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EFFECT OF STORAGE TIME AND TYPE OF PACKAGING ON SEED QUALITY OF TALL FESCUE
UTICAJ VREMENA SKLADIŠTENJA I VRSTE AMBALAŽE NA KVALITET SEMENA VISOKOG VIJUKA

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ABSTRACT

After harvesting, the seed dormancy of grasses occurs. During the maturing period, seed dormancy is slowly reduced, and seed germination reaches the maximum values of use. Germination decreases during longer storage. The levels of seed dormancy and germination prevention determine the complex of physiological and biochemical processes in the seeds, which vary depending on genetic background, environment during maturation, and even the position of seeds on the plant. The goal is to maintain, as long as possible, the maximum germination after seed ripening. However, aging and germination reduction are processes which largely depend of storage conditions and seed packaging. The three tested seed lots of tall fescue were kept in paper, textile and polyethylene (PVC) containers during 10, 16, 24, 28, 34 and 40 months. The dormancy, germination energy, and total germination were examined. The seeds stored in PVC containers required a shorter period of time in order to release from dormancy and achieve maximum germination (16 months, 43% germination). After 40 months, there was a significant decrease in germination (80%). In some seed lots, the germination dropped to 77%, which is the required minimum for marketing authorization (The Official Gazette of the Republic of Serbia, No. 47/48). In the case of the seeds kept in paper containers, the maximum germination (89% and 90%) was obtained after 22 months. The same seed germination was obtained after 40 months of storage.

Key words: *Tall fescue, seed germination, packaging.*

REZIME

Visoki vijuk je u svetu izučavan kao krmna vrsta ili vrsta za specijalne namene (sportski tereni, parkovi, okućnice, sprečavanje erozija na nasipima). Za svaku od ovih namena je neophodna što veća klijavost semena pri setvi. Međutim, višegodišnje krmne trave se manje ili više odlikuju prisustvom dormantnog semena, koje ne klija, iako postoje povoljni uslovi. Nivo dormantnosti i onemogućavanje klijanja određuju složeni fiziološko-biohemijski procesi u semenu koji se razlikuje zavisno od genetskog porekla, životne sredine u toku sazrevanja, uslova za čuvanje semena, ambalaže u kojoj je seme pakovano itd. Nakon naknadnog dozrevanja i oslobađanja semena od dormantnosti nastupa period maksimalne klijavosti i najveće upotrebne vrednosti semena. U ovom radu je na tri partije ispitivan uticaj ambalaže za pakovanje (PVC, papirna i tekstilna) na klijavost semena visokog vijuka u periodu od tri meseca do 40 meseci posle žetve. Rezultati ispitivanja su pokazali da se nakon 9 meseci seme oslobodilo od dormantnosti i imalo maksimalnu klijavost. Ambalaža u kojoj je seme pakovano je pokazala značajan uticaj ($p \leq 0,05$) na klijavost. Nakon smanjenja klijavosti usled starenja semena uticaj ambalaže je takođe bio značajan.

Ključne reči: *Visoki vijuk, seme, klijavost, ambalaža.*

INTRODUCTION

Tall fescue is used as a forage crop or for special purposes (sports fields, parks, yards, embankment erosion prevention, etc.). Great seed germination is essential for sowing and all these purposes. However, perennial forage grasses are more or less characterized by the presence of dormant seed. The levels of seed dormancy and germination prevention determine the complex physiological and biochemical processes in the seeds. The period of maximum germination and highest seed value is after ripening and the release of seed dormancy. Then follows a period of aging, which causes reduced seed germination. In this period of seed storage, conditions are important factors in maintaining germination. Low temperatures and low relative humidity during storage positively affects seed germination after the prolonged storage period (*Justice and Bass, 1978*). The aim of this study was to examine the changes in seed quality during 10 to 40 months of storage, and to determine the maximum of germination, or what is the most suitable period for sowing.

MATERIAL AND METHOD

The tall fescue seeds (Krusevacka-20) for commercial production were taken from three locations (Zaječar: 139 m asl, 43° 51 'N, 22° 22' E, Nis: 206 m asl, 43o19 'N, 21o51' E, and Krusevac: 145 m asl, 44° 39 'N, 17° 13 'E). After the storage of seeds from 10 to 40 months, the following features were examined (every 6 months): seed dormancy (%), germination energy (%) and total germination (%). The seeds were kept during the whole period in the paper, textile, and polyethylene (PVC) packaging. During the testing of seeds in stock, the maximum temperature and maximum relative humidity, minimum temperature and minimum relative humidity, mean daily temperature (ºC) and average daily relative humidity (%) were determined daily. Consequently, the average values for each month were calculated (Table 1). Since the seeds were kept under conventional warehouse conditions (Table 1), the humidity was lower than 12%. In the case of germination, 4x100 seeds from each replicate were tested on filter paper (TP). After a pre-chill treatment at 5°C for 5 days, seeds germinated at alternating temperatures of 30/20 °C (30°C for 8 hours of light and 20°C for 16 hours of dark). The energy of germination was determined on the 7th day, and germination on the 14th day. The tetrazolium test was performed in order to identify dormant and dead seeds (ISTA, 2010). The data were analyzed by ANOVA and the differences between the means were compared by the least significant difference (LSD) test at the $P<0.05$ level. In order to correct for the non-normality of the germination percentage values, the statisti-

cal analyses were realized on arcsine transformed values. These analysis procedures were performed by using the STATISTICA for windows software (Stat Soft 8.0).

RESULTS AND DISCUSSION

The seed tests of grains and vegetables have shown a significant impact of storage on seed germination (*Harrington, 1963, Bass, 1980; Kopeland and McDonald, 1995*). Also, the influence of moisture and temperature on germination has been established as an important factor for preserving the germination of grass seed (*Marshall and Lewis, 2004*). Forage grass type has a significant impact on the changes of seed germination during storage (*Stanisavljević et al., 2011*).

Table 1. Maximum and minimum temperature and relative air humidity values in seed storage rooms

Month	Temperature (ºC)			Relative air humidity (%)		
	Aver.	Min.	Max.	Aver.	Min.	Max.
January	2	1	3	81	75	86
February	6	3	9	79	70	87
Marsh	9	4	13	78	68	87
April	11	6	15	66	49	83
May	13	7	18	65	47	82
June	20	15	24	63	45	80
July	23	16	30	64	48	80
August	24	17	31	68	52	84
September	12	9	23	74	65	82
October	11	5	17	76	68	84
November	6	2	10	77	70	83
December	3	-1	5	79	72	85

The highest external air temperature in Serbia is during July and August, which causes the highest storage temperatures and the lowest relative humidity. In December and January, the lowest temperature and high relative humidity in the stocks were recorded (Table 1). So, environmental conditions of the seed storage were strongly influenced by climatic conditions. Packaging materials used for storing seeds also contribute to the maintenance of seed germination (*Dias et al., 2009, 2010*). If relative humidity is low in seed stock and the seed is in the porous packaging, it can reduce seed germination. But, seed will keep the good germination if dry seed are stored in containers resistant to moisture (*Desay et al., 1997*). After the seed harvest in June, 59-61% germination was achieved. During autumn sowing period (August September), seed germination increased to 72-75% (*Stanisavljević 2011b*). This germination was on the marketing marketing (*The Official Gazette, No. 47/87*). After this period, the seed was storage in common storage conditions (Table 1).

Table 2. Significance according to F test for dormant seed, germination energy and total germination during storage period

Source	df	Dormant seed (%)	Energy of germination (%)	Total germination (%)
Period	5	**	**	**
Packaging	2	**	**	**
Seed lot	2	NS	NS	NS

*Significant at the 0.05 probability level. **Significant at the 0.01 probability level. †NS, not significant

Under these storage conditions (Table 1), the storage period and packaging had a significant impact (P≤0.01) on the release from seed dormancy, as well as the changes in the germination energy and total germination of seeds. The influence of the seed lot had no significant effect on traits (Table 2). This was expected because the same technology was implemented under similar environmental conditions on all locations.

Table 3. Influence of packaging on seed dormancy changes of tall festuca in diferent periods of storage (10-40 months)

Months of storage	Packaging	Dormant seed (%)			
		P1	P2	P3	Mean
10	Paper bags	12	14	10	12
	Textile bags	10	13	14	12
	PVC	6	7	6	6
Mean		9	11	10	10
16	Paper bags	3	2	4	3
	Textile bags	4	3	4	4
	PVC	0	2	1	1
Mean		2	2	3	2
22	Paper bags	2	0	0	1
	Textile bags	0	1	0	0
	PVC	0	0	0	0
Mean		1	0	0	0
28	Paper bags	0	0	0	0
	Textile bags	0	0	0	0
	PVC	0	0	0	0
Mean		0	0	0	0
34	Paper bags	0	0	0	0
	Textile bags	0	0	0	0
	PVC	0	0	0	0
Mean		0	0	0	0
40	Paper bags	0	0	0	0
	Textile bags	0	0	0	0
	PVC	0	0	0	0
Mean		0	0	0	0

Table 4. Effect of packaging on changes in energy of germination Tall festuca seeds

Months of storage	Packaging	Energy of germination (%)			
		P1	P2	P3	Meaan
10	Paper bags	59	63	61	61
	Textile bags	65	61	63	63
	PVC	88	86	85	86
Mean		71	70	70	70
16	Paper bags	81	80	80	80
	Textile bags	83	80	81	81
	PVC	89	90	90	90
Mean		84	83	84	84
22	Paper bags	84	87	85	85
	Textile bags	84	82	83	83
	PVC	88	86	88	87
Mean		85	85	85	85
28	Paper bags	85	84	86	85
	Textile bags	85	88	86	86
	PVC	86	83	83	84
Mean		85	85	85	85
34	Paper bags	88	86	88	87
	Textile bags	87	86	85	86
	PVC	83	82	82	82
Mean		86	85	85	85
40	Paper bags	88	87	90	88
	Textile bags	85	84	88	86
	PVC	79	77	80	79
Mean		84	83	86	84

In terms of agro-ecological conditions in Serbia, the harvesting of forage grass seed is usually in June, three months before the autumn sowing period. In that period, the germination of

seeds kept under conventional storage conditions was reduced (*Stanisavljević at al., 2010a, 2010b, 2011)*. Such seed germination is often on the limit of marketing authorization (*The Official Gazette, No. 47, 1987*). After a period of 10 months of storage in paper and textile packaging, the seed dormancy is reduced to 12%. In the case of seeds stored in PVC containers, the dormant seed percentage was 6% (average for all parties). This has affected the germination energy of 61% and 63% of the seeds in paper and textile containers and 86% of the seeds in plastic containers (Table 4). The germination was 81% in paper, 82% in textile packaging, and 91% in PVC containers (Table 5).

Table 5. The influence of packaging on the total germination change of tall fescue seed during storage from 10 to 40 months

Months of storage	Packaging	Total germination (%)			
		P1	P2	P3	Mean
10	Paper bags	80	83	79	81
	Textile bags	81	84	80	82
	PVC	90	92	90	91
Mean		84	86	83	84
16	Paper bags	87	86	89	87
	Textile bags	88	85	88	87
	PVC	92	93	94	93
Mean		89	88	90	89
22	Paper bags	89	91	89	90
	Textile bags	88	87	90	88
	PVC	90	89	91	90
Mean		89	89	90	89
28	Paper bags	89	88	90	89
	Textile bags	90	91	91	91
	PVC	88	86	85	86
Mean		89	88	89	89
34	Paper bags	90	89	88	89
	Textile bags	89	90	90	90
	PVC	85	84	83	84
Mean		88	88	87	88
40	Paper bags	90	88	91	90
	Textile bags	88	89	90	89
	PVC	80	77	82	80
Mean		86	85	88	86

After 16 months, the percentage of dormant seeds was reduced to 3% and 4% in paper and textile packaging, and to 1% in PVC containers. Dormant seed was not recorded in one lot. At the time of packaging in PVC, the maximum germination of seeds was over 93%. In the following period of seed storage (22-40 months), dormant seed was found too (Table 3). The difference between energy of germination and total germination reduced (Table 4 and 5). In the case of seeds stored in paper and textile packaging, the maximum germination was achieved after 22 months and there was a decline of germination up to 40 months. While after 40 months, the germination of the seeds preserved in PVC packaging was reduced by 13% (average of all parties). In one seed lot (P2), germination dropped to 77%, which is the minimum of germination allowed for seed marketing (*The Official Gazette, No. 47, 1987*).

CONCLUSION

In the case of seeds stored in paper and textile packaging, the maximum germination was achieved after 22 months and there was a decline of germination up to 40 months. While, after 40 months, the germination of the seeds preserved in PVC packaging was reduced by 13% (average of all parties). In one seed lot (P2), the germination dropped to 77%, which is the required minimum for marketing authorization. In the case of the tall fescue seed stored in paper and textile packaging, the seeds slowly release from dormancy. In a period of 22 months after harvesting, seed germination achieved satisfactory results.

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