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NUTRIENTS STATUS IN MAIZE GRAIN FROM SUSTAINABLE AGRICULTURE

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Abstract

Maize cultivation with application of proper organic and bio-fertilizers could increase nutritional value of crop grain and maintain soil fertility. The aim of the study was to examine variations in concentrations of phytate, soluble phenols, total glutathione (GSH), yellow pigment (YP), DPPH radical scavenging capacity (DPPH), Ca, Mg, Fe, Zn and Mn in maize hybrids with white, yellow and red colour grain, under the influence of bio-, organic fertilizer and urea in regard to control (without fertilization). Results indicated that phytate, DPPH, Ca, Mg and, Mn varied slightly (< 10%). Red grain maize was characterized with the highest concentrations of phenols, Ca, Mg, Fe, Zn, and DPPH. White grain maize, particularly in urea and bio-fertilizer treatment, accumulated higher GSH values, while red and especially yellow grain hybrid accumulated higher YP amount in urea treatment. Irrespective to lower variations in Mn concentration, higher values were determined in yellow hybrid. Organic fertilizer mainly induced increase in Mg bio-fertilizer which positively affected Fe accumulation, while urea caused higher Zn and Mn accumulation in maize grain. It could be concluded that yellow and particularly red grain hybrid enabled increased accumulation of mineral elements, together with higher DPPH values, mainly in treatments with organic fertilizer and urea giving it advantage in production of highly nutritious food.

Keywords: *Colored maize grain, Sustainable production, Mineral nutrients, Antioxidants.*

Introduction

All nutrients that humanity consumes came mainly from the agricultural production. When ability of agricultural systems to produce enough of diverse foods fail, people will suffer, mortality and morbidity rates will increase, working productivity will be reduced, societies will deteriorate (Welch 2002). That is one of the main reasons why nutritional deficiencies affect over three billion people globally, irrespective that they live in developed or developing countries, causing chronic diseases, such cancer, cardio-vascular diseases, stroke, diabetes, osteoporosis etc. (Graham et al., 2007). At the same time, soils are deteriorated worldwide Maintenance and even increase of soil is of particular importance for agricultural production. This means that proper mineral nutrition is significant measure when crops are grown on infertile soils. When pea and wheat were grown on soil with adequate Zn and Se supply, they accumulated about three-fold more Zn and five-fold more Se in their grains, when compared to plants grown on Zn- and Se-deficient medium (Miller and Welch, 2013).
Different fertilizer types, such as organic and bio-fertilizers contribute to the maintenance and/or increase of soil organic matter and status of mineral nutrients, thus contributing to the soil fertility, together with the improved availability of nutrients to plants and increased yielding potential. Mineral nutrition is complex practice, since some nutrients are able to promote or reduce absorption of the other ones, like application of higher N rates, which decreases Mg and Zn absorption and promotes Mn absorption and accumulation, thus altering nutritional quality of maize grain (Feil et al., 2005). There are many records about contribution of bio-fertilizers to improved crop production. Vessey (2003) find that bio-fertilizers improve availability of nutrients from the rhizosphere, promoting crop growth and

their nutritional quality. El-Sirafy et al. (2006) underlined that bio-fertilizer significantly affected Fe, Mn and Zn concentration in wheat tissues. Nevertheless, there are some negative aspects of bio-fertilizer application, such as decreased Fe and β-carotene concentrations in maize grain with elevated phytate concentration (Dragicevic at al., 2015).

Irrespective to the status of mineral nutrients in grains, their further bio-availability from digestive organs depends on chemical composition of grain (Nuss and Tanumihardjo, 2010; Welch and Graham, 2000), so it is important to evaluate relation between essential elements and factors that contribute or restrain their bio-availability, like phytic acid, phenols, carotenoids, glutathione, fiber, etc.

The relation between phytate and mineral elements is important trait for evaluation of their potential bio-availability (Dragičević et al., 2014; Dragicevic et al., 2016; Šimić et al., 2012; Wiesler, 2012), indicating that genotypes and cropping practices that reduce phytate content and increase concentrations of essential mineral elements are desirable, from the nutritional standpoint.

The aim of the study was to examine variations in concentrations of phytate, soluble phenols, total glutathione (GSH), yellow pigment (YP), DPPH radical scavenging capacity (DPPH), Ca, Mg, Fe, Zn and Mn in maize hybrids with white, yellow and red colour grain, under the influence of bio-, organic fertilizer and urea in regard to control (without fertilization).

Material and Methods

The research was conducted in Zemun Polje (44°52'N 20°20'E), in the vicinity of Belgrade, on a slightly calcareous chernozem soil in 2017, within an on-going experiment in dry-land conditions. The field experiment was arranged in a split-plot design with 4 replications. Three maize hybrids were used in experiment: ZP 737, ZP 5048*c* and ZP 522*b* with yellow, red and white grain, respectively. Also, three fertilizers were tested: bio-fertilizer (BF) Team Mycoriza Plus (containing *Glomus spp*. 300 spore^{-1} g and rizoshere bacteria 10 UFC^{-1} g, in amount of 0.5 kg 100^{-1} l water; organic fertilizer (OF) – Fertor (containing 65% of organic matter, 65% N, 4.1% organic N, 2.7% K, 2.3% K, 1.1% MgO, 9.3% CaO in amount of 2.5 t ha^{-1}; urea (U), as a standard mineral fertilizer, in amount of 200 kg ha^{-1}; and control (C) – without fertilization. Fertilizers were incorporated into soil at the end of April, prior to sowing.

After harvesting (second half of October) maize grain was milled and chemical composition was determined. Phytate (Pphy) was determined by the method of Dragičević et al. (2011), total glutathione (GSH) by the method of Sari Gorla et al. (1993), yellow pigment (YP) by the method described by Vancetovic et al. (2014), soluble phenols by method of Simić et al. (2004), DPPH radical scavenging capacity (DPPH) by the method suggested by Abe et al. (1998). Mineral elements were determined by Inductively Coupled Plasma - Optical Emission Spectrometry.

Results were analysed with ANOVA and the significance of the treatments effect were determined by the Fisher's least significant difference (LSD) test at p = 0.05 and by correlation (Pearson's coefficients).

Results and Discussion

The main source of variability in content of examined parameters was hybrid (for phytic P, phenols, glutathione, yellow pigment DDPH radical scavenging capacity, Mg and Zn), as well as interaction between hybrid and fertilizer (for all examined factors) (Table 1). Feil et al. (1990) and Mladenović Drnić et al. (2009) also acquired high genotypic variability in seed phosphorus, i.e. phytate content. Fertilizer expressed significant influence on the variation of Mg, Fe, Zn and Mn content in maize grain. Besides, red grain maize was characterised with the highest content of phenols, yellow pigment DPPH scavenging capacity, and all examined minerals, as well as the lowest content of phytic P, signifying it mainly as the favourable source of antioxidants, and so factors that contribute to the potentially increased bio-availability of mineral nutrients. Nevertheless, white grain maize had the highest GSH content. When impact of applied fertilizers was taken into consideration, it could be assumed that bio-fertilizer expressed the highest impact on phytate decrease, as well as increase in content of phenols, GSH, Ca and Fe, while urea was mainly important for increased accumulation of yellow pigment, Cu and Zn and organic fertilizer was reflected positive on increase of Mg and Mn. These results were mainly supported by results of Dragicevic at al. (2015) who pointed rather negative effect of bio-fertilizer, which led to decreased Fe and β-carotene concentrations in maize grown as intercrop with soybean, as well as in maize monocrop. Nevertheless, El-Sirafy et al. (2006) proved that bio-fertilizer increased absorption and accumulation of Fe, Mn and Zn in wheat tissues. Also, Singh and Reddy (2011) and Kaur and Reddy (2015) showed that particular bio-fertilizers could be used to improve availability of some target mineral elements, like P is, for maize and wheat crops, even from insoluble forms.

Table 1. Variations in the content of phytic P (Pphy), phenols (Phen.), total glutathione (GSH), yellow pigment (YP), DPPH radical scavenging capacity, Mg, Ca, Fe, Cu, Zn and Mn in grain of yellow, red and white maize

	Pphy mg g^{-1}	Phen. ug g^{-1}	GSH nmol g^{-1}	YP ug g^{-1}	DPPH %	Mg	Ca	Fe µg g^{-1}	Cu	Zn	Mn
					Yellow grain						
BF	2.73	302.81	995.5	12.43	79.78	1918.3	213.39	54.46	26.97	26.93	9.96
U	2.98	245.85	937.2	17.39	84.14	2234.0	169.70	37.17	36.51	36.50	10.77
OF	2.93	230.86	748.3	16.41	90.30	2305.6	262.07	42.74	31.67	31.73	11.05
C	2.97	203.88	1058.2	15.51	94.66	2394.1	209.17	47.51	38.24	38.31	12.09
Mean	2.90	245.85	934.8	15.43	87.22	2213.0	213.58	45.47	33.35	33.37	10.97
					Red grain						
BF	2.62	776.52	1011.0	14.95	96.51	2129.1	263.09	37.59	29.72	29.80	9.68
U	2.47	668.59	856.1	14.97	98.15	2422.5	329.51	51.35	55.07	54.99	11.00
OF	2.54	623.62	987.1	15.25	91.44	2507.4	177.40	75.33	44.52	44.73	12.03
C	2.60	713.56	897.6	16.72	95.64	1985.5	192.44	88.51	32.29	32.31	10.51
Mean	2.56	695.57	938.0	15.47	95.44	2261.1	240.61	63.19	40.40	40.46	10.80
					White grain						
BF	2.57	326.80	1195.5	1.98	97.11	1584.5	192.48	161.16	37.41	37.09	9.35
U	2.96	317.81	1281.8	1.93	97.17	2123.0	145.36	32.71	31.29	31.36	12.65
OF	2.76	260.84	1172.0	1.87	92.86	1972.5	226.91	25.60	33.16	33.20	9.47
C	2.80	284.83	1021.4	1.39	93.90	1921.6	249.76	32.00	30.58	30.53	9.93
Mean	2.77	297.57	1167.7	1.79	95.26	1900.4	203.63	62.87	33.11	33.05	10.35
					Mean						
BF	2.64	468.71	1067.3	9.79	91.14	1877.3	222.99	84.40	31.37	31.27	9.66
U	2.80	410.75	1025.0	11.43	93.15	2259.9	214.86	40.41	40.96	40.95	11.47
OF	2.74	371.77	969.1	11.18	91.53	2261.8	222.12	47.89	36.45	36.56	10.85
C	2.79	400.75	992.4	11.21	94.73	2100.4	217.12	56.01	33.70	33.72	10.85
					LSD 0.05						
Hyb.	0.14	53.79	115.8	1.91	4.10	204.1	47.39	36.31	15.68	6.75	1.05
Fert.	0.20	223.60	163.5	7.28	5.73	208.6	50.50	33.26	15.87	6.73	0.86

H x F	0.10	39.98	77.4	1.92	1.13	23.2	2.33	1.76	17.27	0.10	0.05

Due to the fact that accumulation of essential elements in maize grain depend on agro-ecological conditions and applied cropping measures (Bender et al., 2013), and that further bio-availability from digestive organs depends on chemical composition of grain (Nuss and Tanumihardjo, 2010; Welch and Graham, 2000), it is important to evaluate relation between essential elements and factors that contribute or restrain their bio-availability. The correlation between these factors and examined minerals from maize grain shown significant and negative dependence between phytate and majority of minerals (Ca, Fe, Cu and Zn) (Table 2), indicating that any factor which reduce phytate content, such as particular usage of bio-fertilizer in yellow and white grain maize, positively impacts accumulation of mineral elements, with exception of Mn, which correlates positive with phytate in maize grain. Feil et al. (2005) also pointed that mineral nutrition, such as application of higher N and P rates affects absorption and accumulation of other mineral elements, thus changing nutritional quality of maize grain. Increased accumulation of mineral elements, particularly micro-nutrients with parallel phytate decrease is positive trend, since many data support finding that parallel increase in concentration of mineral elements and reduction of phytate concentration is desirable for their improved bio-availability (Dragičević et al., 2014; Dragicevic et al., 2016; Šimić et al., 2012; Wiesler, 2012). Potentially increased Mg bio-availability is also supported by increased content of yellow pigment, emphasizing yellow grain maize as potentially better source of Mg in nutrition. Nevertheless, increased phenols content, as it was found in red grain maize, correlates significantly and positive with Cu and Zn, reducing their potential bio-availability to some extent. This is essential, since results demonstrate that red grain maize accumulates higher concentration of mineral elements, when compared to yellow and particularly white grain maize. What is more, increased DPPH radical scavenging capacity, as it was find in red and white grain maize, also positively correlates with Cu and Zn, indicating the importance of antioxidants for potential bio-availability of mineral elements, mainly Cu and Zn.

Table 2. Correlation between phytic P (Pphy), phenols (Phen.), total glutathione (GSH), yellow pigment (YP), DPPH radical scavenging capacity and Mg, Ca, Fe, Cu and Zn

	Pphy	Phen.	GSH	YP	DPPH
Mg	0.119	0.204	-0.471*	0.646*	-0.005
Ca	-0.375*	0.291	-0.532*	0.181	0.227
Fe	-0.510*	0.162	0.145	-0.100	0.216
Cu	-0.463*	0.327*	-0.228	0.259	0.344*
Zn	-0.460*	0.331*	-0.232	0.266	0.342*
Mn	0.364*	-0.054	-0.003	0.272	0.118

*Pearson correlation coefficients at the level of significance of 0.05

Conclusions

Based on obtained preliminary results, it could be concluded that accumulation, and potential bio-availability of mineral elements from maize grain is complex trait, depending mainly on genotype characteristics and its interaction with production conditions. It is shown that red grain maize is better accumulator of mineral elements, having lower phytate and higher content of phenols, yellow pigment and DPPH radical scavenging capacity, making it as desirable source of antioxidants and mineral in nutrition. But, when increased level of phenols is taken into consideration, potential bio-availability from digestive system could be compromised to some extent. Owing to the higher yellow pigment content and little bit lower values of mineral elements, yellow grain maize could be also a great source of carotenoids and minerals. Irrespective that white grain maize is lower among all three genotypes in mineral elements it is also a good source of antioxidants, such as GSH. Among tested fertilizers, bio-fertilizer expressed full potential in increase of antioxidants content and phytate reduction, together with increase of Ca and Fe content in maize grain, while urea is much more important for accumulation of yellow pigment, Cu, Zn and Mn.

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References

Abe N., Murata T., Hirota A. (1998). Novel DPPH radical scavengers, bisorbicillinol and demethyltrichodimerol, from a fungus. Bioscience Biotechnology and Biochemistry, 62: 661-666.

Bender R. R., Haegele J. W., Ruffo M. L., Below F. E. (2013). Nutrient uptake, partitioning, and remobilization in modern, transgenic insect-protected maize hybrids. Agronomy Journal, 105*: 161-170.*

Dragicevic V., Mladenovic-Drinic, S., Stoiljkovic M., Filipovic M., Nikolic B., Babic V., Kravic N. (2016). Maize inbreds from different heterotic groups as favorable sources for increased potential bio-availability of magnesium, iron, manganese and zinc. Chilean Journal of Agricultural Research, 76: 213-219.

Dragicevic V., Oljaca S., Stoiljkovic M., Simic M., Dolijanovic Z., Kravic N. (2015). Effect of the maize and soybean intercropping system on the potential bio-availability of magnesium, iron and zinc. Crop & Pasture Science, 66: 1118-1127.

Dragicevic V., Spasojevic I., Stoiljkovic M., Simic M., Brankov M. (2014). Possible availability of Mg, Fe, Mn and Zn from organically produced maize. Proceedings of the Fifth International Scientific Agricultural Symposium" Agrosym 2014", 23-26 October, Republic of Srpska, Bosnia and Herzegovina; pp. 635-639.

Dragičević V., Sredojević S., Perić V., Nišavić A., Srebrić M. (2011). Validation study of a rapid colorimetric method for the determination of phytic acid and inorganic phosphorus from seeds. Acta Periodica Technologica, 42: 11-21.

El-Sirafy Z. M., Woodard H. J., El-Norjar E. M. (2006). Contribution of biofertilizers and fertilizer nitrogen to nutrient uptake and yield of Egyptian winter wheat. Journal of Plant Nutrition, 29: 587-599.

Feil B., Moser S. B., Jampatong S., Stamp P. (2005). Mineral composition of the grains of tropical maize varieties as affected by pre-anthesis drought and rate of nitrogen fertilization. Crop Science, 45: 516-523.

Feil B., Thiraporn R., Geisler G., Stamp P. (1990). Genotype variation in grain nutrient concentration in tropical maize grown during a rainy and a dry season. Agronomie, EDP Sciences, 10:717-725.

Graham R. D., Welch R. M., Saunders D. A., Ortiz-Monasterio I., Bouis H. E., Bonierbale M., de Haan S., Burgos G., Thiele G., Liria R., Meisner C. A., Beebe S. E., Potts M. J., Kadian M., Hobbs P. R., Gupta R. K., Twomlow S. (2007). Nutritious subsistence food systems. Advances in Agronomy, 92: 1-74.

Kaur G., Reddy M. S. (2015). Effects of phosphate-solubilizing bacteria, rock phosphate and chemical fertilizers on maize-wheat cropping cycle and economics. Pedosphere, 25: 428-437

Miller D. D., Welch R. M., (2013). Food system strategies for preventing micronutrient malnutrition. Food Policy, 42: 115–128.
Mladenović Drinić S., Ristić D., Sredojević S., Dragičević V., Ignjatović Micić D., Delić N. (2009). Genetic variation of phytate and ionorganic phosphorus in maize population. Genetika, 41: 107 -115.
Nuss E. T., Tanumihardjo S. A. (2010). Maize: A paramount staple crop in the context of global nutrition. Comprehensive Reviews in Food Science and Food Safety, 9: 417–436.
Sari Gorla M., Ferrario S., Rossini L., Frova C., Villa M. (1993). Developmental expression of glutathione-S-transferase in maize and its possible connection with herbicide tolerance. Euphytica, 67: 221-230.
Simić A., Sredojević S., Todorović M., Đukanović L., Radenović Č. (2004). Studies on the relationship between content of total phenolics in exudates and germination ability of maize seed during accelerated aging. Seed Science and Technology, 32: 213-218.
Šimić D., Mladenović Drinić S., Zdunić Z., Jambrović, A, Ledencan T., Brkić J., Brkić A., Brkić I. (2012). Quantitative trait loci for biofortification traits in maize grain. Journal of Heredity, 103: 47-54.
Singh H., Reddy M. S. (2011). Effect of inoculation with phosphate solubilizing fungus on growth and nutrient uptake of wheat and maize plants fertilized with rock phosphate in alkaline soils. European Journal of Soil Biology, 47: 30-34.
Vancetovic J., Zilic S., Bozinovic S., Ignjatovic-Micic D. (2014). Simulating of Top-Cross system for enhancement of antioxidants in maize grain. Spanish Journal of Agricultural Research, 12: 467-476.
Vessey J. K. (2003). Plant growth promoting rhizobacteria as biofertilizers. Plant and Soil, 255: 571–586.
Welch R. M. (2002). The impact of mineral nutrients in food crops on global human health. Plant and Soil, 247: 83–90.
Welch R. M., Graham R. D. (2000). A new paradigm for world agriculture: productive, sustainable, nutritious, healthful food systems. Food and Nutrition Bulletin, 21: 361-366.
Wiesler F. (2012). Chapter 9 - Nutrition and Quality, In: Marschner's Mineral Nutrition of Higher Plants (Third Edition) Ed.: Petra Marschner; pp. 271-282.