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INFLUENCE OF GRAIN MOISTURE CONTENT DURING HARVEST ON THE MAIZE SEED GERMINATION
UTICAJ VLAŽNOSTI PRI BERBI NA KLIJAVOST SEMENA KUKURUZA

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ABSTRACT

Modern maize seed drying and processing technology is applied today to ensure high quality grain. The most important factor in preserving seed quality is the moisture content. The time of harvesting, drying, storage and seed conservation is determined by the seed water quantity. At the harvesting time, a lower moisture content is desirable due to seed physiological maturity as well as consequences that may be caused during seed drying. During seed storage, water in seed is maintained at the level of latency to preserve vital seed functions, for maize it is 13-14 %. Influence of different seed moisture content, during harvesting time, on maize seed quality were studied in this research. Two physiological traits of seed were observed: seed energy and germination. Material used in this research were maize hybrids ZP 434 and ZP 666. Moisture content during harvesting time was measured after drying and primary processing, two seed sizes were obtained. From the devided seed samples were taken for laboratory tests. Harvesting was done at different seed moisture content < 25 %, 25-30 %, 30-35 % and > 35 %. Maize cobs were dried in double-pass system drier with air temperature below 42 °C. Cob moisture is measured with moisture meter (Pfeuffer). Seed was divided into two fractions according to size using sieves with mesh sizes ranging from 6.5 - 8.3 mm and 8.4 - 11.0 mm. Seed energy and germination were determined in seed testing laboratory on working samples 4x100 seed, by standard maize germination test with ISTA Rules, and Rule on the quality of seed of agricultural plants. Experimental results were calculated on average mean and total variability ($\overline{X}$, SD i C.V.) for seed energy, germination and moisture content. The three factorial analyse of variance was calculated for both germination traits (seed energy and germination), for factors: hybrid, seed sizes and seed moisture content. The results of all factors and traits had different values. The highest means of seed energy and germination in both fractions of both observed hybrids were recorded with the seed moisture content ranging from 30 to 35 %.

Key words: *Hybrid seed, seed size, moisture content, germination.*

REZIME

U cilju dobijanja što kvalitetnijeg semenskog materijala, danas je u primeni savremena tehnologija dorade i sušenja semena. Jedan od osnovnih činilaca očuvanja kvaliteta semena je voda. Količina vode u semenu određuje vreme berbe, način sušenja, skladištenja i očuvanja kvaliteta semena.U vreme berbe poželjan je manji sadržaj vode, kako zbog fiziološke zrelosti semena tako i zbog posledica koje mogu biti uzrokovane dužim periodom sušenja. Za vreme čuvanja semena voda se održava na nivou latentnosti životnih funkcija, a za kukuruz to je 13-14%. U ovim istraživanjima posmatran je uticaj različitih vlažnosti semena u toku berbe na kvalitet semena. Posmatrane su dve fiziološke osobine semena: energija klijanja i klijavost. Materijal korišćen u istraživanjima su dva hibrida kukuruza ZP 434 i ZP 666. Berba je vršena sa različitom vlažnošću semena, a posle sušenja i krunjenja, iz naturalnog semenskog materijala izdvojene su dve frakcije po krupnoći. Iz podeljenog semenskog materijala izdvajani su uzorci za laboratorijsko ispitivanje semena. Berba je vršena sa različitom vlažnošću semena, koja je bila: < 25%, 25-30%, 30-35% i sa vlažnošću većoj od 35%. Sušenje semenskog klipa obavljeno je u sušarama tipa komora sa dva prolaza fluida za sušenje klipa kukuruza na temperaturi ispod 42°C. Ulazna vlaga klipa merena je laboratorijskim uređajima za određivanje vlage Pfeuffer. Deljenje semena na dve frakcija izvršeno je po krupnoći korišćenjem sita promera 6,5-8,3 mm i 8,4-11,0 mm. Ispitivanje energije klijanja i klijavosti rađeno je u laboratoriji za ispitivanje semena na radnom uzorku 4x100 semena po standardnoj metodi na naizmeničnoj temperaturi 20-30°C po ISTA pravilima i Pravilniku o kvalitetu semena poljoprivrednog bilja. Eksperimentalni podaci obrađeni su na srednju vrednost, standardnu devijaciju i ukupnu varijabilnost ($\overline{X}$, SD i C.V.) za sve osobine semena i svaku varijantu istraživanja. Trofaktorijalna analiza varijanse urađena je za obe posmatrane osobine semena (energiju klijanja i klijavost), za faktore: hibrid, frakcija i vlažnost semena. Dobijeni rezultati po svim osnovama, pokazuju različite vrednosti. Najveća enegija klijanja i klijavost semena utvrđeni su za seme čija je vlaga u toku berbe bila 30-35% za oba ispitivana hibrida.

Ključne reči*: hibridno seme, frakcija, vlažnost, klijavost.*

INTRODUCTION

Maize seed production is aimed at obtaining high and stable yields. Since that there are different maize growing regions, production technology should be adapted to the specific growing conditions of a location and a genotype, so its potential could be fully used. The quality of seeds obtained, in addition to the aforementioned conditions of production, location and genotype, depends on the physiological maturity of seeds. It determines the beginning of harvest, method of harvesting, drying and storage, and it is determined by the seed moisture content. These conditions appear to have significant influence on the quality of seeds (*Egli, et al., 2005*). One of the most unusual properties of water is its undeniable role in the development and maintenance of life. In relation to seed, water performs important functions, as its ingredient of high chemical activity and high thermal conductivity *(Lekić, 2003)*. During seed maturation, the amount of water changes and on the basis of the water content in seeds the following three conditions can be distinguished: 1) the seed moisture content of 65-70 % with a small dry matter content; 2) the seed moisture content of up to 40 % and the increased content of organic matter and 3) dryness and a constant amount of dry mat-

ter. These seed moisture conditions slightly depend on humidity of the environment *(Mirić and Brkić, 2002)*. The optimum moisture content during seed processing and storage is the one that help maintain the latent state of the seed. Production of high quality seed maize would be facilitated by the harvesting of the seed at a kernel maturity which is highly correlated with maximum seedling vigor *(Knittle and Burris, 1976)*. However, after reaching maximum seed quality, seeds tend to age and deterioration processes begin. Thus, seed quality decrease after this phase *(Eskandari, 2012)*. Late harvest increases seed losses and reduces seed germination *(Hrustić et al., 1996)*. Effects of different seed moisture contents during harvest on seed quality were observed in this study. Two physiological properties of seeds were examined: seed energy and germination. The objective of the present study was to determine the difference in seed quality caused by different initial moisture contents at crop harvest.

MATERIAL AND METHOD

Two maize hybrids of the F_1 generation developed by the Maize Research Institute, Zemun Polje, ZP 434 and ZP 666, harvested in 2011, were used as a material in the present study. The moisture content was determined at harvest, and after drying and shelling and then two size fractions were separated from the natural seed material. Seed energy and germination of seeds were determined in samples drawn from these two fractions under laboratory conditions. Seeds of different moisture contents were harvested. These contents were classified into the following four moisture intervals: <25 %, 25-30 %, 30-35 %, and moisture content >35 %. Cob moisture is measured with moisture meter Pfeuffer. Seed maize drying was performed in a double pass maize ear dryer at the Seed processing plant of the Maize Research Institute, Zemun Polje. The thickens of the drying layer, i.e. the amount of ears per a drying chamber, is determined on the basis of input moisture, which directly affects the time of drying. Ears are dried with warm air (42 ^{o}C) which reduces the grain moisture to the desired value (12-13 % moisture). Upon completion of drying to the proper moisture percentage not higher than 13% for national marketing, seeds are divided into two seed factions, using sieves with diameters ranging from 6.5 to 8.3 mm and from 8.4 to 11mm. The identification and determination of physiological seed traits (seed energy, germination) were done using the standard temperature range and filter paper according to Rule on the quality of seed of agricultural plants *(Official Gazette 47/87)* and ISTA Rules *(ISTA 2007)*:

- t_1 = 20-30 ^{o}C (alternate 16-8 h, white light at higher temperature), seed energy is determined on the 4th day, and germination on the 7th day.

Experimental data were analysed for mean, total variability, and standard deviation for all seed traits and each variant. The three factorial analysis of variance was performed for seed fractions and moisture content for both observed properties (seed energy and germination). The experimental data were analysed by applying the appropriate mathematical and statistical methods using the statistical package MSTAT.

RESULTS AND DISCUSSION

Obtained experimental results are grouped and presented by mathematical-statistical methods, which were applied in the processing of the experimental data and during the analysis and evaluation.

The results are presented as:

- variational data rows of hybrid maize seed traits for each experimental variant;
- an indicator of the effect of individual factors included in the study on all observed traits of hybrid maize seed (three factorial analysis of variance)

Means and variability of seed traits

Results of mean values and variational rows are shown in the two tables for each hybrid combination. Each table includes four variants within a hybrid combination. Determined seed energy of ZPSC 434 was high in every initial moisture content variant. It ranged from 92 % to 97 % (Table 1). Highest seed energy was determined in variant 3 (30 %<M<35 %), at both small (97 %) and large seed fractions (95,4 %). Germination was also very high in all variants, and it ranged from 93 % to 98,4 %. For this trait variant 3 also had highest values – 98,4 % at small fraction, and 98,2 % at large fraction. Both seed energy and germination had small variations, and CV in all variants did not exceed 3 %. Mean differences were statistically significant. Highest mean differences for seed energy were recorded between variants 3 and 2 at small fractions, and between variant 3 and variants 2 and 4 at large fractions. Statistically significant difference for germination was determined between variants 3 and 2 at small fraction, and between variant 3 and variants 2 and 4 at large fraction. The results show impact of moisture content during harvest on physiological traits – seed energy and germination. Variant 3 showed best results for both traits. From the above stated it can be concluded that the time of harvest is crucial for the conservation of seed energy and germination. Delays in harvesting, almost always result in the reduction of seed quality *(Herbek i Bitzer, 2004)*.

Table1. Means and seed trait variability of seeds of the hybrid ZPSC434

ZPSC 434	MOISTURE							
	M<25 % (1)		25 %<M<30 % (2)		30%<M<35 % (3)		M>35 % (4)	
	SF		SF		SF		SF	
	e	g	e	g	e	g	e	g
$\overline{X}$	94.8ab	96.8ab	93.4b	94.2b	97.0a	98.4a	95.6ab	96.6ab
SD	1.48	0.84	2.70	3.35	1.58	0.89	1.95	1.14
CV	1.04	0.64	2.08	2.64	1.20	0.72	1.52	0.88
	LF		LF		LF		LF	
	e	g	e	g	e	g	e	g
$\overline{X}$	93.8ab	96.2a	92.4b	93.2b	95.4a	98.2a	92.0b	93.0b
SD	2.28	3.11	1.82	1.48	1.34	1.48	1.22	1.00
CV	1.52	2.16	1.52	1.04	1.12	1.04	0.80	0.80

LSD 0.01 = 2.718

SF - small seed fraction; KF - large seed fraction; M – moisture; e – seed energy; g- germination

Among the variants, differences were determined in the expression of seed energy and germination for ZPSC 666. Seed energy of variant 3 of the small fraction had the highest value of 97.4 %, which was also recorded in its large fractions – 96 % (Table 2). Germination was highest at the variant 3 - 98.4 % (for both small and large fractions). Differences in the mean values of the variants were statistically significant. Variants 3 and 4 for the seed energy and germination of small fraction were significantly different from variant 2 ($p<0.01$). Seed energy for the large fraction was the highest in variant 3 and significantly statistically different from the values obtained in the variant 2

and variant 4 ($p<0.01$). Germination for a large fraction varies significantly between variant 3 and variants 2 and 4, and also between variant 1 and variants 2 and 4. By ranking of mean values using LSD test, similarities were noticed, which indicate that the water status of seed has a regulatory role in seed development and germination *(Egli et al, 1997)*. The variation of the traits was very small and did not exceed 3 %.

Table 2. Means and seed trait variability of seeds of the hybrid ZPSC 666

ZPSC 666	MOISTURE							
	M<25 %(1)		25 %<M <30 % (2)		30 %<M <35 % (3)		M>35 % (4)	
	SF		SF		SF		SF	
	e	g	e	g	e	g	e	g
$\overline{X}$	95.8ab	97.4ab	94.0b	95.2b	97.4a	98.4a	96.6a	98.0a
SD	1.79	1.82	3.08	2.86	1.34	1.34	1.28	0.80
CV	1.44	1.52	2.40	2.24	1.12	1.12	1.52	1.22
	LF		LF		LF		LF	
	e	g	e	g	e	g	e	g
$\overline{X}$	95.6ab	97.0a	93.2bc	94.4b	96.0a	98.4a	92.0c	93.6b
SD	1.14	1.22	1.30	1.14	0.71	0.89	1.58	1.82
CV	0.88	0.80	1.04	0.88	0.40	0.72	1.20	1.52

LSD 0.01 = 2.587

SF - small seed fraction; KF - large seed fraction; M – moisture; e – seed energy; g- germination

Table 3. Three-factorial analysis of variance for total germination

K value	*Source of variation*	*F calculated for seed vigour*	*F calculated for total seed germination*
1	Replication	9.148	11.866
2	Factor A	30.191**	19.997**
4	Factor B	18.133**	34.048**
6	AB	6.091*	8.380**
8	Factor C	18.133**	34.048**
0	AC	0.437**	0.535**
12	BC	6.091**	8.380**
14	ABC	0.341**	0.165**
	CV	1.53	1.43

A – hybrid; B – fraction; C – moisture content

Beside the seed moisture content, as an essential factor, a hybrid and a fraction were included into the analysis of variance to analyse their effects on expression of seed vigour and total germination. Obtained data are presented in Table 3. The level of significance is high for all three stated factors. Furthermore, their mutual interactions show also a high level of significance.

CONCLUSION

Gained results indicate that obtained values of seed traits statistically significantly differed as a result of effects of observed factors (hybrid, seed fraction and moisture). These three factors significantly affected observed traits. Differences occurred within four variants of seed moisture are a result of various physiological seed maturity and differences occurring as a result of manipulations during harvest, transport and processing of seeds. The highest means of seed energy and germination in both fractions of both observed hybrids were recorded with the seed moisture content ranging from 30 to 35%. The determination of the optimum harvest moment affects, to a great extent, quality of a produced seed material.

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