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GENETIC VARIATION OF MACRO AND MICROELEMENTS IN GRAIN OF MAIZE INBRED LINES

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Abstract

In any breeding program, germplasm screening for a trait of interest is an important first step to genetic improvement. In the case of biofortification, nutritional breeding also starts with assembly of parental germplasm for crosses based on the evaluation of a large amount of genetic material. The objective of this work was studying the variability of macro and microelements in grain of 74 maize inbreed lines. The highest protein content had lines from European germplasm and the lowest line of the Lancaster heterotic group. Lines from the BSSS group had the lowest oil content and the lines of Lancaster heterotic group the highest. Starch content was highest in lines from Lancaster heterotic group and lowest in the lines of European germplasm. The highest average concentration of Mg, Fe and P had inbred lines from European germplasm while inbred lines from BSSS germplasm had the highest Zn concentration. Lines from BSSS had the lowest average Mg and Fe content as well as lines from Lancester germplasm had the lowest Zn and P content.

Key words: maize, macroelements, microelements, inbred lines

Introduction

In past crop breeding and production have been focused on increasing yield and maintaining food and feed production stability. At the same time concentration of essential macro and micro nutrients have been decreased. From the nutritional point of view corn grain such as fat, protein, and starch content define corn quality characteristics. Chemical content of maize grain is very important for human and animal diets. Average content of proteins, oil and starch in maize seed is 9%, 4%, 73%, respectively (Balconi *et al.*, 2007). Micronutrients play important physiological roles in humans and animals (Cakmak, 2008, Fisher, 2008). While the traditional remedy of micronutrient deficiencies was in a form of food/feed supplements, suitability of agricultural strategies for enhancing micronutrient concentrations in grain was recently being assessed as a sustainable, long-term solution. Among these strategies, plant breeding strategy (biofortification) appears to be the most sustainable and cost-effective approach (Welch and Graham, 2002; Cakmak, 2008), especially for Fe and Zn. Quantities of micronutrients in maize grain are influenced by numerous complex factors including genotypes, soil properties, environmental conditions and nutrient interactions. Although results reported in literature about micronutrient concentrations in maize grain varied substantially, according White and Broadley (2005) considerable genetic variation in maize can be harnessed for sustainable biofortificaiton strategies. Simic *et al.* (2009) studied relations among boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) concentrations in grain of 297 genotypes of a maize population and suggested that it is possible to improve density of various micronutrients in maize grain simultaneously, although the progress would be very slow. The aim of this study was to investigate chemical composition of grain of 74 maize inbred, belonging to different heterotic groups, to define their nutritional quality.

Material and methods

Grains from 74 maize inbred lines with different genetic background from MRI breeding program were used. The nine inbred lines belonging to European germplasm, 48 to BSSS, and 17 to Lancester germplasm. Seed protein, oil and starch content were determined by near-infrared reflectance spectroscopy (NIRS) using Infratec 1241 Grain analyzer, (Foss Tecator, Sweden) and expressed in a percentage of absolutely dry matter of grain (ADM). Microelements were measured by Inductively Coupled Plasma - Optical Emission Spectrometry after wet digestion with HNO3+HClO4.

Results and discussion

It is well known that total protein composition varies among genotypes (Mladenovic Drinic *et al*., 2009, Stevanovic et al., 2012). The total protein of 74 maize inbred lines ranged from 7.55% to 13.69%, with average value of 10.48% (Table 1). The oil content ranged from value of 2.87% to 5.06%, with average value of3.95%. According to fact that starch is main constituent of maize grain (Balconi *et al*., 2007), it content ranged from 67.29% to 73.16.8%, with average content of 69,91%. Inbred line that has the highest protein content has the lowest starch content. Obtained values for protein, oil and starch are typically for maize genotypes that were not specifically selected for those traits (Pollak and Scott, 2005; Harrelson *et al*., 2008; Idikut *et al.*, 2009).

Table 1. Macro and micro content of maize inbreed lines

line	proteins	oil	starch	Mg mg/g	Zn mg/g	Fe mg/g	P ug/g
				BSSS			
2	8,31	3,20	72,13	965,94	17,84	25,18	7029,79
3	10,83	3,17	70,50	949,69	20,47	17,09	7239,35
6	9,05	**2,87**	71,31	897,19	22,12	23,65	8287,15
7	9,71	3,35	72,10	862,50	22,00	16,18	7677,52
8	8,86	3,07	70,26	774,69	20,28	21,00	7887,08
11	13,55	3,56	67,75	750,32	17,56	15,81	7144,09
13	8,10	3,42	72,18	647,82	27,031	5,90	6553,52
20	10,55	3,59	70,20	872,81	16,06	12,25	7620,37
24	11,51	4,25	69,97	785,31	25,15	22,75	7277,45
30	10,68	3,89	70,46	718,12	**34,59**	22,03	6839,28
31	10,09	3,35	71,42	842,50	27,09	23,28	7487,01
32	9,60	3,08	**73,16**	953,12	29,18	23,03	6934,53
33	10,98	3,60	70,32	718,75	21,18	5,59	7391,76
34	10,97	3,67	70,22	784,37	22,62	13,46	7182,20
36	10,22	3,87	70,00	889,37	20,90	11,59	7144,09
38	12,90	3,89	68,50	895,00	23,78	18,75	7544,16
39	8,89	3,21	71,75	696,25	17,31	**2,31**	7334,60

40	12,19	3,34	69,34	857,50	15,68	4,06	7810,88
41	10,00	3,85	71,10	693,75	34,12	4,81	6572,57
42	10,48	3,21	71,12	862,81	15,84	8,21	8020,44
43	12,93	3,43	68,15	811,87	16,12	15,62	7639,42
44	11,19	3,80	69,39	717,81	11,59	14,06	7201,25
50	10,45	3,74	70,10	780,94	15,68	11,84	6801,18
51	12,12	3,13	69,16	852,81	25,12	23,65	7105,99
53	9,07	4,20	70,70	633,12	15,78	16,62	5734,32
61	11,90	3,55	69,75	664,37	23,25	27,90	6439,21
62	10,10	3,29	71,10	614,37	12,31	10,59	5962,94
63	11,19	3,51	70,15	711,25	22,46	22,03	6153,44
64	10,64	3,55	69,38	**587,81**	30,93	18,12	6039,14
65	**13,69**	3,83	**67,29**	700,94	16,21	18,43	7125,04
66	11,67	3,20	69,19	827,81	**10,84**	20,093	8287,15
67	9,95	3,50	71,01	898,75	26,37	30,50	8020,44
68	10,55	3,77	68,66	930,31	32,25	24,59	8249,05
69	10,85	3,66	69,86	696,87	13,31	12,21	7125,04
71	10,31	3,51	70,80	626,25	30,31	21,18	6039,14
72	10,37	3,25	70,85	738,75	16,28	12,00	7658,47
73	10,08	3,06	71,76	753,75	11,96	10,12	7125,04
74	8,69	3,20	72,25	672,19	18,40	12,18	6686,879
75	7,64	3,75	70,95	762,81	14,68	10,34	7125,04
76	10,50	3,59	70,76	689,06	14,93	13,21	7201,25
77	12,62	3,30	69,18	620,31	17,25	16,4375	6934,53
4	8,97	3,89	70,80	827,18	20,12	21,59375	7696,57
5	9,58	4,58	71,12	725,94	18,96	25,46	6801,18
14	10,35	4,03	70,54	649,06	14,00	9,75	7372,70
27	10,82	3,69	69,46	**980,62**	35,75	24,15	7677,52
28	9,02	3,69	71,04	949,37	23,03	20,50	7906,13
29	**7,55**	3,27	71,96	835,94	26,53	21,40	6572,57
16	9,98	3,42	70,91	597,18	18,90	9,00	6020,09
average	10,38	3,54	70,42	776,56	20,92	16,47	7159,97
Lancester							
9	10,49	4,19	67,23	836,56	24,34	20,43	8439,56
15	8,72	3,71	70,87	774,68	20,15	13,56	7315,55
17	10,11	4,53	69,02	775,00	15,59	28,96	7448,91
21	9,87	3,84	70,15	827,18	21,00	14,65	7582,26
26	8,20	3,75	69,45	887,50	27,18	26,09	7125,04
35	9,37	3,56	70,81	745,31	17,87	10,34	6915,48
45	11,06	3,61	69,65	783,43	16,59	19,37	8172,84
46	12,56	4,34	67,64	926,25	21,84	22,65	**8706,27**
47	10,23	4,22	70,04	867,18	18,00	13,43	7887,08
48	9,74	4,70	70,00	750,00	17,68	11,28	7525,11
49	11,86	4,07	69,39	655,94	15,40	12,90	**5315,20**
56	9,21	4,84	71,61	652,50	16,21	20,65	6058,19
57	8,48	4,72	69,13	682,50	13,03	18,59	6724,97
58	9,93	3,89	70,20	801,56	17,65	16,34	6648,77
59	8,38	3,62	70,74	751,25	18,65	15,50	6248,70

60	9,94	3,93	70,33	726,25	18,15	16,46	6267,75
55	11,45	4,50	69,13	797,18	22	12,71	7144,09
average	9,97	4,12	69,73	778,84	18,90	17,29	7148,58
European germplasm							
1	12,61	**5,06**	67,35	846,25	20,18	17,65	6686,87
10	11,61	4,32	69,05	894,37	21,96	18,96	7791,82
12	12,51	3,96	69,65	726,25	20,15	21,00	7201,25
19	10,56	3,51	68,99	803,75	15,18	27,56	7868,03
22	12,52	4,30	68,37	935,94	19,59	10,18	8611,01
23	10,12	4,06	71,27	711,56	22,28	19,00	6934,53
25	9,89	4,03	70,60	846,87	22,37	18,50	6991,69
54	10,07	4,87	69,28	722,81	20,50	23,62	7601,32
78	9,85	3,62	71,79	768,75	20,28	15,62	7868,03
average	11,08	4,19	69,59	806,28	20,28	19,12	7506,06

The development of an efficient breeding program to increase mineral concentration in maize depends on the presence of genetic variability in this species (Menkir, 2008). The Mg, Fe, Zn, and P content of 74 maize inbred lines are presented in Table 1. The concentration of Mg varied from 587,81mg/g to 980,62mg/g, Fe from 2,31 mg/g to 28,97mg/g, Zn from 10,84 mg/g to 34,59mg/g, and P from 5315,21ug/g to 8706,27ug/g. The highest average concentration of Mg, Fe and P had inbred lines from European germplasm while inbred lines from BSSS germplasm had the highest Zn concentration. Lines from BSSS had the lowest average Mg and Fe content as well as lines from Lancester germplasm had the lowest Zn and P content. Menkir (2008) found similar variation in Fe, Zn, and P concetration in 278 maize genotypes and showed that there were highly significant effect of maize genotypes in mineral content. Queiroz *et al. (*2011) found significant genetic variability in the contents of Fe, Zn and P in 22 maize inbred lines.

Conclusion

Adequate macro and microelements concentration in seed is very important for crop productivity and nutritive value of product. Considerable variability for macro and microelements in grain of 74 maize inbred lines was determined. Inbred lines from European germplasm have the highest protein, oil, Mg, Fe and P content, as well as lines from BSSS germplasm have the highest starch and Zn content and lowest Mg and Fe content. Lines from Lancester germplasm have the lowest Zn and P content.

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