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INHERITANCE OF BORON STATUS IN GRAIN OF MAIZE GENOTYPES

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SUMMARY

Although maize is relatively insensitive to boron (B) deficiency, serious disorders of cob and grain formation may occur. Objective of this study was to determine the role of inheritance for boron status in grain of maize genotypes. Twenty-eight direct diallel progenies of eight genetically divergent maize inbred lines (single cross hybrids or crosses) were grown in Osijek during the 1994 growing season. The field experiment was a randomized block design with four replicates. B contents in grain were determined by ICP technique. The effects of general combining abilities (GCA) and specific combining abilities (SCA) were significant at $p<0.01$. Differences in grain B status among tested crosses under identical environmental conditions were from 1.10 mg/kg B to 2.41 mg/kg B. In general, seven crosses including Os-8Id-93 as a parent had considerably higher B contents in grain (mean 1.94 mg/kg B) in comparison with the remaining 21 tested crosses (mean 1.31 mg/kg B). Also, inclusion of Os1-93 and Os2-93 parents (total 13 crosses) resulted in lower grain B contents (means 1.28 mg/kg B) than in remaining 15 crosses (mean 1.66 mg/kg B). However, the results showed that the crosses containing the line Os8Id-93 as parents had generally the highest mean B content. The exceptions were the respective crosses of this line with the lines Os5-93 and Os 7-93, in which specific combining abilities were notably the lowest. This indicates a specific influence of these two lines on the line Os8Id-93. Moreover, the significantly best specific combination was Os5-93 x Os 7-93. Since only these two lines trace back to original Croatian synthetic populations, we suggest that the genetic background of the material has very important role for the inheritance of B status in maize grains.

Key words: boron (B) status, grain, inheritance, maize,

INTRODUCTION

Environmental conditions in the Eastern Croatia are generally favorable for growing main arable crops. However, nutritional problems accompanied with potassium (K), phosphorus (P) and oversupplies of magnesium (Mg) were found in maize plants (Kovačević and Vukadinović, 1992; Kovačević et al., 1997; Kovačević and Bašić, 1998) on some soils at river Sava lowland area. Concerning boron (B), only disorders of sugar beet caused by B deficiency, were found. Maize is the first-ranged field crop in Croatia and it occupies near one third of its arable land (Kovačević and Josipović, 1998). For this reason, maize is grown on soils of different properties including less fertile soils with nutritional problems (Kovačević et al., 2001). Although maize is relatively insensitive to B deficiency, serious disorders of cob and grain formation may occur under extreme conditions including anthesis inhibition and/or sterility of the anthers. Most of the grains, if any are formed at all, are blind. Concerning the susceptibility of plants to B deficiency, some studies are published relating not only to "boron-intensive species of crops", but also to varietal differences (Bergmann, 1992).

Since inheritance plays important role in nutrient uptake by plants (Rahka, 1992; Silva, 1993; Pandey, 1994; Kovacevic and Vujevic, 1989), testing different maize hybrids according to their B contents in grain under identical environmental conditions seems reasonable. In recent investigations, genotypic variation in B efficiency has been found among wheat genotypes (Ahmed et al., 2001; Nachiangmai et al., 2001; Rashid et al., 2001; Wongmo et al., 2001). To our knowledge, response of maize genotypes to B nutrition is not documented in literature. Objective of this study was to determine the role of inheritance for boron status in grain of maize genotypes.

MATERIALS AND METHODS

Twenty-eight direct diallel progenies of eight genetically divergent maize inbred lines (single-cross hybrids or crosses) were grown under field conditions on Osijek eutric cambisol (very fertile soil of favorable physical and chemical properties) during the 1994 growing season. The field experiment was a randomized block design with four replicates (exp. plot 5.0 m^2). Self-pollination was conducted with two randomly chosen plants per plot of three replicates. B contents in grain were determined by ICP (Inductively Coupled Plasma) technique at Research Institute for Soil Science and Agricultural Chemistry (RISSAC) of Hungary Academy of Science and Arts, Budapest, Hungary. Results were calculated on dry matter basis in mg/kg. The effects of general combining abilities (GCA) and specific combining abilities (SCA) were calculated as sources of variation in ANOVA. Combining ability analysis of diallel crosses was estimated according to Griffing's method IV, fixed model (Griffing, 1956).

RESULTS AND DISCUSSION

There were significant differences among the 28 crosses for boron status in grain. Replications did not differ significantly (data not shown). Hybrids varied due to general combining ability (GCA) and specific combining ability (SCA) both at $p<0.01$ in the analysis of variance. When pooled over all respective crosses, the greatest parental mean had the line Os8Id-93 (Table 1). This inbred line had correspondingly greatest positive and significant GCA effect.

Table 1. Parental mean boron content in grain [mg/kg] and general combining ability (GCA, gi) effects for eight maize genotypes evaluated in Eastern Croatia

Tablica 1. Srednje vrijednosti roditelja za sadržaj bora u zrnu [mg/kg] i efekti općih kombinatornih sposobnosti (GCA, gi) za osam genotipova kukuruza procijenjenih u Istočnoj Hrvatskoj

Genotype Genotip	Parental mean Prosjek roditelja	GCA effects GCA efekti
Os1-93	1.34	-0.21
Os2-93	1.34	-0.21
Os3-93	1.43	-0.10
Os4-93	1.37	-0.15
Os5-93	1.62	0.12
Os6-93	1.66	0.16
Os7-93	1.42	-0.11
Os8Id-93	1.94	0.49
Standard error gi - Standardna greška gi		0.08
Overall mean with standard error Prosjek sa standardnom greškom	1.52±0.04	

Differences in grain B status among tested crosses under identical environmental conditions were from 1.10 mg/kg B to 2.41 mg/kg B (Table 2). In general, seven crosses including Os-8Id-93 as a parent had considerably higher B contents in grain with 1.94 mg/kg B in comparison to the remaining 21 tested crosses (1.31 mg/kg B in average). Further, the lines Os1-93 and Os2-93 as parents (a total of 13 crosses) resulted in lower grain B contents (1.28 mg/kg B) than in other 15 crosses (1.66 mg/kg B). Interestingly, the parental lines Os1-93 and Os2-93 did not have the closest genetic background in the trial. However, the results showed that the crosses having the line Os8Id-93 as a parent had generally the highest mean B content. The exceptions were the respective crosses of this line with the lines Os5-93 and Os 7-93, in which specific combining abilities were notably the lowest. This indicates a specific influence of these two lines on the line Os8Id-93. Moreover, although the combination Os6-93 x Os8Id-93 had the highest mean in the experiment, notably best specific combination was Os5-93 x Os 7-93. Since only these two lines trace back to original Croatian synthetic populations, it suggests that the genetic background of the material plays a very important role for the inheritance of boron content in maize grains.

Table 2. Mean boron content in grain [mg/kg] and specific combining ability effects (SCA, sij) for 28 crosses including eight maize lines evaluated in a diallel cross in Eastern Croatia

Tablica 2. Srednje vrijednosti sadržaja bora u zrnu [mg/kg] i efekti specifičnih kombinatornih sposobnosti (SCA, sij) za 28 križanaca koji ukjučuju osam linija kukuruza procijenjenih u dialelnim križanjima u Istočnoj Hrvatskoj

Genotype (crosses) Genotip (križanci)	Mean Srednja vrijednost	SCA effects SCA efekti
Os1-93×OS2-93	1.10	-0.002
Os1-93×OS3-93	1.17	-0.040
Os1-93×OS4-93	1.35	0.196
Os1-93×OS5-93	1.37	-0.063
Os1-93×OS6-93	1.36	-0.113
Os1-93×OS7-93	1.22	0.017
Os1-93×OS8Id-93	1.81	0.004
Os2-93×OS3-93	1.34	0.130
Os2-93×OS4-93	1.10	-0.057
Os2-93×OS5-93	1.36	-0.069
Os2-93×OS6-93	1.33	-0.143
Os2-93×OS7-93	1.16	-0.039
Os2-93×OS8Id-93	1.99	0.180
Os3-93×OS4-93	1.18	-0.084
Os3-93×OS5-93	1.48	-0.060
Os3-93×OS6-93	1.45	-0.130
Os3-93×OS7-93	1.26	-0.043
Os3-93×OS8Id-93	2.14	0.227
Os4-93×OS5-93	1.48	-0.007
Os4-93×OS6-93	1.43	-0.100
Os4-93×OS7-93	1.11	-0.147
Os4-93×OS8Id-93	2.06	0.200
Os5-93×OS6-93	2.00	0.196
Os5-93×OS7-93	2.04	0.503
Os5-93×OS8Id-93	1.64	-0.500
Os6-93×OS7-93	1.63	0.056
Os6-93×OS8Id-93	2.41	0.234
Os7-93×OS8Id-93	1.56	-0.346
LSD 0.05	0.58	
Standard error s_{ij} - Standardna greška s_{ij}		0.174

CONCLUSIONS

We found considerable role of genotype on B concentrations in corn grain. This finding could be useful in regard to improvement of corn quality as food. Further, similar investigation could be made with B uptake by vegetative organs (e.g. leaf contents at silking stage) in commercial corn hybrids. More efficient B genotypes could be recommended for growing on calcaric soils or similar soil types characterizing low levels of available B contents.

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NASLJEĐIVANJE SADRŽAJA BORA U ZRNU KOD GENOTIPOVA KUKURUZA

SAŽETAK

Iako je kukuruz relativno neosjetljiv na nedostatak bora (B), ipak su mogući ozbiljni poremećaji u formiranju oklaska i zrna. Cilj ovoga rada je odrediti ulogu nasljeđivanja sadržaja bora u zrnu kod različitih genotipova kukuruza. Tijekom 1994. godine u Osijeku posijano je 28 direktnih dialelnih križanaca sastavljenih od osam genetski divergentnih inbred linija. Pokus je postavljen prema randomiziranom bloknom planu u četiri ponavljanja. Sadržaj bora određen je tehnikom ICP. Efekti općih (GCA) i specifičnih (SCA) kombinatornih sposobnosti bili su signifikantni na razini $p<0.01$. Razlike u sadržaju bora između križanaca bile su između 1.10 mg/kg B i 2.41 mg/kg B. Općenito, sedam križanaca koji su imali liniju Os-8Id-93 kao roditelja imali su značajno viši sadržaj bora u zrnu (u prosjeku 1.94 mg/kg B) nego ostali 21 križanac (prosjek 1.31 mg/kg B). Križanci s linijama Os1-93 i Os2-93 kao roditeljima (ukupno 13 križanaca) imali su niži sadržaj bora (1.28 mg/kg) nego ostali križanci (prosjek 1.66 mg/kg B). Međutim rezultati pokazuju da su križanci s linijom Os8Id-93 kao roditeljem imali općenito najviše sadržaje bora u zrnu. Izuzeci su križanci te linije sa linijama Os5-93 odnosno Os 7-93, kod kojih su specifične kombinatorne sposobnosti bile najniže. Ovo ukazuje na specifičan utjecaj ovih dviju linija na liniju Os8Id-93. Nadalje, značajno najbolja kombinacija bila je upravo Os5-93 x Os 7-93. Budući da obje ove linije potječu iz originalnih hrvatskih sintetičkih populacija, može se zaključiti da je genetička osnova materijala imala vrlo važnu ulogu u nasljeđivanju sadržaja bora u zrnu kukuruza.

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