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Zinc and Iron Concentrations in some Soft Wheat Albanian Genotypes

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Abstract

Selected samples of different soft wheat genotypes, grown organically in the local region, were tested for zinc (Zn) and iron (Fe) concentrations in wheat grain by flame atomic absorption spectrometry (AAS). The experiment with ten Albanian lines of soft wheat, was conducted under field conditions on slightly alkaline soil (pH= 7.80). Obtained data of this study showed that Albanian wheat genotypes grown organically had higher levels of protein, Zn and Fe compared to other studies using conventional system, indicating that organic conditions with suitable genotypes may enhance mineral concentration in wheat. The statistical evaluation showed that there exists a good positive correlation between the Zn and Fe content (r= 0.489), as well between Fe and thousand kernel weight (TKW) (r = 0.440).

Keywords: organic, conventional, genotype, wheat, minerals.

1. Introduction

Wheat represents one of the most important food grains in the world, and for this reason it is considered to be an important source of food minerals [5]. Apart from containing nutrients, (high level of proteins, vitamins and cellulose fibers) wheat grain also contains a number of elements (Cu, Zn, Fe, Ni, Mn) vital to our biological functions. Wheat also contains some toxic elements (As, Hg, Pb, Cd) [16]. These minerals are important components of enzymes and hormones, making them crucial for bone formation and the synthesis of vitamins [2].The uptake and accumulation of these metals in plants are dependent on different factors, such as the type and the chemical composition of the soil, soil fertility, the root-soil interface, the absorption mechanisms, and translocation in the plants [8]. More than three billion populations in the world are facing a deficiency in minerals. Fe and Zn are major deficient nutrients in the world [6].To increase the concentration of minerals in wheat products; it is advisable to use whole grain flour instead of white flour. Fe deficiency (ID) and Fe-deficiency anemia are the most common disorders in humans throughout the world [13]. Fe deficiency has a negative impact on brain functioning in infants [11]. Zn is essential for human growth and development. Zn is required for the immune system, tissue repair and wound healing, optimum insulin action, reproduction, vision, taste, and behavior [10]. The objective of this work was to provide information about the concentrations of Zn and Fe in different soft wheat Albanian genotypes.

2. Material and Methods

2.1. Samples

The content of Zn and Fe were analyzed in 10 lines of soft wholegrain wheat, grown organically during the year 2012 - 2013 in the Experimental Didactics Economy (E.D.E) of Agricultural University of Tirana, on slightly alkaline soil (pH= 7.80), the humus and nitrogen contents were 2.2% and 0.15%, respectively. The other soil parameters are presented in Table 1. The experiment was set up according to a randomized block design in three replications. About 50g of wheat of each grain sample was milled to flour (whole grain) with a laboratory mill (Pulverisette 14). Afterward, after the flour samples were dry, they were placed in a vacuum where they were packed and stored at -75°C until analyses.

2.2. Climatic conditions during the experiment

Climatic conditions during the experiment, given from Albanian Institute of Hydrology, are shown in Table 2. The average temperature during the growth period of the lines of soft wheat was 13.5 °C, while the sum of precipitation was very high (1093.7 mm) .

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Table 1. General characteristics of soil in the experimental field

$CaCO_3$ (%)	P_2O_5 (mg/kg)	K (mg/kg)	Na (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Texture		
						Sand (%)	Silt (%)	Clay (%)
8.7	0.74	242	43.7	4812	1081	25.5	44.4	30.1

Table 2. Monthly mean temperatures and monthly cumulative precipitation

		Month									
		Period	Dec	Jan	Feb	Mar	Apr	May	Jun	Average (Xm)	Total
Temperature	(^{0}C)	2012/13	7.7	8.1	8.9	11.4	16.4	19.6	22.1	13.5	
Precipitation	(mm)	2012/13	203.7	209	232.8	261	54.2	81.2	51.8	156.2	1093.7

2.3. Chemical analyses

All the samples were digested in a microwave oven according to a previous published procedure [9]. The prepared solutions were than diluted to 25 mL with Milli-Q water. Blanks were treated identically and together with the samples. The concentration of Zn and Fe were determined by flame atomic absorption. Each sample was analyzed in duplicate and the results were expressed as mg/kg of dry weight (DW). The protein content was measured with Kjeldahl method (AACCI 46 – 30, 01) and the average thousand kernel weight (TKW) was determined by counting and weighing samples of 500 kernels twice and then we found values were averaged and multiplied by two. The specific nitrogen to protein conversion factor 5.7 was used for the calculation of crude proteins content in flour.

2.4. Statistical analyses

A descriptive statistical analysis for all the obtained results was performed. All chemical and physical measurements were performed with three repetitions, while TKW measurements were performed one. Pearson's correlation and the analysis of variance (ANOVA) between obtained results were performed using StatSoft Statistica 10.0 software. Significant differences were calculated according to post – hoc Tukey's (HSD) test at $p<0.05$ significant level, 95% confidence limits.

3. Results and Discussion

The averages and variations in moisture content and the content of Fe and Zn were determined from the wheat grain of different lines of wheat, for which the data are presented in Table 3. The results for Zn and Fe are expressed in mg/kg, whereas the content of moisture and protein content are expressed in percentages (%), and the thousand kernel weight (TKW) is expressed in grams (g).

The line PZA 9 had the lowest mean moisture content (9.46 ±0.15%), whereas the highest mean moisture content (10.77 ±0.10%) was found to be PZA 2. The wholegrain wheat flour, due to the presence of bran fraction (seed coat and embryo) has higher levels of protein. In the lines of wheat presented in this study the protein content range from 13.57 ± 0.01% for PZA8 to 16.41 ± 0.01% for PZA3. All the lines of soft wheat presented in this study showed high levels of Fe and Zn compared to other published results (Spiegel *et al.*, 2009). High levels of protein and minerals are considered indicators of high dietary quality of cereal product for human and farm animal [4]. PZA 6 showed the lowest content of Zn (40.53±2.24 mg/kg), while PZA 1 (53.48±2.22 mg/kg) had a high content of this mineral. The line PZA 2 (54.24±0.27 mg/kg) had a low content of Fe, while the line PZA 10 (80.41±0.86 mg/kg) had a high level of Fe. Both ANOVA and Tukey's HSD test were conducted and statistically differences were found in the content of moisture, Fe, Zn, protein and TKW among the lines of soft wheat. The high concentration of minerals in the present study might be attributed to the organic farming system. However, we have to consider the specific genotypes, as a central factor in the organic farming system. According to [12], the genotypes and production system interactions have a significant effect upon the performance of a genotype in a cropping system. Also, photosynthetic activity of vegetative tissue is an important factor in determining grain mineral concentrations as well as the yield. Different wheat genotypes vary in photosynthesis and chlorophyll concentrations [1].

Correlation between the chlorophyll and Fe concentrations was reported by [1].

Table 3. The mean concentrations of Zn and Fe in (mg/kg) among different lines of wheat.

Name	Moisture (%)	Zn	Fe	Protein content (%)	Thousand kernel weight (TKW) (g)
PZA 1	10.62 ± 0.15^{bcde}	53.48 ± 2.22^{h}	78.92 ± 0.34^{fg}	15.13 ± 0.01^{cde}	38
PZA 2	10.77 ± 0.10^{a}	42.23 ± 0.33^{bcd}	54.24 ± 0.27^{ab}	15.70 ± 0.01^{ef}	35
PZA 3	10.39 ± 0.10^{defg}	49.94 ± 1.48^{gh}	75.71 ± 1.83^{efg}	16.41 ± 0.01^{fg}	36
PZA 4	10.36 ± 0.15^{cdefg}	46.99 ± 0.33^{efg}	71.64 ± 0.54^{e}	15.59 ± 0.02^{de}	34
PZA5	10.35 ± 0.15^{bcde}	49.47 ± 1.25^{fgh}	77.86 ± 3.79^{fg}	13.67 ± 0.01^{a}	32
PZA 6	9.69 ± 0.10^{defg}	40.53 ± 2.24^{ab}	77.17 ± 1.82^{efg}	14.77 ± 0.01^{c}	35
PZA7	10.16 ± 0.15^{h}	43.03 ± 0.53^{bcde}	65.21 ± 0.75^{d}	15.30 ± 0.01^{cde}	31
PZA8	10.36 ± 0.20^{efgh}	42.92 ± 0.32^{bcde}	62.80 ± 1.42^{d}	13.57 ± 0.01^{a}	34
PZA9	9.46 ± 0.15^{b}	41.68 ± 1.86^{bcd}	73.01 ± 3.76^{ef}	15.29 ± 0.02^{cde}	35
PZA10	9.48 ± 0.10^{gh}	44.93 ± 1.44^{cde}	80.41 ± 0.86^{g}	14.59 ± 0.01^{bc}	42

[ab]values with the same latter are not statistically different at the $p < 0.05$ level (according to post-hoc Tukey's HSD test).

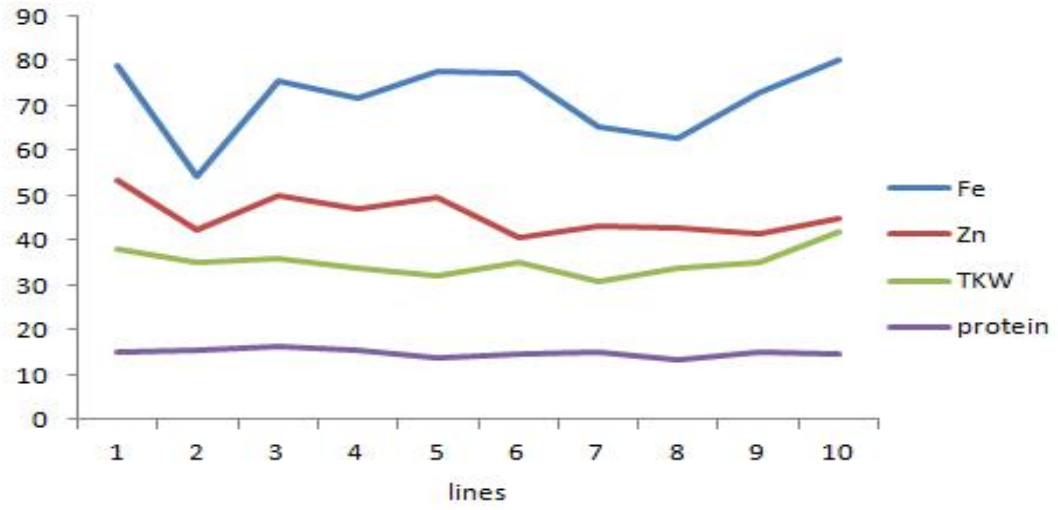

Figure 1. The mean concentration of Zn, Fe, protein content and TKW among different lines of wheat.

The content of Fe, showed a good positive linear correlation with Zn content (r = 0.489) and with TKW (r = 0.440) (Table 4). The linear positive correlation between Fe and TKW (thousand kernel weight) was observed in another study [6,15]. This positive correlation indicates that grain weight and Fe concentration can be improved simultaneously by traditional breeding strategies. The positive linear correlation between Fe and Zn concentrations indicates that they might have the same genetic base to some extent.

Table 4. Pearson correlation and P-value (P > 0.01) between Zn, Fe and TKW

	Zn	Fe	TKW	Protein content
Zn	1			
Fe	**0.489**	1		
TKW	0.197	**0.440**	1	
Protein content	0.112	-0.112	0.104	1

4. Conclusions

Based on obtained results by testing Zn and Fe content in different genotypes of soft wheat, it can be concluded that all lines of wheat showed higher values of protein content, indicating a good quality of wheat. The concentrations of Zn and Fe in all genotypes of wheat were higher than those observed in previous studies in conventional systems. The type of genotypes and the organic farming systems are two main factors that can influence the increase of content in Zn and Fe.

Thus, organic farming systems can be used in further breeding to improve the nutritional quality of wheat grain. However, much more detailed work should be done to obtain furher information by using a large number of wheat genotypes in different locations and in different farming systems.

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