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Effect of phosphorus and zinc fertilizer application to ıncreasing the quality of nourishment in winter wheat

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Abstract

Balanced fertilization is one of the most important factors for increasing yield and improving the quality of wheat crop. In human nutrition PA / Zn ratio is an important factor and nutrients absorption will be reduced by high levels of PA / Zn ratio in diet. Effect of Phosphorus and Zinc fertilizer application to increasing the quality of nourishment in winter wheat a field experiment was carried out from 2008 to 2009 in researching Karaj region. In a factorial experiment with a randomized complete block design and three replicates per treatment, tree levels of P (0, 100 and 200 $kg.ha^{-1}$ as DAP), two levels of Zn (0 and 40 $kg.ha^{-1}$as zinc sulfate) and 300 $kg.ha^{-1}$ urea fertilizer added to the trial plots. All other management practices were done in conventional methods. The seeds were Pishtaz variety that was planted. The Anova results showed that the effect of different rates of P and Zn on chemical characteristic of wheat grain was significant ($P < 0.05$). P and Zn increased the P and Zn grain concentration also increased grain protein and total grain nitrogen. The interactive effect of P and Zn on above characteristic was significant ($P < 0.05$) the best treatment in this study was obtained in Zn_1P_1. The effect of P on the PA/Zn ratio of grain was significant at 5% level and increased it (87.1%) but Zn application significantly ($P < 0.05$). As far the results of this study reveal that consumption of these two fertilizers it's significant on flour pH and acidity. For reduction of PA / Zn ratios balanced and have a good quality wheat flour, fertilization especially Zn application and apply P fertilizers only on the basis of soil testing are necessary.

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Introduction

Wheat (Triticum aestivum L.) has been cultivated throughout the world especially in such countries as Iran, Greece, and Egypt, as early as 2500 B.C. (Araste, 1991). It is the most consumed cereal crop constituting approximately 30% of the total cereals grown, making it a major source of nutrition including minerals for many people (McKevith, 2004). Consumption of whole wheat bread prepared from high extraction flours has been recommended because of their high content of fiber, vitamin, and minerals. Despite their beneficial effects, these breads contain high amounts of undesirability compounds like phytic acid (Malakouti, 2001; Faridi, 1980; Reinhold *et al.*, 1974). High extraction flour is the commonly used especially in the rural areas of Iran. On the other hand, because of population growth and the necessity to shorten the time of bread preparation, most bakeries do not use the proper yeast and skip fermentation. The isolation of cereal low phytic acid (Lpa) mutants provides a novel approach to studying the biology of seed phytic acid (Myo-inositol-1,2,3,4,5,6-hexakisphosphate or Ins P6), and to dealing with environmental and nutritional problems associated with it (Raboy *et al.*, 2001).This leads to a production of breads with high PA content (Sheikh-ol-Eslami and Jamalian, 2003). Malnutrition of iron (Fe), Zn, and calcium (Ca) observed in many parts of the Middle East, especially in Iran and Egypt is believed to result from consumption of breads prepared from high extraction flours (Malakouti, 2001; Reinhold *et al.*, 1974; Hurrel, 2001). Bio fortification of commonly eaten foods with iron (Fe) and zinc (Zn) might be a solution to global "hidden hunger" (Amarakoon *et al.*, 2012). Zinc (Zn) and iron (Fe) deficiencies may prevail in populations dependent on cereal-based diets containing few animal products. The contribution of Zn and Fe from foods of preschool children of a hill country village in Sri Lanka, is discussed as it is known that the presence of phytic acid (PA) in the diet limits bioavailability of micronutrients (Karunaratne *et al.*, 2008).

Food enrichment process is the most reliable, cheapest, and best solution for a compensation of microelements' deficiency in calcareous soil conditions.

(Nagi, 1996). In fertilized areas, a large fraction of wheat grain micronutrients is accumulated in the bran that does not ordinarily enter the peoples' diets; therefore it is recommended that bread be prepared from whole wheat flour which has a low PA / Zn ratio. Erdal *et al.* (1998b) consider PA / Zn molar ratio, especially in cereals and legumes, to be a good criterion for assessment of Zn adsorption with PA / Zn of 25-30 as critical values in foods. Gibson *et al.* (1998) reported that PA / Zn molar ratio of 12 or higher caused a decrease in Zn absorption. According to WHO (1996), 55% of Zn content of foods is expected to be absorbed if PA/Zn ratio of foods is less than 5; whereas it would be 35% if the ratio is 5-15 and only 15% if it is higher than 15. Malakouti (2001) reported that PA / Zn ratio of Sangak, Barbary, Lavash, Taftun, and Baget bread flours, i.e., the bread types popular in Iran, was higher than the standard limit. Studies conducted about the effect of grinding and debranning have revealed that while total P, PA-P, and phytase are accumulated in the outer layers of cereal grains, however variation in phytase activities is high within foodstuffs, depending on genetic and environmental factors (Cossa *et al.*, 2000). The ratio of phytic acid to minerals present in foods may serve as an indication of the availability of the minerals in question. For example, a high phytic acid to zinc molar ratio (>15:1) indicates low mineral availability from that food. The role of increasing N supply in enrichment of whole grain and grain fractions, particularly the endosperm, with Zn and Fe in wheat. The endosperm is the most widely consumed part of wheat grain in many countries (Kutman, 2011).The results demonstrate that improved N nutrition, especially when combined with foliar Zn treatment, is effective in increasing Zn and Fe of the whole grain and particularly the endosperm fraction (Kutman, 2011). pH is a way that showed the acidity and alkali the materials and give us total taking from the nutritious sample. So flour pH showed the decay of oxidation. In other words pH consist of measured the H+ in sample but acidity is a require amount of Potassium hydroxide to neutralize the fat acid in 100 gr dry sample according to milligram. In healthy flour this amount is less than 20 and more than this is showed that the fat oxidation start and we have growth the fungal (Akbarniya *et al.*, 2006). Mineral bioavailability from reconstituted whole wheat flour can be improved by bread making. Although yeast fermentation minimizes the unfavorable effects of phytic acid, sourdough bread is a better source of available minerals, especially magnesium, iron, and zinc (Lopez *et al.*, 2003). The objectives of the present study were to reduce the phytic acid and PA / Zn molar ratio to have a better flour quality also enrichment the wheat grain and balance of flour pH and acidity by use balanced of consumption Phosphorus and Zinc fertilizer.

Materials and methods

To study the Effect of Phosphorus and Zinc fertilizer application to increasing the quality of nourishment in winter wheat a field experiment was carried out from 2008 to 2009 in Karaj Region in poor Zn soil. In a factorial experiment with a randomized complete block design and three replicates per treatment, tree levels of P (P_0 = 0, P_1 = 100 and P_2 = 200 $kg.ha^{-1}$ as DAP), two levels of Zn (Zn_0 = 0, Zn_1 = 40 $kg.ha^{-1}$ as zinc sulfate) and 300 $kg.ha^{-1}$ urea fertilizer added to the trial plots. Pishtaz variety taken, to be used in this study and any other management practices were done in conventional methods. Planting pattern was strip cropping and seed were planted by hand. No pesticide was used for pest management. When the plants were at full maturity stage and dried, harvest was conducted by hand from the end of wheat stem. To do this, from each 12.5 m^2 plot, only 6 m^2 (1.5 m × 4 m) was harvested to reduce the error in decrease the effects of other plots.

After harvesting, pounding the samples and detaching grains from straw, laboratory analyses were conducted. Phytic acid was extracted from seed wheat by the method of Fill and Fossati, Zinc by Atomic Absorption and phosphorus by (FA).

The phytic acid content and distribution of phosphorus during cereal flaking were determined as well as the level of some minerals, and the molar ratios of phytic acid: zinc were calculated. To calculate the zinc molar ratio uses this formula as bellow:

$$PA/Zn = \frac{(PA \times M_{Zn}) \times 1000}{M_{PA} \times Zn}$$

To measure the Flour pH used the method of (AACC, 1983) and for measure the flour acidity used the number 103 methods of Morrison, *et al.*, 1994.

All statistical evaluations were done with the use of SPSS software. Analysis of variance results were considered significant if $P < 0.05$.

Results and discussion

The Anova results showed that the effect of different rates of Phosphorus and Zinc on chemical characteristic of wheat grain was significant at ($p < 0.05$). Simple effect of Phosphorus and Zinc fertilizer were shown in table 1 and table 2. Table 1 and 2 showed the major effect of P and Zn application on Zn & P concentration of wheat grain, the phytic acid and PA / Zn molar ratio, Total Nitrogen, amount of grain protein, Flour pH and acidity.

Table 1. Mean Comparison of P Application on Chemical Characteristic of Wheat Grain.

Treatment	P concentration (%)	Zn concentration (ppm)	Phytic acid ($gr.kg^{-1}$)	PA / Zn molar ratio	Total N (%)	Protein (%)	Flour pH	Flour Acidity
P_0 (0 $kg.ha^{-1}$)	0.27^b	24.38^b	3.75^b	14.97^b	2.05^b	11.70^b	6.19^a	18.65^b
P_1 (100 $kg.ha^{-1}$)	0.31^a	27.58^a	2.31^c	8.96^c	2.06^b	11.77^b	6.19^a	18.05^a
P_2 (200 $kg.ha^{-1}$)	0.32^a	23.01^c	5.66^a	28.01^a	2.22^a	12.67^a	6.20^a	18.68^b

*Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.

In addition to table (1) Results showed Phosphorus increased phytic acid concentration and PA / Zn molar ratio also Total nitrogen, grain protein and p concentration. But consumption of Phosphorus in level 200 $kg.ha^{-1}$ reduced the Zn concentration in grain. The p application not significant in flour pH but had effect on flour acidity. Raboy *et al.*, (1991) observed that variation in PA-P was highly and positively correlated with variation in grain total P, and as well with variation in grain protein, in winter wheat.

Table 2. Mean Comparison of Zn Application on Chemical Characteristic of Wheat Grain.

Treatment	P concentration (%)	Zn concentration (ppm)	Phytic acid ($gr.kg^{-1}$)	PA / Zn molar ratio	Total N %	Protein %	Flour pH	Flour Acidity
Zn_0 (0 $kg.ha^{-1}$)	0.309[a]	21.51[b]	5.47[a]	26.01[a]	1.84[b]	10.48[b]	6.17[b]	2.66[a]
Zn_1 (40 $kg.ha^{-1}$)	0.298[b]	27.70[a]	2.3[b]	8.72[b]	2.39[a]	13.61[a]	6.25 [a]	2.68[a]

*Values within the same column and followed by the same letter are not different at $P < 0.05$ by an ANOVA protected Duncan's Multiple Range Test.

Zinc application fertilizer decreased phytic acid concentration, PA / Zn molar ratio and P concentration. But consumption of Zn fertilizer cause to increase the Zn concentration, Total nitrogen and protein of grain also increase Flour pH to have a good condition table (2).

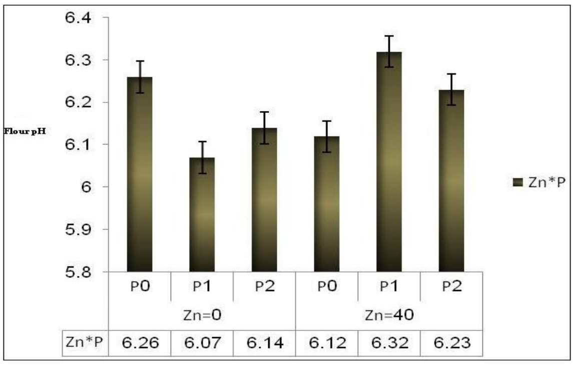

Fig. 1. Interaction Between Different Phosphorus and Zinc Levels on Flour Ph.

Results of Roohani *et al.*, (2012) showed The Zn concentration in cooked rice and bread were 0.88 ± 0.34 and 1.32 ± 0.16 mg/100 g of DW in the suburban area and 1.29 ± 0.45 and 1.77 ± 0.21 mg/100 g of Dw in the rural area, respectively. The PA: Zn molar ratio of flat bread was 24 in the suburban and 22 in the rural area. Cooked rice and composite dishes had PA: Zn molar ratio between 4 and 13. The results indicated a low Zn absorption from the common flat breads but moderate absorption from the composite dishes. Manzeke *et al.*, (2014) showed that in all cases, Zn application resulted in added maize grain and quality benefits and the Zn-based treatments increased grain Zn concentration and yield by 67 and 29%, respectively, indicating that there was much more benefit in grain quality than just yield after external Zn application. Combined organic resource and Zn fertilization also resulted in a significant buildup of plant available soil P and Ethylenediaminetetraacetic acid (EDTA) extractable Zn.

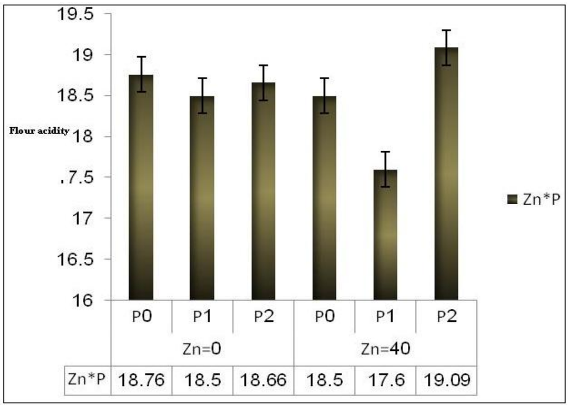

Fig. 2. Interaction Between Different Phosphorus and Zinc Levels on Flour Acidity.

With increasing P, the proportion of Zn and P content in the grain relative to the whole plant decreased. P and Zn acted antagonistically in roots. Excess P inhibited Zn uptake in roots, while Zn decreased the transfer of P from roots to shoots. For P that had been transported to the shoots, supplemental Zn facilitated its transfer to the grain.

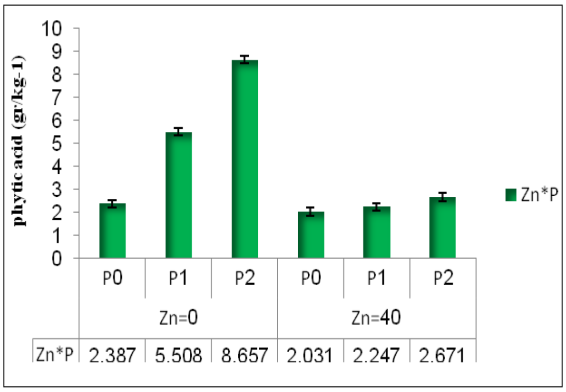

Fig. 3. Interaction Between Different Phosphorus and Zinc Levels on (PA) Concentration.

The interaction effect of P and Zn fertilizer on grain protein, Zn concentration, and Total nitrogen of wheat grain was significant. Interaction between P and Zn showed that the P concentration not significant at (P < 0.05). The highest grain protein and Zn concentration was obtained in Zn_1P_0 treatment that arranged increasing 51.8 and 71.8 percentage. Also the most grain nitrogen is related to Zn_1P_1 treatment for about 15.2 % than the Zn_0 P_1 treatment..

Figures 1 and 2 show the Interaction between different phosphorus levels and Zinc showed that flour pH and flour acidity was affected by these treatments so that increase of both fertilizer levels increased the quality of our wheat flour that was significant (P < 0.05). Application of 100 kg.ha^{-1} phosphorus significantly increased flour pH and acidity under 40 kg.ha^{-1} Zinc. As for Shahedi (2005) results flours pH not significant with others because flour pH have a trace changes because component such as proteins in alkali and poor acid have a buffer characteristic can adjust the pH (Oiliver *et al.*, 1993).
Figure 3 indicate the Interaction between different phosphorus levels and Zinc showed that phytic acid (PA) concentration was affected by these treatments so that increase of Phosphorus level increased the PA concentration. The highest level of (PA) concentration related to Application of 200 kg.ha^{-1} phosphorus and no Zn fertilizer (8.67 gr.kg^{-1}) When 200 kg.ha^{-1} phosphorus was applied zinc had not positive effect on PA concentration..

Figure 4 shows the Interaction between different phosphorus levels and Zinc showed that PA / Zn molar ratio was affected by these treatments so that increase of phosphorus level increased the PA / Zn ratio molar that were significant (P < 0.05). Although there was significant difference between 0 and 40 kg.ha^{-1} zinc levels in PA / Zn molar ratio.

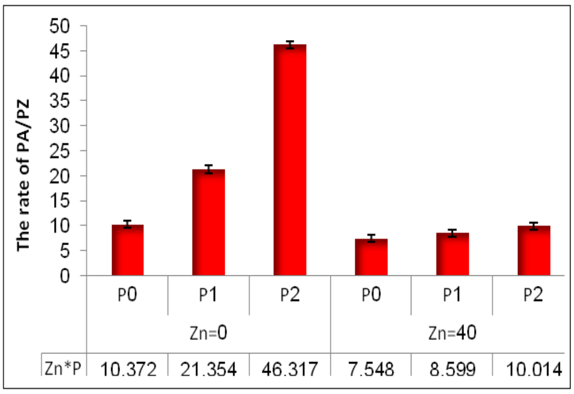

Fig. 4. Interaction Between Different Phosphorus and Zinc Levels on PA / Zn Molar Ratio.

Excess P decreased the distribution of Zn in grain, while Zn enhanced the uptake of Zn and P in grain, The combined application of Zn fertilizer with the extensive use of P fertilizer can effectively increase the P and Zn concentration and Zn bioavailability of wheat grain, and hence Zn nutritional quality. These results were consistent with the findings researchers such as Malakuti (2001), Erdal *et al.*, (1998). The PA / Zn molar ratio in this research in ordinary sample and fertilize sample were 36.58 and 5.58 calculate. All samples analyzed had a phytate / iron molar ratio > 1.3, and of the 6 samples, 5 had a phytate/zinc molar ratio > 14. The bioavailability of minerals is particularly important during weaning when minerals stores in infants are naturally low. Further studies are needed to evaluate the efficacy and effectiveness of phytase treatment to increase mineral bioavailability in infant foods (Frontela, 2008).

The PA / Zn molar ratio in fertilize sample was according to permissible that researches said especially Erdal *et al.*, (1996) and WHO (1996). The PA / Zn ratio should be below 25 in food materials (e.g., bread) so that nutrients in the food can get absorbed during digestion. While the (PA / Zn) ratio in wheat grain produced on calcareous soils can exceed 40, mainly due to imbalanced fertilization and overuse of P-fertilizers, the application of $ZnSO_4$ considerably decreased PA / Zn ratios. Thus, by following this practice, additional yield increase, increased bioavailability of micronutrients in whole wheat bread to be absorbed into our body and human health promotion can be achieved.

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