried out to assess effect of different level of micro nutrient (Zinc) and macro nutrient (Nitrogen) on effective traits on wheat grain yield.

METHODS: This research was done via factorial experiment based on randomized complete blocks design (RCBD) with three replications along 2016 year. The treatments included foliar application Zinc sulphate (Control, 3, 5 and 7 $L.1000L^{-1}$ water) and Urea fertilizer (Control, 10, 20, 30 $kg.ha^{-1}$).

RESULT: According result of analysis of variance effect of Zinc sulphate, Urea fertilizer and interaction effect of treatments on all measured traits was significant (instead 1000 grain weight and harvest index). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of grain per spike (30.58), number of spikelet per spike (17.39), grain yield (4547.78 $kg.ha^{-1}$) and biological yield (13776.03 $kg.ha^{-1}$) was noted for 7 $L.1000L^{-1}$ water zinc sulphate and 30 $kg.ha^{-1}$ Urea fertilizer and lowest ones belonged to control.

CONCLUSION: In general, according result of current research foliar application of urea (30 $kg.ha^{-1}$) and zinc sulfate (7 $L.1000L^{-1}$ water) can replace soil application to increase wheat production and can be advised to producers.

KEYWORDS: *Grain weight, Micro element, Nitrogen, Nutrition, Yield.*

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1. BACKGROUND

Micronutrients such as zinc and iron are essential for plant growth and are involved in physiological processes such as photosynthesis, plant hormone production and plant chlorophyll formation and their deficiency can cause plant nutrient imbalances and ultimately reduce the quantity and quality of the product (Malakoti *et al.*, 2005). Foliar application is a method to reduce the fixation of chemical fertilizers in the soil and as a result reduce environmental risks, including reducing soil and water pollution, and it makes nutrients available to plants in a controlled manner (Kannan, 2010). Today, in addition to high-consumption food elements, the use of micronutrient elements as an important tool to achieve maximum yield per unit area is considered (Mosavi *et al*., 2007). Zinc plays an important role in reducing ROS generation and protects cells from the damaging effects of ROS (Cakmak, 2000). Zinc deficiency in cases caused by the limitations of the subsoil, dryness of the surface soil and diseases cannot be completely and definitively resolved through the consumption of fertilizers containing zinc. Therefore, the use of effective genotypes for the absorption of zinc can be an effective and sustainable solution for the production of more crops in conditions of zinc deficiency (Sadeghzadeh, 2013). Zinc sulfate has been reported to play an important role in regulating the stomatal closure and maintaining ionic balance in the plant to reduce drought stress and also significantly increase SOD, POD and CAT activities in response to drought stress (Tabatabai *et al.* 2015; Yavas and Unay, 2016). Different mechanisms influence the difference in the response of different plant cultivars to the application of nutrients (Baligar *et al*., 2001; Erenoglu *et al.*, 2002; Karimian and Moafpouryan, 1999). These mechanisms are: interactions related to the root in order to increase the ability to use the zinc element for absorption by the root, increasing the absorption and transfer of zinc from the root to the aerial organs, changing the intracellular composition of zinc in the aerial organs of the plant (so that more amount of zinc is placed in the cytoplasm) and improvement or increase in the biochemical utilization efficiency of zinc in plant cells (Malian *et al*., 2014). Ferrari *et al* (2021) by compare foliar application of nitrogen versus its soil application on wheat reported by reducing 25 to 40% of nitrogen consumption in agricultural fields through foliar spraying, it will improve the efficiency of food consumption and have beneficial environmental effects. Afshari (2020) reported foliar application of zinc sulfate at non-irrigation at vegetative growth stage and the early stage of grain growth resulted in a significant increase in grain yield. 10 $g.l^{-1}$ $ZnSO_4$ concentration increased grain yield compared to 5 $g.l^{-1}$ concentration, significantly. That study provides evidence for the use of $ZnSO_4$ and $FeSO_4$ application in arid and semiarid environments to increase grain yield. Nitrogen is the most limiting essential nutrient for maize production (Aftab *et al.*, 2007). A low nitrogen content in the soil leads to poor absorption of micronutrients by plants, which may be insufficient for the complete development of the plant tissue (Szulc, 2013). On the other hand, an excessive accumulation of mineral nitrogen in the soil poses a risk of water pollution as a result of nitrate leaching by precipitation (Ladha *et al*., 2005). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). Foliar application of Zn increased the grain yield of corn (Hussain *et al.*, 2012; Tabatabai *et al.*, 2015). Nitrogen (N) critically plays indispensable role in crop growth, development and yield formation. Adequate supply of N is crucial for maintaining the morpho-physiological and metabolic processes of the crops including nutrients uptake, antioxidant activities, photosynthesis, and respiration (Yousefirad *et al*., 2020). However, it's over supply is a serious problem in intensive agriculture production as it leads to soil acidification, enhancement of reactive N components in the environment as well as modification of soil N structure, with consequent deterioration of the ecosystem (Luo *et al*., 2016). Therefore, N application in suitable ratio can candidly regulate crop growth and yield, and escape N pollution (Negrao *et al*., 2017). Additionally, the highest effects of N efficiency increased leaf length and width, light interception, and biomass and grains production (Ben Chikha *et al*., 2017).

2. OBJECTIVES

This research was carried out to assess effect of different level of Micro nutrient (Zinc) and Macro nutrient (Nitrogen) on effective traits on wheat grain yield.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was done via factorial experiment based on randomized complete blocks design with three replications along 2016 year. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The treatments included foliar application Zinc sulphate (Z_1: Control, Z_2: 3, Z_3: 5 and Z_4: 7 $L.1000L^{-1}$ water) and Urea fertilizer (U_1: Control, U_2: 10, U_3: 20, U_4: 30 $kg.ha^{-1}$). The physical and chemical soil properties was mentioned in table 1.

Table 1. Chemical and physical properties of studied soil (0-30 cm)

K (ppm)	P (ppm)	Soil texture	Silt	Clay (%)	Sand	OC (%)	EC ($ds.m^{-1}$)	Na^+	Ca^{2+} ($Me.l^{-1}$)	Mg^{2+}	pH
65.23	15.74	C.L	37	30	33	0.75	1.26	6.13	3.20	0.99	7.8

3.2. Farm Management

In this plan, urea and zinc sulfate fertilizers were divided into four equal parts in the early morning in specified amounts and 25% at the time of planting (pre-planting), another 25% at the 3-5 leaf stage, 25% at the 7-8 leaves stage and the last 25% were used in the booting stage. In the four-leaf stage of the plant, weeds were weeded every two weeks. In order to carry out the calibration operation of urea spraying, a certain amount of pure water, the volume of which is precisely determined, was poured into the sprayer tank and mixed with the desired fertilizer. Then, according to the speed of the sprayer, the type of nozzle, the amount of sprayer pressure and the determined area, the amount of water and fertilizer was determined. Foliar spraying was done at the four-leaf stage and at the beginning of the stem growth stage.

3.3. Measured Traits

In order to determine the yield and yield components, the two side rows and half a meter of the beginning and end of each plot were eliminated as the marginal effects and finally the ultimate samples were taken from an area of 1 m^2. In order to determine the number of spikes per area unit, the spikes were taken from an area of 1 m^2 of then three middle lines of each plot after considering half a meter of beginning and end of each line as the margin and after counting the spikes their mean was considered as the number of spikes per area unit. As many as 10 spikes were randomly selected from the middle lines of each plot and the number of grains was counted carefully and their mean was recorded. Two 500-grain samples were randomly selected from the produced grains by each plot and if the weight difference of the two samples was less than 5%, the total weight of the two samples was considered as weight of 1000-grain. After full maturity of the grains, the spikes were taken from the 3 middle lines of each plot in an area of 1 m^2 and the grain yield of each plot with moisture of 14% was calculated per area unit and then was recorded. Harvest index (HI) was calculated according to formula of Gardener *et al*. (1985) as follows: **Equ.1.**

HI= (Grain yield/Biologic yield) ×100.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. *Number of grains per spike*

According result of analysis of variance effect of Zinc sulphate on number of grain per spike was significant at 1% probability level, also effect of Urea fertilizer and interaction effect of treatments was significant at 5% probability level (Table 2). Mean comparison result of different level of zinc sulphate indicated that maximum number of grain per spike (29.47) was noted for 5 $L.1000L^{-1}$ water zinc sulphate and minimum of that (21.04) belonged to control treatment (Fig.1). As for Duncan classification made with respect to different level of Urea fertilizer maximum and minimum amount of number of grain per spike belonged to 30 $kg.ha^{-1}$ (27.66) and control (24.80) (Fig.2).

Table 2. Result analysis of variance of measured traits

S.O.V	df	No. Grain per spike	No. Spikelet per spike	1000 Grain weight	Grain yield	Biological yield	Harvest index
Replication (R)	2	33.57**	30.7**	48.86**	1322932.53**	8316817.46**	289.6**
Zinc sulphate (Z)	3	153.94**	36.74**	27.36**	3225718.81**	10637726.63**	178.15**
Urea (U)	3	18.89*	8.13*	18.49*	2903793**	7095569.6**	107.54*
Z × U	9	9.54*	6.49*	4.74^{ns}	450432.06*	3315811.44**	46.46^{ns}
Error	30	3.25	2.47	5.3	150303.04	848163.15	32.22
CV (%)	-	11.49	13.23	10.54	10.59	9.45	16.71

$^{ns,\ *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

Biomass production due to nitrogen consumption increases the re-transfer of photosynthetic materials, more fertility of grains per spike and better grain filling after the flowering stage of the plant, which leads to an increase in grain yield (Feiziasl *et al*., 2014).

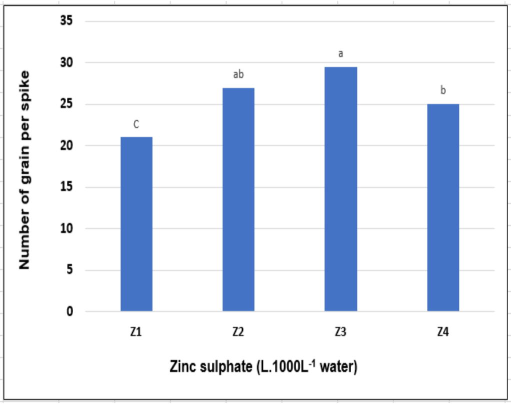

Fig.1. Mean comparison effect of different level of zinc sulphate on number of grain per spike. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Evaluation mean comparison result of interaction effect of treatments indicated maximum number of grain per spike (30.58) was noted for 7 L.1000L^{-1} water zinc sulphate and 30 kg.ha^{-1} Urea fertilizer and lowest one (20.29) belonged to nonuse of zinc sulphate and 10 kg.ha^{-1} Urea fertilizer treatment (had not significant difference with none use of urea treatment) (Fig.3). Because nitrogen plays a crucial role in the formation of amino acids and proteins, and since proteins are essential to the health of plants, an increase in nitrogen has led to an increase in plant grain production. The results mentioned earlier agree with those of Belete *et al*. (2018) and Ma *et al*. (2019).

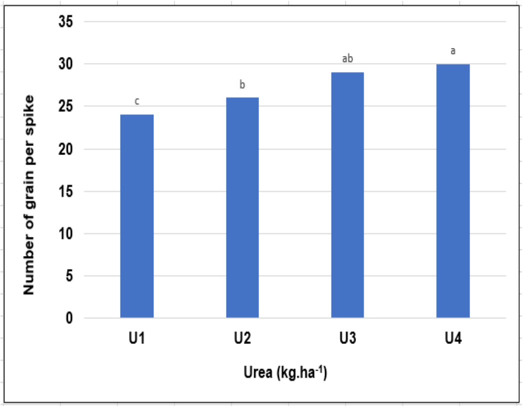

Fig.2. Mean comparison effect of different level of Urea on number of grain per spike. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

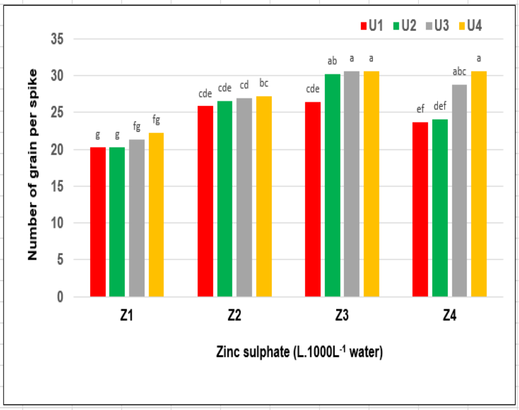

Fig.3. Mean comparison interaction effect of different level of zinc sulphate and Urea on number of grain per spike. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

In another study conducted by Garg *et al.* (2005) increasing nitrogen to soil increased the plant photosynthetic efficiency and ultimately increased the grain yield and growth rate. On the other hand, since the rate of light absorption by leaves and converting it into photosynthetic materials are the other factors affecting the plant growth and production, the increase of leaf area in the farm leads to the increase of light absorption and ultimately leads to the increase of grain yield.

4.2. *Number of spikelet per spike*

Result of analysis of variance revealed effect of Zinc sulphate on number of spikelet per spike was significant at 1% probability level, also effect of Urea fertilizer and interaction effect of treatments was significant at 5% probability level (Table 2). Evaluation mean comparison result revealed in different level of Zinc sulphate the maximum number of spikelet per spike (17.03) was noted for 5 L.1000L^{-1} water and minimum of that (11.66) belonged to control treatment (Fig.4). Between different levels of Urea fertilizer the maximum number of spikelet per spike (16.03) was observed in 30 kg.ha^{-1} and the lowest one (14.22) was found in control treatment (Fig.5). Foliar spraying of urea fertilizer reduces the number of sterile spikes and thus increases the number of fertile spikes in the plant and wheat yield (Rajabi *et al.*, 2022). The results of a research showed that the highest and the lowest number of spikes per square meter of barley was assigned to the treatment of 60 kg.ha^{-1} and no application of zinc fertilizer, respectively (Seyed Hayat Gheyb *et al.*, 2019).

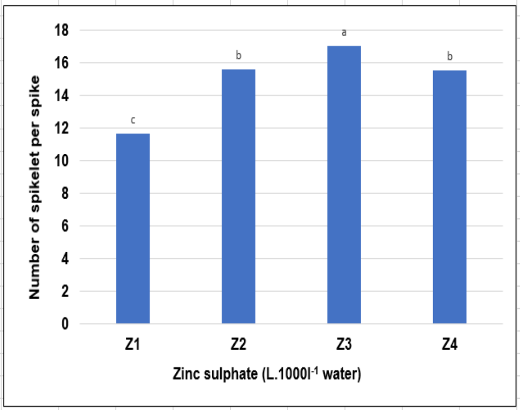

Fig.4. Mean comparison effect of different level of zinc sulphate on number of spikelet per spike. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

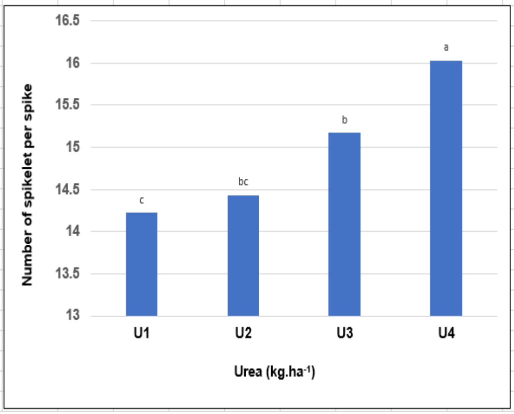

Fig.5. Mean comparison effect of different level of Urea on number of spikelet per spike. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Assess mean comparison result of interaction effect of treatments indicated maximum number of spikelet per spike (17.39) was noted for 7 L.1000L^{-1} water zinc sulphate and 30 kg.ha^{-1} Urea fertilizer and lowest one (10.11) belonged to nonuse of zinc sulphate and 10 kg.ha^{-1} Urea fertilizer treatment (Fig.6). Nitrogen fertilizer application has a discernible impact on grain yield because it is effective in biochemical interactions, lengthening the growing season and accumulating dry matter in aerial organs and grain yield components (Klikocka *et al*., 2016).

4.3. *1000 grain weight*

According result of analysis of variance effect of Zinc sulphate and Urea fertilizer on 1000 grain weight was significant at 1% and 5% probability level, respectively, but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of zinc sulphate indicated that maximum 1000 grain weight (41.60 g) was noted for 7 L.1000L^{-1} water zinc sulphate and minimum of that (38.01 g) belonged to control treatment (Fig.7). As for Duncan classification made with respect to different level of Urea fertilizer maximum and minimum amount of 1000 grain weight belonged to 30 kg.ha^{-1} (41.29 g) and control (38.39 g) (Fig.8).

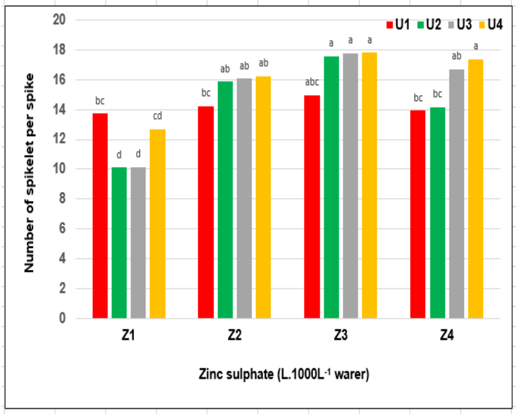

Fig.6. Mean comparison interaction effect of different level of zinc sulphate and Urea on number of spikelet per spike. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level).

Sadeghi and Kazemeini (2011) reported increasing the amount of nitrogen application increased the weight of 1000-grain in barley varieties. Since nitrogen fertilizer increases dry matter production and leaf area, barley grain also became heavier with increasing nitrogen application. Shah *et al*. (2017) investigated the effect of foliar application of urea in before and after pollination the stages of wheat and reported that foliar application of urea fertilizer increased the 1000-grain weight.

4.4. *Grain yield*

Result of analysis of variance revealed effect of Zinc sulphate and Urea fertilizer on grain yield was significant at 1% probability level, also interaction effect of treatments was significant at 5% probability level. Evaluation means comparison result revealed in different level of Zinc sulphate the maximum grain yield (4145.12 kg.ha^{-1}) was noted for 5 L.1000L^{-1} water and minimum of that (2868.45 kg.ha^{-1}) belonged to control treatment (Fig.9).

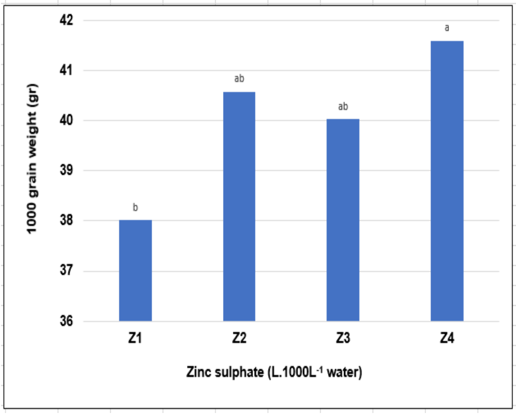

Fig.7. Mean comparison effect of different level of zinc sulphate on 1000 grain weight. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Mirsaleh Mahabadi *et al*. (2020) recommended the simultaneous application of nitrogen and zinc fertilizers to increase wheat yield. In this study, the 1000 grain weight of the wheats were treated with zinc foliar spraying had 23.4% more than the control cultivars.

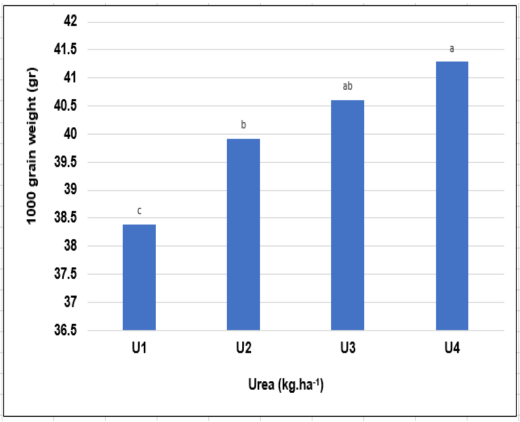

Fig.8. Mean comparison effect of different level of Urea on 1000 grain weight. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

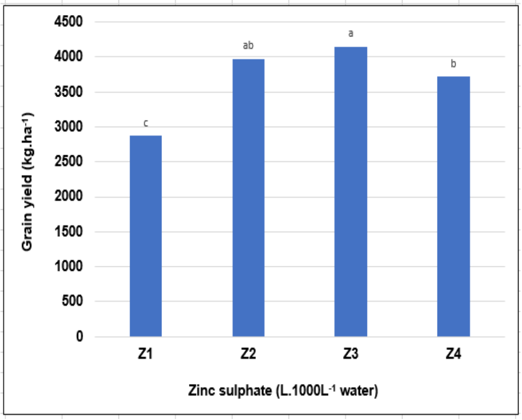

Fig.9. Mean comparison effect of different level of zinc sulphate on grain yield. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Between different levels of Urea fertilizer the maximum grain yield (4160.05 kg.ha^{-1}) was observed in 30 kg.ha^{-1} and the lowest one (2996.07 kg.ha^{-1}) was found in control treatment (Fig.10).

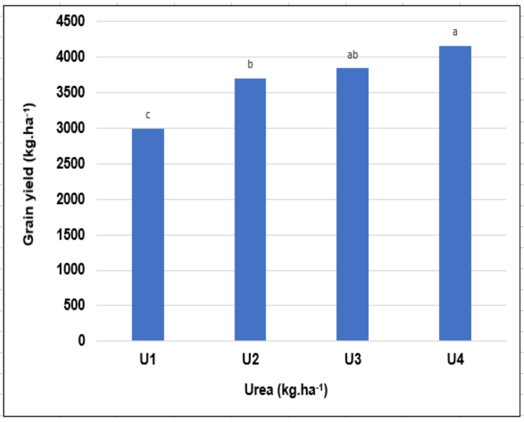

Fig.10. Mean comparison effect of different level of Urea on grain yield. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Evaluation mean comparison result of interaction effect of treatments indicated maximum grain yield (4547.78 kg.ha^{-1}) was noted for 7 L.1000L^{-1} water zinc sulphate and 30 kg.ha^{-1} Urea fertilizer and lowest one (2506.22 kg.ha^{-1}) belonged to control treatment (Fig.11). Shabankareh (2018) stated increasing nitrogen use efficiency is important and strategies such as cultivars with higher nitrogen uptake efficiency change in fertilizer type, management time of fertilizer application and more split fertilizer need to be recommended.

4.5. *Biological yield*

According result of analysis of variance effect of Zinc sulphate, Urea fertilizer and interaction effect of treatments on biological yield was significant at 1% probability level. Mean comparison result of different level of zinc sulphate indicated that maximum biological yield (11564.67 and 11537.11 kg.ha^{-1}) was noted for 3 and 7 L.1000L^{-1} water zinc sulphate and minimum of that (9554.67 kg.ha^{-1}) belonged to control treatment (Fig.12). The increase in wheat yield with the use of zinc fertilizer has been reported by Tao *et al.* (2018). As for Duncan classification made with respect to different level of Urea fertilizer maximum and minimum amount of biological yield belonged to 30 kg.ha^{-1} (11733.12 kg.ha^{-1}) and control (10084.72 kg.ha^{-1}) (Fig.13).

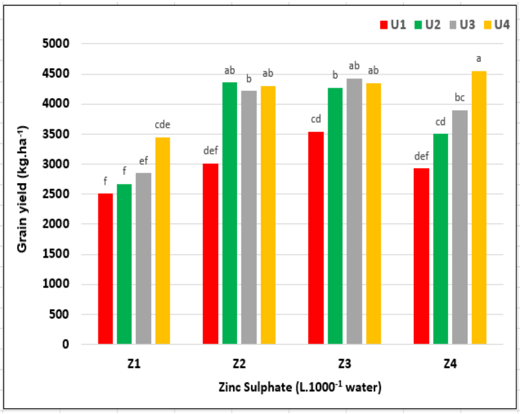

Fig.11. Mean comparison interaction effect of different level of zinc sulphate and Urea on grain yield. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level).

Assess mean comparison result of interaction effect of treatments indicated maximum biological yield (13776.03 kg.ha^{-1}) was noted for 7 L.1000L^{-1} water zinc sulphate and 20 kg.ha^{-1} Urea fertilizer and lowest one (9323.31 kg.ha^{-1}) belonged to control treatment (Fig.14).

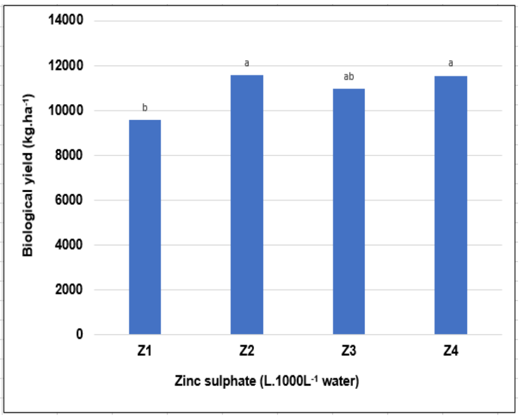

Fig.12. Mean comparison effect of different level of zinc sulphate on biological yield. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

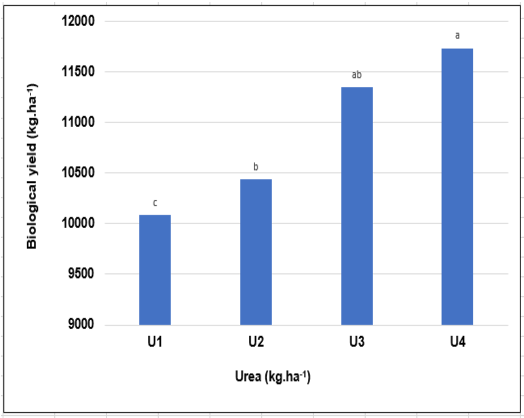

Fig.13. Mean comparison effect of different level of Urea on biological yield. U_1= Control, U_2= 10 kg.ha^{-1} U_3= 20 kg.ha^{-1} U_4= 30 kg.ha^{-1}. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Walsh *et al*. (2018) studied nitrogen fertilizer management in wheat planting systems (Zero, 45, 90 and 135 kg of nitrogen per hectare). They claimed that different nitrogen treatments applied at various periods considerably impacted wheat protein content and grain production. There was no statistically significant difference between the treatments using 90 and 135 kg of nitrogen per acre. The endurance of the plant's photosynthetic surface is strengthened by providing nitrogen at various growth phases. The weight of the grains has increased due to the transfer of additional photosynthetic components to the grains (Tehulie and Eskezia, 2021).

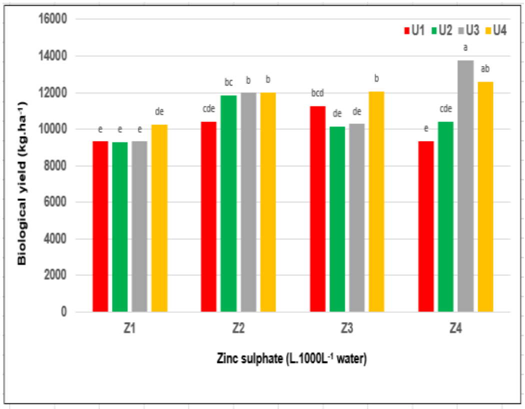

Fig.14. Mean comparison interaction effect of different level of zinc sulphate and Urea on biological yield. U_1= Control, U_2= 10 kg.ha^{-1}, U_3= 20 kg.ha^{-1}, U_4= 30 kg.ha^{-1}. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level).

4.6. *Harvest index*

Harvest index shows the way of dividing the nutritional materials between the growing structures of grain and plant. As one of the components for calculating the HI is grain yield, the changes in HI depend very much on the changes of grain yield. Based on the formula of HI, every factor can change the harvest index when the grain yield is influenced more than total dry weight (Sinclair *et al*., 1990). According result of analysis of variance effect of Zinc sulphate and Urea fertilizer on harvest index was significant at 1% and 5% probability level, respectively, but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of zinc sulphate indicated that maximum harvest index (39.31%) was noted for 5 $L.1000L^{-1}$ water zinc sulphate and minimum of that (31.02%) belonged to control treatment (Fig.15).

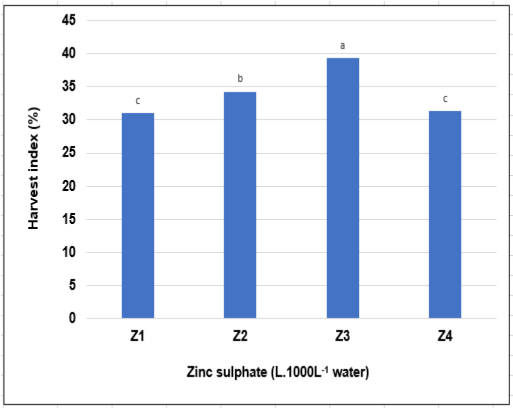

Fig.15. Mean comparison effect of different level of zinc sulphate on harvest index. Z_1= Control, Z_2= 3 L.1000 L^{-1} water zinc sulphate, Z_3= 5 L.1000 L^{-1} water zinc sulphate, Z_4= 7 L.1000 L^{-1} water zinc sulphate. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

Ali *et al*. (2009) studied the effect of zinc and boron fertilizer application on wheat yield. Their results showed that foliar application of zinc and boron fertilizers increased grain yield, biological yield and harvest index of wheat crop. As for Duncan classification made with respect to different level of Urea fertilizer maximum and minimum amount of harvest index belonged to 10 and 30 $kg.ha^{-1}$ (36.08 and 35.48%) and control (29.55%) (Fig.16). According to Klikocka *et al*. (2016), nitrogen fertilizer can enhance the allocation of photosynthetic materials in the economically important section of the plant (grain) and raise the harvest index by expanding the reservoir.

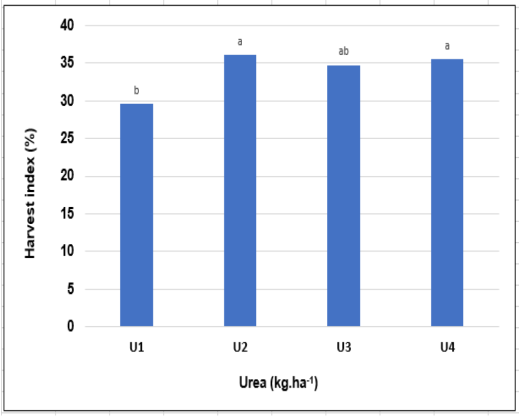

Fig.16. Mean comparison effect of different level of Urea on harvest index. U_1= Control, U_2= 10 $kg.ha^{-1}$, U_3= 20 $kg.ha^{-1}$, U_4= 30 $kg.ha^{-1}$. (Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level)

5. CONCLUSION

In general, according result of current research foliar application of urea (30 $kg.ha^{-1}$) and zinc sulfate (7 $L.1000L^{-1}$ water) can replace soil application (second step) to increase wheat production and can be advised to producers.

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FOOTNOTES

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