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EFFECT OF ENDOSPERM MUTANTS ON MAIZE SEED GERMINATION

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The expression of genetic potential of yielding and quality of a certain genotype depends among other factors on seed quality. Seed is very important not only for the reproduction of the particular plant species, but also, for the contemporary plant production. Each part of maize seed (pericarp, endosperm and germ) has a specific function in the complex process of germination and emergence. The following three genotypes of different endosperm types were observed: ZPSC 42A (standard grain quality dent hybrid), ZPSC 504 *su* (sweet maize hybrid with a *sugary* gene) and ZPSyn.II *sh2* (synthetic population with a *shrunken2* gene). Seed viability of the stated genotypes was determined by the accepted ISTA methods: standard method, accelerating age and cold test. Obtained results point out to differences in the germination capacity of the observed genotypes. The greatest reduction of the germination capacity and the emergence rate was expressed by the application of the accelerating ageing method. Appeared differences are probably a result of the endosperm texture (type), grain weight, sugar content and pericarp thickens and composition.

Key words: Maize seed, sweet maize, seed germination

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INTRODUCTION

Maize grain is composed of three principal parts: pericarp, endosperm and germ. Each of stated parts has a certain role in the process of seed germination and emergence. The seed of high quality represents an important segment within the series of factors on which the expression of genetic yielding potential of a certain genotype depends upon. A high percentage of germination capacity (100%) is a very significant parameter of seed quality. Maize seed of a different endosperm type differently behaves under different conditions of storing, sowing and emergence under favourable and unfavourable conditions (standard grain quality hybrid, standard sweet maize with a *sugary* gene and augmented-sugary sweet /super-sweet/ with a *shrunken2* gene).

The endosperm mutant seed used in sweet maize breeding has a higher sugar content, and at the same time, a lower starch content. The content of starch, i.e. sugar amounts to 20-30%, i.e. 15-35%, respectively, at the milk stage when sweet maize is consumed, while these contents at the same stage in the grain of standard quality amount to 65% and approximately 5%, respectively, HANNAH *et al*., 1993. All commercial sweet maize hybrids are based on one or several endosperm mutants. The mutants are enzymic "injuries" on the way of starch syntheses that alter the endosperm carbohydrate composition, and result, almost in all cases, in the decrease of the starch content. The kernel (seed) at full maturity is of a irregular form, shrunken, angular and prone to injuries. Therefore, germination and early growth of augmented-sugary mutants (for instance *sh2*) are lower in these types in relation to seed germination of standard grain quality maize, TRACY, 1994.

MATERIAL AND METHODS

The following three genotypes of different endosperm types were observed: ZPSC 42A (standard grain quality hybrid), ZPSC 504 *su* (standard sweet maize hybrid with a *sugary* gene) and ZPSyn.II *sh2* (synthetic population with a *shrunken2* gene). The trial was performed in the experimental field and the Seed Testing Laboratory of the Maize Research Institute, Zemun Polje.

Seed viability of selected genotypes was evaluated according to ISTA methods:

-standard method (optimum conditions), ISTA, 1993

-cold test (unfavourable conditions), ISTA, 1995

-accelerating ageing (unfavourable conditions), ISTA, 1995

-field conditions (optimum and unfavourable conditions), ISTA, 1995.

Seeds used in the experiment were produced in the experimental field of the Maize Research Institute, Zemun Polje. Harvest and shelling were done by hand to avoid seed injuries. The seed was naturally dried and was not treated with plant protective agents.

RESULTS AND DISCUSSION

The objective of the present study was to determine the effect of favourable and unfavourable factors under laboratory and field conditions on germination percent and seed emergence rate of both, grain of standard quality and different endosperm mutants. Maize grain of standard quality (dent, flint) at the biological maturity stage (seed) contains about 73% of starch, seed of *sugary* (*su*) sweet maize contains approximately 35% of starch, while mutant seed with the *shrunken2* (*sh2*) gene or supersweet contains about 21% of starch in the endosperm, TRACY and JUVIK, 1989.

Beside the protective role, the pericarp has a certain function in the process of seed germination and emergence. The pericarp thickness depends on an endosperm type. The thickness is conditioned by a kernel location on the ear and the pericarp position on the kernel. The pericarp is the thinnest above the germ and it is the thickest on the kernel dorsal side. Sweet maize is a type with the thinnest pericarp (40-70ημ), while this thickens in standard grain quality maize amounts to 70-120ημ, BREWBAKER, 1981.

Obtained results on seed germination point out to differences among genotypes and applied methods. The highest germination was recorded by the standard method (optimum conditions): 100% - hybrid ZPSC 42A, 97.5% - ZPSC 504*su*, standard sweet maize with the *sugary* (*su*) gene, and 59.5% - II*sh2* - augmented-sugary sweet maize, supersweet, with the *shrunken2* (*sh2*) gene, (Table 1). Laboratory maize seed germination is expressed by the germination capacity and represents a percentage of seeds capable to germinate into strong, sound, uninjured seedlings, i.e. seedlings that can develop into normal plants under filed conditions.

The environmental conditions are not most often favourable for germination and development of seedlings: cold, wet or dry soils, inadequately prepared soils result in the seed germination reduction and seedling death. Unfavourable environmental conditions affect sweet maize seed and especially mutants with the *shrunken2* gene. Seeds of these mutants are small, shrunken and need warm, light, wet and well prepared soils so that kernels could make a contact with moisture, TRACY, 1994.

Table 1. Germination means of different endosperm type seeds

Genotype	Germination (%)			
	I	II	III	IV
ZPSC 42A	100.0	98.7	33.0	97.5
ZPSC 504su	97.5	96.7	28.5	97.0
Syn.IIsh2	59.5	11.0	1.5	33.0

I - Standard method; II- Cold test; III- Accelerated ageing; IV- Field emergence

Results obtained by the method of cold test (unfavourable conditions) indicate that the highest decrease of germination was in the *shrunken2* type, ZPSC 42A -98.7%, then in ZPSC 504*su* - 96.7% and in Syn.II*sh2* - 11.0%.

Older seed lower germination capacity, which results in non-germination, occurrence of abnormal seedlings that are week and of uneven development due to a different ageing rate of the tissue within the seed, STYER and CAUTLIFFE, 1983; VESKOVIĆ *et al*. 1994. Studied genotypes showed the following values of germination by the method of accelerating ageing: 33.0% - ZPSC 42A, 28.5% - ZPSC 504*su* and 1.5% - Syn.II*sh2* (Table 1). Such results are a consequence of several factors, such as genetic origin (endosperm type), grain weight, and especially sugar reserves in the endosperm (*sugary, shrunken2*), CHURCHILL and ANDREW, 1984.

Table 2. Analysis of variance

Source of variation	d.f.	F - test
Method (A)	3	882.699**
Replication	12	0.596
Genotype (B)	2	854.254**
AB	6	47.470**
Error	24	

CV = 6.91; LSD (0.05)=3.166; LSD (0.01)=4.290

The analysis of variance shows that there are significant differences in germination capacity of observed genotypes and applied methods (Table 2). When the average obtained by all applied methods is analysed, the lowest germination was expressed by the genotype with the *shrunken2* gene, then the genotype with a *sugary* gene. As sweet maize is based on one or several endosperm mutants, the production of high quality seed is more difficult than the seed production of other maize types. Sweet maize kernels with a lower starch content in the endosperm are shrunken and "air pockets" are formed between the endosperm and pericarp. These "pockets" aggravate a normal moisture contact with the inner kernel content. This is also one of reasons that germination is reduced under unfavourable conditions, TRACY, 1994; PAJIĆ *et al*., 1996. The lowest germination under field conditions (the percent of the developed plants was evaluated a month after sowing) was recorded in the genotype with the *shrunken2* gene. The reasons for this is a light kernel with a low starch content, a thin, shrunken pericarp and a higher sugar level than in the kernel of standard maize.

CONCLUSIONS

Obtained results point out to differences in seed germination capacity of different endosperm types (standard, *sugary*, *shrunken2* sweet maize) under both, favourable and unfavourable germination conditions.

The greatest reduction in germination capacity was expressed by the application of accelerating ageing method, then by the cold test method (unfavourable conditions). These differences are most likely a consequence of a type (texture) of the endosperm, which affects grain weight, the sugar and starch content in the endosperm, the pericarp thickness and structure.

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EFEKAT MUTANATA ENDOSPERMA NA KLIJAVOST SEMENA KUKURUZA

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I z v o d

Ispoljavanje genetičkog potencijala rodnosti i kvaliteta određenog genotipa zavisi, pored drugih faktora, i od kvaliteta semena. Svaki od delova semena kukuruza, perikarp, endosperm i klica, ima određenu funkciju u kompleksnom procesu klijanja i nicanja. Ispitivana su tri genotipa različitog tipa endosperma: ZPSC 42A, hibrid standardnog kvaliteta zrna (zuban), ZPSC 504 su (hibrid šećerca sa sugary genom) i ZPSyn.II sh2 (sintetička populacija sa shrunken2 genom). Za određivanje vitalnosti semena navedenih genotipa korišćene su priznate ISTA metode: standardni metod, ubrzano starenje, cold test i nicanje u polju. Rezultati ispitivanja klijavosti semena pokazuju da postoje razlike između genotipova i metoda koje su korišćene. Najveće vrednosti za klijavost semena utvrđene su standardnom metodom (optimalni uslovi). Rezultati dobijeni metodom cold testa (nepovoljni uslovi) pokazuju da je najveće smanjenje klijavosti kod shrunken2 tipa. Starenjem semena kapacitet klijavosti opada, što je posledica više faktora, genetičko poreklo (tip endosperma), težina zrna, a naročito rezerve šećera u endospermu (sugary, shrunken2).

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