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EFFECT OF STORAGE LONGEVITY UNDER DIFFERENT STORAGE CONDITIONS ON SEED VIGOR AND OIL CONTENT IN MAIZE, SOYBEAN AND SUNFLOWER

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SUMMARY

The study aimed to examine the changes in seed vigor and oil content in different genotypes of maize, soybean and sunflower over three years (2002-2005) in two type storage conditions differed in terms of air temperature and humidity: 25°C/75% and 12°C/60%, respectively. Affected by storage longevity, on an average, seed vigor decreased by 13.5% in maize and by 26.5% in both soybean and sunflower, respectively. Seed oil content decreased by 0.58% in maize, 1.68% in soybean and 8.04% in sunflower. Differences in seed vigor and oil content affected by storage longevity were significant among tested crops and genotypes into crop. Storage longevity was negatively associated with seed vigor and oil content. At storage conditions by 12°C/60%, decline of seed vigor was less by 7% (maize), by 11% (sunflower, soybean) and decreasing of seed oil content was less for 0.25% (maize), 0.53% (soybean) and 1.75% (sunflower) than in storage conditions by 25°C/75%. In summary, the lowest seed quality losses were in maize, followed by soybean and the highest ones in sunflower. Decreasing seed quality losses is possible with providing suitable storage conditions, particularly for soybean and sunflower.

Key-words: maize, soybean, sunflower, seed vigor, seed oil content, storage longevity, storage conditions

INTRODUCTION

Seed quality is a multiple criterion that encompasses several important seed attributes: genetic and chemical composition, physical condition, physiological germination and vigor, size, appearance and presence of seedborne pathogens, crop and varietals purity, weed and crop contaminants and moisture content. During storage, seed quality can remain at the initial level or decline to a level that may make the seed unacceptable for planting purpose what is related to many determinants: enivronments conditions during seed production, pests, diseases, seed oil content, seed moisture content, mechanical damages of seed in proccessing, storage longevity, package, pesticides, air temperature and relative air humidity in storage, biochemical injury of seed tissue and similary (TeKrony et al., 1987, 1993; Reuzeau and Cavalie, 1995; Anfinrud, 1997; Al-Yahya, 2001; Šimić et al., 2004; Guberac et al., 2003; Heatherly and Elmore, 2004). Storage longevity may vary from six months (usually for maize, soybean and sunflower), up to 20 months or longer if the seeds are to be carried over. Longevity of seed in storage is influenced by the stored seed quality as well as storage conditions. Irrespective of initial seed quality, unfavourable storage conditions, particularly air temperautre and air relative humidity, contribute to accelerating seed deterioration in storage. Hence, it's difficult to assess the effective storage period because the storability of the seed is a function of initial seed quality and the storage conditions (Wych, 1988; Anfinrud, 1997; Fabrizius et al., 1999; Heatherly and Elmore, 2004). Intensity of quality decreasing of stored seed is different among plant species and within plant species (genotypic variability), implying considerable influence of genetic (heritable) component on phenothypic expression of traits which determine seed quality (Zanakis et al.,1993; Morenomartinez et al., 1994; Al-Yahya, 1995, 2001; Guberac et al., 2003; Vieira et al., 2001). The objective of this

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study was to examine the changes in two seed quality attributes: seed vigor and oil content in maize, soybean, and sunflower affected by storage longevity under two levels of storage conditions differed in terms of air temperature and relative humidity.

MATERIAL AND METHODS

This study was carried out during three years (2002-2005) at the Agricultural Institute Osijek (Croatia) using basic seed of three agronomic crops: maize, soybean and sunflower. Selected maize hybrids ('OSSK 596', 'OSSK 602'-FAO group 600), sunflower hybrids ('Fakir', 'Apolon'-middle-early) and soybean cultivars ('Tisa'-maturity group (MG) I; 'Kaja'-MG 0) are designed by the Institute. The testing began after harvest of sunflower, maize and soybean in 2002 year. Samples of dried, cleaned and processed seeds for each of tested crops were taken as follows: 2x500 kg for maize and soybean, and 2x200 kg for sunflower. The seed moisture content, seed vigor and seed oil content of all tested genotypes were determined before storage. Seed samples were packed in bags and stored separately in two small storages with controlled conditions: Storage 1– 75% air relative humidity; 25^{o}C air temperature and Storage 2 – 60% air relative humidity 60%; 12^{o}C air temperature. After three years of storage, average seed samples of each genotype were taken from both storages for laboratory analysis. Seed vigor (%) was determined by the cold test (AOSA, 1983) and seed oil content (% in absolutely dry matter-ADM) by Nuclear Magnetic Resonance (NMR) analyzator. The obtained experimental data were statistical processed (ANOVA, LSD test, coefficient of variation, particular correlation coefficient, t-test) using computer program Statistical Analysis System Version 8.2 (SAS Institute, 1989).

RESULTS AND DISCUSSION

The means of seed vigor and oil content for tested genotypes of maize, soybean and sunflower before and after storage in both type of storages with results of statistical analysis are presented in Table 1. From the analysis of presented data it is obvious that analyzed seed quality traits varied amongst tested agronomic crops as well as within crops (genotypic variation), with statistically highly significant differences ($P \leq 0.01$). Prior to storage, the seed vigor means were 91% in maize, 88.5% in soybean and 89% in sunflower. After three years of storage, on an average for both type of storage, seed vigor values were in maize 77.5%, in soybean 62% and in sunflower 62.5%.
These observation suggested that greater decline of seed vigor was in soybean and sunflower (decreasing 26.5%) than in maize (decreasing 13.5%) in response to effect of storage longevity. Differences in level of seed vigor between years of storage (storage longevity) were statistically justifiable on level $P \leq 0.01$. As regards seed oil content, before storage, mean values of this trait were 4.45% in maize. After three years, on an average for both storages, seed oil content was 3.87% in maize, 21.61% in soybean and 42.51% in sunflower. By comparison the means of this trait before and after storage, greater decline of oil content was in sunflower (decreasing for 8.04%), than in soybean (for 1.68%) and maize (for 0.58%). Differences in seed oil content affected by storage longevity (between storage years) were statistically highly significant ($P \leq 0.01$) consistent across tested crops. The effect of storage longevity on level of seed vigor and oil content varied between storages. After three years of storage, in the Storage 1 (25°C/75%), the average decline of seed vigor was 17% in maize, 32.5% in soybean and 32% in sunflower. Over the same stored period, in the Storage 2 (12°C/60%), the average decreasing of seed vigor was by 10% in maize, by 21.5% in soybean and by 21% in sunflower. Comparing the changes in level of seed vigor between two examined storages affected by storage longevity, the changes were less in the Storage 2 by 12°C/ 60% by 7% in maize and by 11% in soybean and sunflower in relation to the Storage 1 by 25°C/75%. As regards seed oil content, in the Storage 1, the average decreasing of oil was by 0.70% in maize, by 1.94% in soybean and by 8.91% in sunflower. In the Storage 2, the average decreasing of oil was by 0.45% in maize, by 1.41% in soybean and by 7.16% in sunflower. It is obvious that changes in oil content were less in the Storage 2 by 0.25% in maize, by 0.53% in soybean and by 1.75% in sunflower than in the Storage 1. Differences in intensity of decreasing seed vigor as well as oil content affected by different storage conditions were highly significant at level of $P \leq 0.01$ during the same period of storage consistent across tested crops. Analysis of variance showed that interaction between tested crops and examined

storage longevity, between storage longevity and storage type were highly significant (P≤0.01) for both traits, while interaction between crops and storage type was significant at the level of P≤0.01 for seed vigor and at the level of P≤0.05 for seed oil content, respectively.

Table 1. Means of seed vigor (%) and oil content (% in ADM) of tested genotypes of maize, soybean and sunflower regarding storage longevity (2002-2005) and storage conditions: S1 (25°C/75%); S2 (12°C/60%)

Tablica 1. Srednje vrijednosti vigora (%) i sadržaja ulja (% AST) ispitivanih genotipova kukuruza, soje i suncokreta nakon skladištenja (2002-2005) u različiti uvjetima skladištenja: S1 (25°C/75%); S2 (12°C/60%)

Crops *(vrsta bilja)*	Genotype *(genotip)*	Seed Vigor (%) *(vigor sjemena)*		Oil content in seed (% in ADM) *(Sadržaj ulja %/AST)*	
		Storage 1 *(Skladište1)*	Storage 2 *(Skladište1)*	Storage 1 *(Skladište1)*	Storage 2 *(Skladište1)*
Before storage (2002) - *Prije skladištenja 2002.*					
Maize *(Kukuruz)*	OSSK 596	91	91	4.70	4.70
	OSSK 602	91	91	4.20	4.20
Soybean *(Soja)*	Tisa	89	89	23.18	23.18
	Kaja	88	88	23.40	23.40
Sunflower *(Suncokret)*	Fakir	90	90	47.76	47.76
	Apolon	88	88	53.35	53.35
After storage (2003) - *Prije skladištenja 2003.*					
Maize *(Kukuruz)*	OSSK 596	90	91	4,60	4,65
	OSSK 602	90	90	4,15	4,20
Soybean *(Soja)*	Tisa	85	87	22,98	23,07
	Kaja	84	85	22,87	23,04
Sunflower *(Suncokret)*	Fakir	87	89	46,07	41,15
	Apolon	82	85	47,16	48,76
After storage (2004) - *Prije skladištenja 2004.*					
Maize *(Kukuruz)*	OSSK 596	82	85	4,37	4,42
	OSSK 602	80	83	3,87	4,05
Soybean *(Soja)*	Tisa	67	77	22,17	22,35
	Kaja	62	71	21,15	22.03
Sunflower *(Suncokret)*	Fakir	73	79	43,18	43,31
	Apolon	58	73	42,36	43,39
After storage (2005) - *Prije skladištenja 2005.*					
Maize *(Kukuruz)*	OSSK 596	76	82	3.80	4.10
	OSSK602	72	80	3.70	3.90
Soybean *(Soja)*	Tisa	60	72	21.80	22.07
	Kaja	52	64	20.90	21.70
Sunflower *(Suncokret)*	Fakir	68	74	42.97	43.47
	Apolon	46	62	40.32	43.21

Sources of variation *Izvori varijacije*	*F* test	LSD test		*F* test	LSD test	
		0.05	0.01		0.05	0.01
Crops(A)	5675.333**	1.001	1.387	59537.441**	0.238	0.328
Storage longevity (B)	4422.239**	0.699	0.920	7128.33**	0.071	0.093
Storage type (C)	22.358**	0.786	1.034	35.020**	0.058	0.077
Interaction AxB	364.333**	2.012	2.930	1601.833**	0.204	0.297
Interaction AxC	1.533**	2.265	3.300	3.355*	0.168	0.244
Interaction BxC	12.739**	1.040	1.410	14.667**	0.105	0.147
Interaction AxBxC	1.479	3.43	5.681	2.467	n.s.	n.s.

*, **, n.s. - significant at level P≤0.05, P≤0.01, not significant, respectively

Table 2. Coefficient of variation (CV-%) for seed vigor and seed oil content of analyzed agronomic crops affected by storage longevity (2002-2005) in two storage conditions: Storage 1 (25°C/75%); Storage 2 (12°C/60%)
Tablica 2. Koeficijent variranja (CV-%) vigora i sadržaja ulja kultivara nakon skladištenja (2002-2005) u dva tipa skladištas: S1 (25°C/75%); S2 (12°C/60%)

Crops *(Vrsta bilja)*	CV for seed vigor (%) *(CV vigora sjemena-%)*		CV for seed oil content (%) *(CV sadržaja ulja-%)*	
	Storage 1 *(Skladište1)*	Storage 2 *(Skladište2)*	Storage 1 *(Skladište1)*	Storage 2 *(Skladište2)*
Maize *(Kukuruz)*	11.3	4.8	8.0	4.2
Soybean *(Soja)*	25.2	22.7	8.3	5.1
Sunflower *(Suncokret)*	27.8	23.3	11.5	6.9

Coefficients of variation for seed vigor and oil content of tested crops (Table 2) were higher in the storage by 25°C/75% than in the storage by 12°C/60%, consistently at all tested crops. Among tested crops, the lowest variability in both traits had maize, followed by soybean and the highest variability of both traits had sunflower.

Table 3. Correlation coefficients (r) between analyzed seed quality traits and treatments: storage longevity (2002-2005), storage conditions - S1 (25°C/75%); S2 (12°C/60%)
Tablica 3. Koeficient korelacije (r) između kakvoće sjemena, duljine uskladištenj(2002-2005) i uvjeta skladištenja S1 (25°C/75%); S 2 (12°C/60%)

Crops *(Vrsta)*	Traits *(Svojstva)*	Oil Content *(Sadržaj ulja)*	Storage longevity *(Dužina skladištenja)*	Storage 1 *(Skladište 1)*	Storage 2 *(Skladište 2)*
Maize *(Kukuruz)*	Seed Vigor (*vigor sjemena)*	0.784**	-0.653*	- 0.912**	-0.358*
	Oil Content *(Sadržaj ulja)*	-	-0.704**	-0.850**	-0.417*
Soybean *(Soja)*	Seed Vigor (*vigor sjemena)*	0.833**	-0.858**	-0.763**	-0.522*
	Oil Content *(Sadržaj ulja)*	-	-0.896**	-0.715**	-0.560*
Sunflower *(Suncokret)*	Seed Vigor (*vigor sjemena)*	0.980**	-0.905**	-0.810**	-0.435*
	Oil Content *(Sadržaj ulja)*	-	-0.870**	-0.826**	-0.382*

Interrelationships between analyzed seed quality traits, storage longevity and storage types were presented by coefficient of correlation (r) in Table 3. Seed vigor was highly negatively correlated with storage longevity at level $P \leq 0.05$ in maize (r=-0.653*) and level $P \leq 0.01$ in soybean (r=-0.858**) and sunflower (r=-0.905**). The correlation of seed vigor with storage conditions resulted in the seed vigor having a highly negative coefficient correlation with conditions in the Storage 1, which was consistent across species. Although significant ($P \leq 0.05$) negative correlation was existed between seed vigor and conditions in the Storage 2, correlation coefficients were much lower. Furthermore, at all tested crops seed oil content was highly ($P \leq 0.01$) negatively correlated with storage longevity as well as conditions by 25°C/75%, while correlations with conditions by 12°C/60% were also negative, but on a lower degree and significance at level $P \leq 0.05$. Significant ($P \leq 0.01$) positive correlations existed between seed vigor and oil content, consistently across tested crops.
Summarizing the obtained results of this study, it is obvious that the effect of storage longevity is negative at the level of seed vigor and oil content in maize, soybean and sunflower, with significant differences amongst these crops in intensity of decreasing quality stored seed. Thus, on an average for both storages, decreasing of seed vigor and oil content was less in maize in relation with soybean and

sunflower, suggesting higher stability of analyzed quality seed attributes during storage in maize than in both soybean and sunflower, respectively. In the same time, differences in seed deterioration between soybean and sunflower were also existed, particularly in oil content. It could be connected with differences amongst crops in expression of protective system of enzymatic and non-enzymatic processes which influence intensity of seed deterioration. Thus, in oil crops, such as soybean and sunflower, autooxidation of lipids and increasing the content of free fatty acids during storage period are the main reasons for rapid deterioration of seed of oil plants as announced by Reuzeau and Cavalie, 1995; Trawatha et al., 1995; Balašević-Tubić et al., 2005). Longevity of stored seed of any crops considerably depends of the stored conditions, primarily in terms of air temperature and relative air humidity in storage. Results of our study showed that in the worst storage conditions (25°C/75%) were higher seed quality losses than in the storage with lower temperature and lower relative humidity (12°C/60%). These findings corresponded well with those reported that unfavorable storage conditions (high air temperature and high humidity of air) accelerate seed deterioration, causing seed quality losses and therein lower germinability percentage of stored seed (Burris, 1980; Tewari and Gupta, 1981; Al-Yahya, 1995; Depaula et al., 1996; Beratlief and Iliescu, 1997).

CONCLUSION

In summary, data obtained in this study indicate that effect of storage longevity on seed vigor and oil content is more or less negative and considerably affected by storage conditions. If suitable storage conditions aren't supplied, quality and quantity losses increase. Decreasing these losses is possible providing suitable storage conditions and storage management, what enables the preserving seed quality attributes, such as seed vigor and oil content, on the satisfactory level acceptable for production purposes. Furthermore, over the same storage period and under same storage conditions, the intensity of seed quality decline is different among plant species due to genetic diversity, affecting importance of creating suitable storage conditions according to crop that will be stored.

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UTJECAJ SKLADIŠTENJA NA VIGOR I SADRŽAJ ULJA U SJEMENU KUKURUZA, SOJE I SUNCOKRETA

SAŽETAK

Istraživanjem je utvrđen utjecaj uvjeta skladištenja dorađenog nezaprašenog sjemena hibrida kukuruza i suncokreta te sorata soje na vigor i sadržaj ulja nakon skladištenja od 36 mjeseci (2002.-2005.) u dva tipa skladišta različite temperature i vlage zraka (S1: 25°C/75% i S2 12°C/60%). Nakon skaldištenja, vigor sjemena je umanjen za 13,5% kod kukuruza, 26,5% kod soje i 27,1% kod suncokreta. Sadržaj ulja u zrnu je umanjen za 0,58% kod kukuruza, 1,68% kod soje i za 8,04% kod suncokreta. Duljinom skladištenja umanjen je vigor i sadržaj ulja. U uvjetima skladišta S1 je manje umanjenje vigora za 7% (kukuruz), 11% (suncokret, soja), kao i manje umanjenje sadržaja ulja za 0,25% (kukuruz), 0,53% (soja) i 1.75% (suncokret) u odnosu na uvjete skladištenja u skladištu S2. Kakvoća sjemena je tijekom skladištenja ovisna o vrsti kultivara, genotipu i uvjetima skladištenja.

Ključne riječi: kukuruz, soja, suncokret, skladištenje, vigor sjemena, dužina uskladištenja, uvjeti uskladištenja

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