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Research Article

Evaluation of Wheat (*Triticum aestivum* L.) Performance under Different Levels of Zinc and Phosphorus

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Abstract | The aim of this research was to assist the performance of wheat under several levels of Zinc (Zn) and phosphorus (P). This research was planned in RCB design (split-plot Structure). All the treatments were repeated 4 times to reduce the chances of natural errors. The various levels of P (0, 75, 90 and 105 kg ha-1) were assigned to major plots and Zn levels (0, 4, 8, 12 and 16 kg ha-1) were allocated to sub-plot. 'Atta Habib' wheat variety was sown @ 120 kg ha-1. Result of the experiment shows that both factors had considerably affected all measured parameters. Application of P @105 kg P ha-1 resulted maximum tiller m-2 (304), taller plants (95.40 cm), maximum spike length (10.72 cm), more grain spike-1(49), greater 1000-grains weight (42 g), greater biomass (10719 kg ha-1), maximum grain yield (4148 kg ha-1) and highest economical yield (38%). Regarding Zn levels Plots treated with Zn @ 16 kg ha-1 produce more plants m-2 (295), taller plants (93.5 cm), maximum spike length (10.57cm), more grains in spike (49), higher 1000-Grains weight (41.9 g), maximum biomass (10337 kg ha-1), greater grain yield (4007 kg ha-1) and economical yield (38%). It was concluded that wheat performed better in terms of yield and yield contributing parameters when P and Zn were applied @ 105 and 16 kg ha-1, respectively.

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Introduction

Wheat (*Triticum aestivum* L.) is a food crop that belongs to the Poaceae family. It is a key food source for Pakistanis and ranking first among agricultural crops (GOP, 2014). Due to an increase in population wheat requirement is increasing day by day in Pakistan. Wheat is grown on huge area still its production is not enough to compensate the increasing population (Adnan *et al*., 2014). Reduction in wheat productivity is occurred due to high infestation of weeds, shortage of water at severe stages of growth, traditional growing practices and inadequate use of fertilizers (Jame *et al*., 2011). Mineral fertilization has the ability to improve cereals yield (Rehim *et al*., 2012).

According to reports, Pakistan's soil is low in minerals such as phosphate, nitrogen, organic matter, and zinc.Therefore, it is required to use optimum level of fertilizers to compensate nutrients deficiency problem and to overcome low yield (Shah *et al*., 2010). Phosphorus (P) is main plant nutrients in crop production and Phosphorus application in many agricultural systems is necessary to the soil that ensures plant productivity (Marilyn and Dalen, 2012). Several plant physiological functions are dependent on phosphorus such as energy storage and transfer, photosynthesis and consumption of sugar starch. It is also a component of nucleus cell and is necessary for division of cell and development of meristem tissues (Ali *et al*., 2012). Phosphorus increases cereal straw strengthening, stimulates development of root, flower promotion, fruit production, seed formation and maturity hastening of the crop (Hussain *et al*., 2011). Besides the quality of certain vegetables, fruits and grain crops, it also improves their resistance to adverse conditions and diseases (Ahmad *et al*., 2013). For better crop production, plants need optimum P in early growth stages. In Pakistan, overall, 90% of soil is deficient in P (Ahmad et al., 2013). Therefore, P management regarding optimum level and method are important for getting the maximum benefits (Iqbal *et al*., 2013).

Zinc (Zn), an important plant nutrient needed in modicum amount. It has also a constituent or co-factor regulator of enzymes involved in the biological systems (Keram *et al*., 2012: Aref, 2011). Zn is necessary in biochemical processes such as cytochrome, metabolism of growth hormone, synthesis of nucleotide and production of chlorophyll (Mousavi *et al*., 2013). Regulation of physiological functions has greatly dependent on presence of Zn in soil. Zinc availability promotes activities of phytochromes, integrity of the membrane and plant reproduction (Keram *et al*., 2012). The principal factors that usually affect the Zn quantity are generally soil organic matter, pH soil texture, carbonate content and its interactions with other nutrients (Bameri *et al*., 2012). In long term crop production, the Zn shortage is the most is one of the limiting factors (Zhao *et al*., 2011). Zn fertilization is the strategy that can overcome deficiency of Zn in soil and cereal grain (Alloway, 2009). Addition of phosphorous with other nutrients may create antagonism or synergism affect that reduced nourishment of plants. Interaction of P and Zn mostly act as antagonistically (Rasavel and Ravichandran, 2012). Antagonistic phenomenon between P and Zn occurs under their imbalance levels but mostly with the solicitation of phosphatic fertilizer (Rehim et al., 2012). It is crucial to know the optimum Zn level and also find out its interaction with P and others nutrients in the soil for crop production.

This study was designed by keeping in view the significance of Zn and P for crop cultivation and along with interactive effects of Zn and P on the performance of wheat.

2. Materials and Methods

The aim of this research was to assist wheat performance under various doses of Zn and P levels. Two factors were studied in this research, their details as bellow.

Factor –A:	**Phosphorus (P)**
	$P_1 = 0$ kg ha^{-1}
	$P_2 = 75$ kg ha^{-1}
	$P_3 = 90$ kg ha^{-1}
	$P_4 = 105$ kg ha-^{1}
Factor –B:	**Zinc (Zn)**
	$Z_1 = 0$ kg ha^{-1}
	$Z_2 = 4$ kg ha^{-1}
	$Z_3 = 8$ kg ha^{-1}
	$Z_4 = 12$ kg ha^{-1}
	$Z_5 = 16$ kg ha^{-1}

RCB design with split plot structure was choose for this experiment as it was suitable for this research. There were 4 replications under plot size was 3 x 3.5 m^2 in this experiment. Phosphorus was added to main plots, while Zn was assigned to sub plots. Wheat variety 'Atta habib-2010' was sown @ 120 kg ha^{-1}. Recommended dose of nitrogen was used from urea, of which half was applied at sowing and remaining and half was applied with second irrigation. For Zn and phosphorus application, $ZnSO_4$ and DAP was used respectively. Irrigation was given as needed by the crop. All other cultural measures were maintained uniform for all plots. Data was collected from each plot for all described parameters and was averaged and analyzed statistically.

2.1 Statistical analysis

Steel and Torrie (1980) described procedures of statistical analysis suitable for RCB Design with split plot arrangement was used for the collected data. LSD test was also use to compare the difference between the means.

3. Results and Discussion

3.1 Emergence m^{-2}

Emergence m^{-2} is presented in Table 1 shows that P and Zn level has found insignificant for emergence m^{-2}. Zinc and phosphorus interaction was likewise determined to be insignificant. It is due to wheat seed inherent potential and constant field capacity which doesn't resulted any variation in the emergence of seedlings. Our outcomes are confirmed via Nawab *et al.* (2011) and Kaleem *et al.* (2009) reported that emergence of seedling is not effected by external application but is effected by amount of starch store in seed, seed vigor and viability.

3.2 Tillers m^{-2}

The influence of both Zn and P was significant, while their interactive impact was non-significant for tillers number (Table 1). The plots received P @ 105 kg P ha^{-1} ensued maximum number tillers m^{-2} (304), while un-treated plots resulted in least (267). In case Zn treatments higher tillers m^{-2} was recorded (295) for 16 kg ha^{-1} Zn application which is statistically alike for the number of tillers (293) obtained for 12 kg ha^{-1} Zn treatment and least (285) tiller m^{-2} was recorded in control plot. Fioreze *et al.* (2012); Khalid *et al.* (2004) are also confirmed our results as they reported that P application to crop plants boost their root growth and enhance more tiller production. There is synergetic influence of Zn on the availability of other nutrients by the plants which had boost tillers m^{-2} (Mafi *et al.*, 2013).

3.3 Plant height (cm)

Phosphorus and zinc considerably affected plant height of wheat as shown by statistical analysis in Table 1, while their interference between Zn and P was found non-significant. Maximum plants height was recorded whereas phosphorus was added @ 90 and 105 kg ha^{-1}, while in the control plots, dwarf plants (87.67 cm) were found. For zinc application, taller plants were identified in plots where Zn @12 and @ 16 kg ha^{-1} was applied, whereas short plants (91.12 cm) were observed in control plots. It was noted that Plant stature was enhanced with application phosphorus to the soil and it was due to better roots development and improvement in the soil environment (Zafar *et al.*, 2011). Our results were further confirmed by (Jan *et al.*, 2013) as he stated that application of Zn enhances cell division and elongates internodes and ultimately increase in plant height occurs.

Table 1: Emergence m^{-2}, tiller m^{-2}, plant height, spike length, grains $spike^{-1}$, 1000 grains weight, biological yield, grain yield and HI of wheat as influenced by several zinc and phosphorus levels.

Phosphorus Kg ha^{-1}	Emergence m^{-2}	Tiller m^{-2}	Plant height (cm)	Spike length (cm)	Grain spik-1	1000 grain weight (g)	Biological yield (kg ha-1)	Grain yield (kg ha-1)	Harvest index %
0	66	267c	87.67c	8.18c	42c	37c	8716c	2938c	34b
75	68	288b	90.82b	9.44b	46b	39b	9370b	3653b	37a
90	63	303a	95.40a	10.52a	49a	42a	10719a	4148a	38a
105	64	304a	95.35a	10.72a	49a	42a	10850a	4039a	37a
LSD (0.05) for P	NS	11.1	0.94	0.724	1.64	1.65	476.467	258.5	1.875
Zinc kg ha-1									
0	65	285c	91.12c	8.469c	43d	37.47c	9341c	3296d	34.85c
4	63	288bc	91.74c	9.338b	46c	39.34b	9702b	3512c	35.79bc
8	65	290abc	92.03bc	9.805b	47b	39.71b	9907b	3711b	37.40ab
12	65	293ab	93.19ab	10.393a	48ab	41.41a	10281a	3947a	38.80a
16	67	295a	93.48a	10.565a	49a	41.91a	10337a	4007a	38.40a
LSD (0.05) for Zn	NS	6.5	1.39	0.566	1.14	1.60	337.731	142.5	3.096
P X Zn	NS	NS	NS	**	**	NS	NS	**	NS

Using the LSD test, the overall means of the same sections followed by the same alphabets are statistically equivalent. **: Significant at 5 % probability, NS: Not Significant.

3.4 Spike length (cm)

Zinc, Phosphorus, and their interactions have a significant impact on wheat spike length data (Table 1). Regarding P applications, longer spikes (10.72 cm and 10.52 cm) are produced by high dosages of P @ 90 and 105 kg ha^{-1}, but smaller spikes (8.18 cm) were found in control plots. For Zn longer spike was recorded (10.56 cm) was observed in 16 kg Zn ha^{-1} treated plots, whereas smallest spike length (8.47) was documented for control plots. Similar findings were endorsed by Memon *et al.* (2011) and Khan *et al.* (2009) who investigated that addition of P improved spike length of wheat. Similar to our results Morshedide and Farahakhsh (2011) noticed longer spikes with addition of each increment of zinc.

3.5 Grain spike^{-1}

Statistically scrutiny of the data exhibited that various levels of zinc and phosphorus had notable impact on grain spike^{-1}. There was also positive influence between Zn and P for grains number in a spike (Table 1). The grain number in a spike was enhanced as phosphorus levels were increased; higher grains number in a spike was obtained at 90 and 105 kg P ha^{-1}, whereas in untreated plots, a least number of grain spike^{-1} was found. Concerning zinc, 12 and 16 kg Zn ha^{-1} application has produced greater numbers of grain spike^{-1}, while lowest grain spike^{-1} was observed in untreated plots. Results indicated that rise in P application has increased the number of grains spike^{-1} (Memon *et al*., 2011). Zn application has positive effect on grains spike^{-1} the availability of micronutrient to plants was enhanced by the application of Zn to soil due to which the efficiency of grain formation period and number of grain spike^{-1} was also enhanced (Zeidan *et al*., 2010; Morshedi and Farahbakhsh, 2011).

3.6 1000-Grains weight (g)

The result demonstrates that different levels of zinc and phosphorus had a positive impact on the 1000-Grain weight of wheat; however, their combination had no measurable influence (Table 1). At 105 kg P ha^{-1}, the highest 1000-Grain weight was 42 g, while the least was obtained in untreated control. In the case of zinc, greater 1000-Grains weight (41. 91 g) was found in plots fed with Zn 16 kg ha^{-1}, while control plots exhibited lower thousand-grain weight (37.47 g). Mishra and Abidi (2010) found a similar conclusion when they studied whether plants require phosphorus throughout their early crop growth period, which might be reflected in the heavy grain weight. It could be owing to the active metabolism and assimilate buildup aided by phosphorus availability. Because zinc plays a role in the carbonic enzyme, better crop yield and optimal fruit size may be the result. Zinc is involved in carbohydrate metabolism, activating enzymes, protein synthesis, and speeding up processes, all of which contribute to an improvement in thousand grain weight efficiency. Morshedi and Farahbakhsh (2011) conducted similar studies and found that adding zinc to the grain increased the thousand-grain weight.

3.7 Biological yield (kg ha^{-1})

The data of Table 1 indicated that phosphorus and zinc had major impacts on biological yield, but their combination was not significant. Plots treated with 90 and 105 kg ha^{-1} of P had produced highest biomass, whereas control plots had the lowest biomass. In the case of Zn treatment, the plots treated with 12 and 16 kg Zn ha^{-1} had the highest biomass, whereas the untreated plots had the lowest biomass. Without a doubt, phosphorus is an important ingredient for plant growth which boosted root elongation, tillering, and other functions i.e carbohydrate metabolism and protein synthesis, so ultimately improved biological yield. Our findings are consistent with Hussian *et al*. (2011), they reported that increasing phosphorus levels increased biomass production. In comparison to the control, a 16 kg Zn ha^{-1} application resulted in a greater grain yield. This could be related to zinc's stabilizing role in RNA and DNA structure, which promotes growth and development. Zinc also played a role in cell division and elongation, which increased biological yield. Mousavi *et al.* (2013) confirmed our findings, claiming that zinc fertilization was responsible for the highest biomass output.

3.8 Grain yield (kg ha^{-1})

Table 1 above indicates wheat grain yield as a consequence of zinc and phosphorus treatments. Grain yields were considerably impacted by zinc and phosphorus, also with an interaction between the two minerals. Result obtained from P application shows that the plot getting 90 and 105 kg P ha^{-1} resulted higher grain yield while Average grain yield was lower in the control treatment. According to zinc, the treated plot with 12 and 16 kg Zn ha^{-1} produced the greater grain whereas least was noted for untreated plots. It was due beneficial effect of phosphorus and Zn in root development, in healthy plant growth, chlorophyll production and due to increase of grains spike^{-1}. Ahmad *et al.* (2013) reported the effect of Zn and P in grain yield improvement. Our findings revealed that using zinc at the right dose increased carbohydrate metabolism, resulting in assimilate translocation in the form of grains. Our findings support those of Zeidan *et al.* (2010) and Sing *et al.* (2012), who found that Zn and P application boosts grain production in cereal crops.

3.9 Harvest index (%)

The application of P and Zn had significant effects on the harvest index, according to statistical analysis of the data (Table 1). The phosphorus and zinc interaction were determined to be in-significant. In the case of phosphorus, the 90 and 105 kg ha^{-1} phosphorus treatment yielded a higher harvest index than the 75 kg ha^{-1} treatments, whereas the un-treated plots yielded a lowest than all. Zinc treatment @ 12 and 16 kg ha^{-1} resulted in a maximum HI, whereas in control plots, lowest harvest index was recorded. Present results are also supported by Ahmad et al. (2013), who stated that the use of P fertilizers increases growth as well as greatly improve the harvest index. In comparison to the control, adding zinc to the soil enhanced the harvest index. This increase in the harvest index could be due to the use of Zn and P, which resulted in higher grain yields (Hussain *et al*., 2011).

Conclusions and Recommendations

The finding of the experiment revealed that the application of 90 to 105 kg ha^{-1} P and 12 kg ha^{-1} Zn improved wheat performance in term of yield and yield component significantly. As a conclusion, to summarise, a phosphorus dose of 90 to 105 kg ha^{-1} and a zinc dose of 12-16 kg ha^{-1} are strongly suggested for improving wheat performance and yield.

Novelty Statement

This research about P and Zn application in wheat presents the significance of P and Zn in the field of crop production especially in wheat; therefore it is very helpful for young scientists and researchers of plant sciences and agriculture for understanding the importance of P and Zn in the production of wheat crops.

Author's Contribution

MB paper composition and materials. AQ original draft. MM and SR result and discussion. MNK and GY designing and statistical analysis. WS reviewing and editing. SK introduction. AB data collection.

Conflict of interest

The authors have declared no conflict of interest.

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