









Yield and phenological indices of wheat as affected by exogenous fertilization of Zinc and Iron

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ABSTRACT: Micronutrients (zinc and iron) play a vital role in the functioning of all living organisms. These nutrients are indispensable for plant nourishment and development - though required in small amount. The current research work was performed at the Agronomy Research Farm, The University of Agriculture Peshawar in winter, 2015-16. Combinations of soil applied Zn levels (5, 10, 15 and 20 kg ha⁻¹) and Fe levels (5, 10, 15 and 20 kg ha⁻¹) with a control were allotted randomly to the experimental units using randomized complete block design. The results elucidated that days to anthesis, plant height, productive tillers, yield and yield components of wheat were significantly inclined with Zn and Fe levels. The plots enriched with 15 kg Zn ha⁻¹ and 10 kg Fe ha⁻¹ exhibited higher grain yields (3775 and 3802 kg ha⁻¹, respectively). Results conceded that the interaction for Zn and Fe was significant for days to anthesis. It was concluded that the plots fertilized with 15 kg Zn ha⁻¹ and 10 kg Fe ha⁻¹ resulted in improved yield and yield components. Hence, fertilization of plots with 15 kg Zn ha⁻¹ and 10 kg Fe ha⁻¹ is recommended for improved wheat yield in the agro-climatic condition of Peshawar.

Key words: grain yield; growth; micronutrients; *Triticum aestivum*

Rendimento e índices fenológicos de trigo afetados por fertilização exógena de zinco e ferro

RESUMO: Os micronutrientes (zinco e ferro) desempenham um papel vital no funcionamento de todos os organismos vivos. Estes nutrientes são indispensáveis para a nutrição e desenvolvimento das plantas - embora necessários em pequena quantidade. O atual trabalho da pesquisa foi realizado na Agronomy Research Farm, Universidade da Agricultura Peshawar no inverno, 2015-2016. Combinações de níveis de Zn aplicados no solo (5, 10, 15 e 20 kg ha⁻¹) e Fe (5, 10, 15 e 20 kg ha⁻¹) com um controle foram distribuídas aleatoriamente para as unidades experimentais usando o delineamento experimental em blocos ao acaso. Os resultados mostraram que dias para antese, altura de planta, perfilhos produtivos, componentes de produção e rendimento biológico de trigo foram significativamente influenciados pelas doses de Zn e Fe. As parcelas enriquecidas com 15 kg Zn ha⁻¹ e 10 kg Fe ha⁻¹ apresentaram maiores rendimentos de grãos (3775 e 3802 kg ha⁻¹, respectivamente). Os resultados mostraram que a interação para Zn e Fe foi significativa para dias a antese. Concluiu-se que as parcelas adubadas com 15 kg de Zn ha⁻¹ e 10 kg de Fe ha⁻¹ resultaram uma produção melhor dos componentes. Assim, a adubação de parcelas com 15 kg de Zn ha⁻¹ e 10 kg de Fe ha⁻¹ é recomendada para melhorar o rendimento de trigo na condição agroclimática de Peshawar.

Palavras-chave: produtividade de grãos; crescimento; micronutrientes; *Triticum aestivum*

Introduction

Micronutrients deficiencies are getting attention global wise. The micronutrients deficiency occurs in the result of high yielding cultivars and excessive utilization of macro nutrients like nitrogen (N), phosphorus (P), and potassium (K). Almost 50% of the agricultural lands around the world are Zn deficient for the cereal productivity (Cakmak 2008). Our planet soil is naturally comprised of 1 to 5% of the Fe however it has an imperative role in the soil properties (phosphorus accumulation, ions inequality, soils texture and compaction of soil) (Mengel & Kirkby, 2001). Moreover, the excessive bicarbonate and high pH of Pakistani soil inhibit the availability of Zn and Fe to the plants (Jalilvand et al., 2014). Micronutrients are needed in trace quantity for the crop growth and development but still there importance cannot be negotiated and therefore deficiency of micronutrients may be in soil, food or feed has become the cry of the day (Tahir et al., 2013).

The most reliable source of Zn is zinc sulphate which is prominently involved in various enzymatic activities, nitrogen metabolism and protein formation (Cakmak, 2002). Zn is an active and essential nutritional microelement for a number of biochemical activities and hence efficiently associated with quantitative and qualitative yield of crops (Mousavi et al., 2013). It has key role in cellular and physiological processes of all living organisms and enhancing protein contents in seed whereas its deficiency in human leads to memory loss, skin issues and muscles weakness (Hafeez et al., 2013).

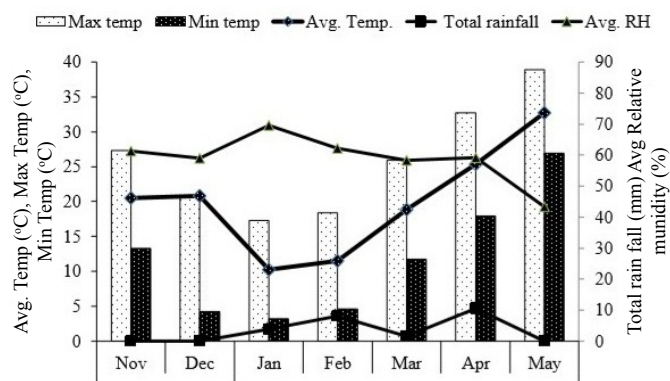
Iron (Fe) has imperative role in chlorophyll synthesis, respiration and photosynthesis which result in crop growth and development. It has vital role in the breakdown of nucleic acid and carbohydrates into nitrate and ammonium in plant cell (Havlin et al., 2014). The ultimate reason of Fe deficiency in the edible portion of the crop and human is due to the Fe deficient (White & Broadley, 2009).

As Zn and Fe are the important micronutrients both for plant and human. The current study was therefore conducted to evaluate the main effect of Zn and Fe as well as to identify their interaction on phenology, yield components and yield of wheat crop in the agro climatic zone of Peshawar.

Material and Methods

Experimental details and location

An experiment entitled "Phenology and yield of wheat as affected by exogenous fertilization of zinc and iron" was designed at the Agronomy Research Farm (ARF) of The University of Agriculture (UoA), Peshawar in winter 2015-16. The experimental farm is situated at 34.01° N latitude, 71.35° E longitude and an altitude of 350 m above sea level. Peshawar is situated in the north of Indian Ocean at nearly 1600 km with continental climate. The research farm is irrigated (surface irrigation) by Warsak Canal from River Kabul. Rainfall, temperature and relative humidity data were collected and are summarized in Figure 1.



Source: Digital weather station of Agronomy Research Farm- The University of Agriculture Peshawar- Pakistan.

Figure 1. Meteorological data for wheat growing season from November, 2015 to May, 2016.

Soil analysis

The soil of the research site is clay loam, alkaline in reaction with electrical conductivity of 0.08 dSm⁻¹. The N, P and K contents of the soil were 1%, 4.52 mg kg⁻¹ and 70.2 mg kg⁻¹ respectively. The soil was deficit in organic matter (Table 1). Soil N content was determined with the help of kjeldahl apparatus (Bremner & Malvaney, 1982). Soil P, K, Zn and Fe content were determined by using AB-DTPA extracting solution as described by Soltanpour & Schwab (1977) and was determined by spectrophotometer, flame photometer and atomic absorption spectroscopy, respectively. Organic matter of soil was determined by following the Walky-Black technique as demonstrated by Nelson & Sommers (1996). Soil pH was determined by using pH meter (Mclean, 1982). Electrical conductivity of soil extract was determined by electrical conductivity meter (Black, 1965a, b).

Table 1. Chemical properties of pre harvest soil sample. The University of Agriculture Peshawar, 2016.

| Soil properties | Units | Values |
|-------------------------|---------------------|--------|
| N content | % | 0.1 |
| P content | mg kg ⁻¹ | 4.52 |
| K content | mg kg ⁻¹ | 70.2 |
| Zn content | mg kg ⁻¹ | 1.18 |
| Fe content | mg kg ⁻¹ | 0.65 |
| Organic matter | % | 1.53 |
| pH | ---- | 8.67 |
| Electrical conductivity | dS m ⁻¹ | 0.08 |

Source: The author's own elaboration.

Experimental layout

The experiment was consisting of two factors (Zinc and Iron) each having four levels; 5, 10, 15 and 20 kg ha⁻¹, respectively. All the treatments combinations and a control (16+1) were randomly allotted to the experimental units using randomized complete block design (RCBD) with 4 replications. Zn and Fe, as per their levels were applied from ZnSO₄·7H₂O & FeSO₄·7H₂O sources respectively.

Crop husbandry

Wheat variety 'Atta Habib-2010' was planted at the rate of 120 kg ha⁻¹ on flat beds with 30cm apart rows. Plot size was

2.4 x 4 m. The recommended dose of nitrogen (120 kg ha^{-1}) was applied from urea in two equal splits with Zn and Fe. Phosphorus was applied in the form of DAP. Keeping in view the supply of sulfur while applying Zn as $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ & Fe as $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, the supply of sulfur was made uniform in entire plots by utilizing ammonium sulfate ($(\text{NH}_4)_2\text{SO}_4$) as nitrogen-cum-sulfur source, rest of nitrogen (N) was maintained from the urea. Irrigation was adjusted on crop requirement basis whereas standard and constant agronomic practices were maintained for the entire treatments.

Parameters evaluated in the experiment

Data on days to anthesis were noted when 80% plants produce spike in each of the treatment. Days were totaled from the seeding date till the date of completion of 80% spikes in each plot. The productive tillers m^{-2} were documented by calculating the fertile tillers at three randomly chosen positions in a meter long row and then converted into m^2 area via the formula:

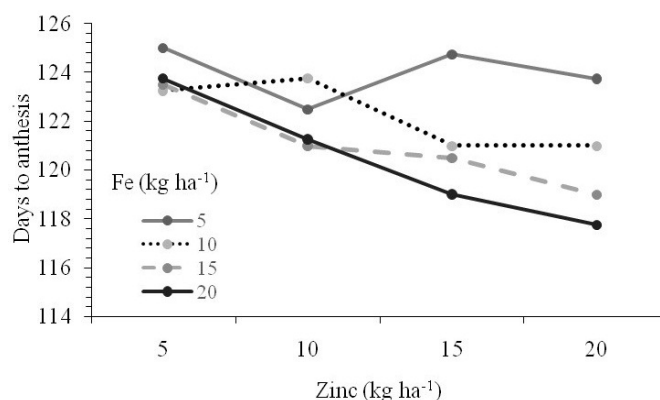
$$\text{Productive tillers (m}^{-2}\text{)} = \frac{\text{Total productive tillers counted}}{\text{Row - row distance} \times \text{Row length} \times \text{No. of rows}}$$

At physiological maturity, ten plants were selected at random for the plant height and then average was taken. Grains of ten randomly selected spikes were counted and then averaged. For data of 1000- grains weight; 1000 grains were counted and weighed with electronic balance. Grains of four central rows were weighed for grain yield and then converted into kg ha^{-1} , using formula:

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Grain yield in four central rows}}{\text{Row - row distance (m)} \times \text{Row length (m)} \times \text{No. of rows}} \times 10000$$

Results and Discussion

Wheat is a determinate crop which is determined by vegetative and reproductive stages. As the vegetative growth duration ends, wheat crop is reaching to start flowering (anthesis). Days to anthesis was significantly affected by different zinc (Zn) and iron (Fe) levels. The treatments against control were found significant. The interaction of Zn with Fe was also significant (Table 2). Mean values of the data revealed that Zn at the rate of 20 kg ha^{-1} took fewer days to anthesis (120). It was further shown that late anthesis (124) was recorded at 5 kg Zn ha^{-1} . Among different Fe levels, more days to anthesis (124) were recorded for Fe at the rate of 20 kg ha^{-1} . Early anthesis (120) was observed at 5 kg Fe ha^{-1} . More days to anthesis (126) were observed at control as compare to the treated plots (122). The interactive effect of Zn and Fe exhibited that increasing Zn level decreased days to anthesis at all levels of Fe except 5 kg Fe ha^{-1} whereas no decrease in days to anthesis was observed with increasing Zn levels (Figure 2). Vigorous crop growth and precedence in the anthesis might be because of the reason that Zn has a vital role in auxin formation, metabolism, cell expansion, biochemical



Source: MS Excel designed graph with original data from first author's master thesis.

Figure 2. Interaction of zinc and iron for days to anthesis of wheat. The University of Agriculture Peshawar, 2016.

activities and induction of primordia for reproductive components (Keram et al., 2014). Balanced fertilization of Fe and Zn promotes early tillering, early booting, early anthesis, spike length and grain spike⁻¹ (Jalilvand et al., 2014). A detailed literature exposes that micro element as a mineral and chelating agent when provide sole or in combination improved growth and yield (Mosanna & Behrozyar, 2015).

The number of productive tillers has vital importance in the determination and achieving of final yield in cereal. Analysis of variance revealed that productive tillers were suggestively influenced by Zn and Fe. The comparison of control with the treatment revealed significant differences, while the interactive effect of Zn and Fe was illustrated insignificant (Table 2). Means of the data presented that Zn at the rate of 15 kg ha^{-1} resulted in higher productive tillers (299), which was statistically similar with the number of productive tillers (293) produced with the 10 kg Zn ha^{-1} . The productive tillers (281) were lower with 5 kg Zn ha^{-1} . Among different Fe levels, Fe at the rate of 10 kg ha^{-1} produced higher productive tillers (298), which was statistically at par with the number of productive tillers (296) attained with the 5 kg Fe ha^{-1} . Lower number of productive tillers (282) was attained with the 20 kg Fe ha^{-1} . The control plots against fertilized plots produced lower number of productive tillers (244). This might be due to the fact that zinc application has key role in metabolic, physiological and biochemical processes which improve morphological characters of the plant and assimilates partitioning to the spikes (Vankhadeh, 2002). Khan et al. (2008) investigated that zinc application had positive impact on plant growth which lead to increase plant height, number of fertile tillers m^{-2} , spike length, grains spike⁻¹, biological yields and culminating in better grain yield. Maximum number of productive tillers was noted in the plots treated with 10 kg Fe ha^{-1} . This might be due to Fe has marked role in cellular events and mitochondrial homeostasis which in turn effect the plant growth and development (Vigani et al., 2013). Application of Fe at different levels hastened the number of tillers, 1000 grains weight and grain yield of the wheat (Abbas et al., 2012). Rawashdeh & Sala (2014) studied the importance of Fe in the enhancement of quantitative and qualitative specifications of

the wheat grain which significantly increase the number of fertile tillers and plant height. Boorboori et al. (2012) reported that soil application of Zn and Fe has positive impact on fertile tillers and more productive tillers were attained through soil application of Zn and Fe.

Plant height is a function of combined effect of both genetic and environmental factors. Significant differences were observed in plant height as a result of different Zn and Fe levels. The treatments against control were found significant, while interaction of Zn and Fe was found non-significant (Table 2). Mean values of data exposed that fertilization of 15 kg Zn ha⁻¹ resulted in taller plants (94), which was statistically comparable with the plant height (93) obtained at 20 kg Zn ha⁻¹. Short statured plants (90) were noted at 5 kg Zn ha⁻¹ treated plots. Among different Fe levels, taller plants (94) were produced by plots treated with Fe at the rate of 10 kg ha⁻¹, which was statistically comparable with the plants (93) established by 5 kg Fe ha⁻¹ treated plots. Dwarf plants (90) were developed with 20 kg Fe ha⁻¹. Furthermore, treated plots improved the plant height (92) in a momentous way over control (87). It might be due to the maximum availability and absorption of Zn from soil solution which increase photosynthesis rate, respiration rate, auxin metabolism, cytochrome synthesis and faster cell division and root-shoot development consequently heighten wheat plants (Mahdi et al., 2012). Zn is an essential micro element in growth and development of plant (Badshah & Ayub, 2013). Taller plants were noticed in the plots treated with 10 kg Fe ha⁻¹. Fe has an imperative role in photosynthetic reactions and triggers several enzymes that contributes in RNA synthesis and improve plant growth (Malakouti & Tehrani, 2005). Bameri et al. (2012) reported in a field experiment that Zn, Fe and Mn had positive effect plant height, 1000-grains weights, grains yield, biological yields and harvests index.

Significant differences were observed in days to maturity as consequences of different levels of Zn and Fe. The treatments

against control were found significant, while interactive effect of Zn and Fe was found insignificant (Table 2). Means of data presented that maximum days to physiological maturity (160) were recorded at 15 kg Zn ha⁻¹, which were followed by days to physiological maturity (159) noted with both 10 and 20 kg Zn ha⁻¹ treated plots. Early physiological maturity (158) was observed at 5 kg Zn ha⁻¹. Among different Fe levels, more days to physiological maturity (160) were resulted in the plots with 10 kg Fe ha⁻¹, which was followed by days to physiological maturity (159), obtained with the 15 and 20 kg Fe ha⁻¹ treated plots. Fewer days to maturity (158) were recorded with fertilization of 5 kg Fe ha⁻¹. The control plots against fertilized plots took least days to physiological maturity (157). Delay in maturity might be due to Zn cause rise in the chlorophyll contents, similarly, might enhance the level of indole acetic acids which is consider to be one of the plants indispensable hormones, necessary both for growth and development (McCauley et al., 2009). Asif et al. (2013) demonstrated that Zn application increase nitrogen uptake, which improve vegetative growth and delayed days to maturity. Determined days to maturity were observed in the plots fertilized with 10 kg Fe ha⁻¹. Fe plays critical role in plant growth and development, inclusive of chlorophyll formation, thylakoid synthesis, nitrogen fixation and enzymatic activities of photosynthesis along with respiration (Masoud et al., 2012).

Better nutrition enhanced the source capacity to better fill the sink. Significant differences were observed for grains spike⁻¹ as a result of Zn and Fe levels. The treatments against control were found significant, while the interaction of Zn with Fe was discovered insignificant (Table 3). Mean values of the data resulted that Zn at the rate of 15 kg ha⁻¹ produced more grain spike⁻¹ (52), which was statistically at for with grain spike⁻¹ (50) recorded with 20 kg Zn ha⁻¹. Fewer grains spike⁻¹ (48) were observed in the plots treated with 10 kg Zn ha⁻¹. Among different Fe levels, Fe at the rate of 10 kg ha⁻¹ produced more grains spike⁻¹ (54), which was followed by grains spike⁻¹ (50)

Table 2. Days to anthesis, productive tillers (m²), days to maturity and plant height (cm) of wheat as affected by zinc and iron. The University of Agriculture Peshawar, 2015/2016.

| Zinc (kg ha ⁻¹) | Days to anthesis | Productive tillers (m ²) | Days to maturity | Plant height (cm) |
|-----------------------------|------------------|--------------------------------------|------------------|-------------------|
| 5 | 124 a | 281 c | 158 c | 90 b |
| 10 | 122 b | 293 b | 159 b | 91 b |
| 15 | 121 c | 299 a | 160 a | 94a |
| 20 | 120 d | 291 b | 159b | 93 a |
| LSD for zinc (Zn) | 0.9 | 5.6 | 0.8 | 1.7 |
| Iron (kg ha ⁻¹) | | | | |
| 5 | 124 a | 296 a | 158 c | 93 a |
| 10 | 122 b | 298 a | 160 a | 94 a |
| 15 | 121 c | 288 b | 159 b | 91 b |
| 20 | 120 d | 282 c | 159 b | 90 b |
| LSD for iron (Fe) | 0.9 | 5.6 | 0.8 | 1.7 |
| Planned mean comparison | ** | ** | * | ** |
| Control | 126 | 244 | 157 | 86.9 |
| Rest | 122 | 291 | 159 | 92.0 |
| Interaction | | | | |
| LSD for Zn x Fe | ** | ns | ns | ns |

** and * = significant at 1% and 5% level of probability, ns = non-significant

Mean values of the different categories in each column with different letters discloses significant differences (p<0.05) using LSD test.

obtained with both 5 and 15 kg Fe ha⁻¹. Fewer grain spike⁻¹ (45) was produced with the 20 kg Fe ha⁻¹. The control against the treated plots resulted in fewer grain spike⁻¹ (36). It might be due to the enhancement of enzymatic processes. Microelements efficiently enhanced the photosynthesis and translocate assimilates to seed. In a long-term experiment, Hao et al. (2003) concluded that fertilization of Zn improved the nutritional value, grains spike⁻¹ and thousand grain weight per unit area. The grains spike⁻¹ increases in plots treated with 10 kg Fe ha⁻¹. This might be due to better starch utilization and translocation of assimilates to developing grains, which increase the grain size and grains spike⁻¹. Nadim et al. (2013) demonstrated that grains spike⁻¹ in wheat are improved with the soil application of Fe. Fathi & Enayat Gholizadeh (2010) demonstrated that increased level of Zn and Fe as soil fertilizer increases grain yield, 1000 grain weight and grains spike⁻¹ in barley plant.

Analysis exhibited that different Zn and Fe levels significantly affected thousand grains weight of wheat. The treatments against control were found significant, while the interaction effect of Zn with Fe was illustrated insignificant (Table 3). Mean values of the data indicated that Zn at the rate of 15 kg ha⁻¹ attained more 1000 grains weight (45.5), which was followed by thousand grains weight (44.4) produced with 20 kg Zn ha⁻¹. Lighter thousand grains (43.2) were recorded with 5 kg Zn ha⁻¹. Among different Fe levels, Fe at the rate of 10 kg ha⁻¹ documented heavier grains (45.4), which were followed by thousand grains weight (44.6) obtained with 5 kg Fe ha⁻¹. Minimum thousand grains (42.9) weight was produced with 20 kg Fe ha⁻¹. The control plots in comparison with the fertilized plots produced less thousand grains weight (39.2). This perhaps due to the fact that Zn plays key role in biosynthesis of IAA, synchronizing the auxin concentration in plant and other biochemical and physiological processes and initiation of primordia for reproductive parts and thus ascribed the beneficial effect of to better translocation of

desired metabolites to the yield contributing parts of plant. The increase in yield attributing characters like spike length, grains spike⁻¹, number of effective tillers and 1000-grain weight with Zn application has been reported by Bameri et al. (2012). Soil application of Zn hastens wheat Zn dietary standard and improve spike number, grains spike⁻¹ and 1000-grain weight (Hao et al., 2003). Heavier grains were documented with fertilization of 10 kg Fe ha⁻¹. This perhaps due to the key role of Fe in plant respiration, photosynthetic processes and chlorophyll formation, addition of Fe improves grain yield components. Application of Zn, Mn and Fe have key importance in crop growth, involving in photosynthesis, respiration and other biochemical and physiological processes and thus attributed to higher yields (Zeidan et al., 2010). Application of Zn with Fe improves 1000 grain weight in rice in comparison to sole application of Zn and Fe (Zayed et al., 2011).

Grain yield was suggestively exaggerated by different zinc (Zn) and iron (Fe) levels. The comparison of control plots vs treated plots was also found significant, while the interaction had non-significant response for Zn and Fe (Table 3). Mean values of the data revealed that Zn at the rate of 15 kg ha⁻¹ produced greater grain yield (3775 kg ha⁻¹), which was statistically comparable with grain yield (3751 kg ha⁻¹) produced with the 20. kg Zn ha⁻¹. The grain yield (3496 kg ha⁻¹) was lower with the 5 kg Zn ha⁻¹. Among different Fe levels, Fe at the rate of 10 kg ha⁻¹ produced more grain yield (3802 kg ha⁻¹), which was statistically at par with the grain yield (3747 kg ha⁻¹) obtained with the 5 kg Fe ha⁻¹. Lower grain yield (3449 kg ha⁻¹) was produced with the 20 kg Fe ha⁻¹. The control plots in comparison with the rest plots produced lower grain yield (2919 kg ha⁻¹). This improvement in the grain yield might be due to the fact that Zn has catalytic role in photosynthesis, respiration, biochemical and physiological activities and thus result in higher grain yield (Dahiya et al., 2008). Zn contributes in conversion of nitrates to ammonia and here after, improve

Table 3. Grain spike⁻¹, thousand grain weight (g) and grain yield (kg ha⁻¹) and harvest index (%) of wheat as affected by zinc and iron. The University of Agriculture Peshawar, 2015/2016.

| Zinc (kg ha ⁻¹) | Thousand grain weight (g) | Grain spike ⁻¹ | Grain yield (kg ha ⁻¹) | Harvest index (%) |
|-----------------------------|---------------------------|---------------------------|------------------------------------|-------------------|
| 5 | 43.2 c | 49 b | 3496 c | 44.47 b |
| 10 | 43.7 c | 48ab | 3592 b | 44.71 a |
| 15 | 45.5a | 52a | 3775a | 45.88 a |
| 20 | 44.4b | 50a | 3751a | 45.90 a |
| LSD for zinc (Zn) | 0.7 | 2.9 | 55 | 1.2 |
| Iron (kg ha ⁻¹) | | | | |
| 5 | 44.6 b | 50 b | 3747 a | 45.50 a |
| 10 | 45.4 a | 54 a | 3802 a | 46.08 a |
| 15 | 43.9 b | 50 b | 3616 b | 44.85 ab |
| 20 | 42.9c | 45 c | 3449 c | 44.53 ab |
| LSD for iron(Fe) | 0.7 | 2.9 | 55 | 1.2 |
| Planned mean comparison | ** | ** | ** | ** |
| Control | 39.2 | 36 | 2919.1 | 42.6 |
| Rest | 44.2 | 49 | 3653.5 | 45.2 |
| Interaction | | | | |
| LSD for Zn x Fe | ns | ns | ns | ns |

** = significant at 1% level of probability and ns = non-significant

Mean values of the different categories in each column with different letters discloses significant differences (p<0.05) using LSD test.

grain yield of wheat by 4-9% (Thakur et al., 2001). The grain yield increases in plots treated with 10 kg Fe ha⁻¹. This might be due to the fact that Fe has a vital role in the plant respiration and photosynthesis thereby translocate more assimilates toward source which result in higher grain yield. Abbas et al. (2009) reported increased grain yield of wheat by the application of Fe whereas the higher rate of Fe had insignificant influence on crop yield.

Harvest index is an indicator of dry matter partitioning towards the reproductive organs. Harvest index of wheat was significantly affected by different zinc (Zn) and iron (Fe) levels. The comparison of control vs rest was also found significant, while the interactive effect of Zn and Fe was found non-significant (Table 13). Mean values of the data shown that Zn at the rate of 20 kg ha⁻¹ had higher harvest index (45.90), which was statistically similar with the harvest index (45.88) attained with 15 kg Zn ha⁻¹. The harvest index (44.47) was lower with the 5 kg Zn ha⁻¹. Among different Fe levels, Fe at the rate of 10 kg ha⁻¹ had more harvest index (46.08), which was statistically at par with the harvest index (45.50) attained with the 5 kg Fe ha⁻¹. Lower Harvest index (44.53) was obtained with the 5 kg Fe ha⁻¹. The control plots in comparison with the fertilized plots had lower Harvest index (42.6). This might be due to sufficient Zn nutrition which improve cell division, photosynthesis, respiration, nitrogen metabolism, protein synthesis and physiological activates which is therefore, reflected in better straw, grain yield as well as harvests index (Sharma et al., 2013) Dehghanian & Madandoost (2008) exhibited that linear Zn inclination enhance harvest index. Higher harvest index noted with application of 10 kg Fe ha⁻¹. This perhaps due to the basic role of Fe in plant respiration, photosynthetic processes and chlorophyll formation, Fe addition cause improvement in grain yield components. Application of micro-elements prominently improve grains spike⁻¹, 1000 grains weight, tillers meters⁻², grain yield, biological yields and harvest index of the wheat (Zain et al., 2015).

Conclusions

Fe and Zn uptake are controlled by the two major factors, availability of these elements in the soil and the ability of plants to acquire them. Exogenous application of Zn and Fe is simple and easy method to correct their deficiency in the soil and plants. The available results exhibited that exogenous application of Zn and Fe at the rate of 15 and 10 kg ha⁻¹ enhanced phenology, yield and yield components of wheat and therefore recommended for higher productivity of wheat under agro-climatic condition of Peshawar.

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