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Influence of relative humidity and temperature on changes in grain moisture in stored wheat and sunflower

M. Volenik,V. Rozman, I. Kalinovic, A. Liska, B. Šimic

Abstract

These investigations aimed to determine influence of changes in relative humidity and temperature in storage facilities to the moisture in the grain of stored wheat and sunflower. Wheat ("Zitarka" variety) and sunflower ("Orion" hybrid) were stored during 34 days at the temperature of 0 °C and 20 °C, and relative humidity of 55 %, 73 %, 80 % and 98 %. At the temperature of 0 °C and relative humidity of 55 % and 73 %, moisture in wheat grain decreased, as following, 0.8 % and 0.2 %, while at the relative humidity of 80 % and 98% it increased 0.5 % and 0.7 % after 34 days storage. At the temperature of 20 °C and relative humidity of 55 %, moisture in wheat grain decreased 1.6 %, while at the relative humidity of 73 %, 80 % and 98 % it increased, as following 0.7 %, 1.1 % and 2.6 %. During 34 days storage at 0 °C and relative humidity of 55 % and 73 %, moisture in sunflower grain decreased 0,8 % and 0.2 %, while at the relative humidity of 80 % and 98 % it increased, as following, 0.5 % and 0.7 %. At the temperature of 20 °C and relative humidity of 55 % and 73 % moisture in sunflower grain decreased 1.6 % and 0.1 %, and increased at the relative humidity of 80 % and 98 %, as following, 0.4 % and 0.1 %. There were no significant differences of the temperature to the changes in grain moisture in both treatments, with wheat, as well as with sunflower. Such investigations enable additional insights into the rate of changes in grain, and the influence to grain viability in changed storage conditions.

Key words: wheat, sunflower, grain moisture, temperature, relative humidity, viability.

Introduction

Seed moisture content (m.c.) is one of the most important factors which influence on germination length and on viability duration as well as on total health condition of the seed.

Though, grain as a hygroscopic material establishes moisture content equilibrium with ambient in which it is stored. High m.c. during storage is unacceptable because abilities of grain viability preserving are reduced. Toward to enhanced breathing enables the activity of stored fungi, bacteria and also occurring favourable medium (increasing temperature, moisture and heat releasing) for stored pests such as insects and acarine. Equilibrium between seed m.c. and relative humidity (r.h.) is critical for grain storage.

In different literatures about grain storage and

[1] Institute of Agriculture Osijek, Juzno predgrađe 17, 31000 Osijek, CROATIA

[2] Faculty of Agriculture in Osijek, Trg Sv. Trojstva 3, 31000 Osijek, CROATIA

* Corresponding author: E-mail address: *vrozman@.pfos.hr* (Vlatka Rozman); Fax: ++385 31 207 017

grain drying technology, in huge number of researches there has been an attempt of quantitative identification of link between stored factors and grain viability loss. One of the first trials for defining quantitative relation took Groves (1917). The author has studied viability of wheat on temperatures ranging from 50-100 ºC. Period relation of viability and temperature he described with equation:

$$T = a - b \log Z$$

Where is: T= temperature (ºC), Z= time required for destroying of 75 % seeds, a and b= constants. This equation, like others which accompanied, didn't consider grain moisture influence, so according to that, they were, without changing constant values, correct only for some individual m.c.. Later, through many other investigations developed equation which considered also influence of the seed moisture and temperature. By the results utilization investigated on wheat and grain cereals which had been stored on the range temperatures of 15 -25 °C and with the grain moisture content of 11 - 23 %, The following equation was suggested (Roberts, 1960). which specifies interrelation between temperature, grain m.c. and grain viability:

$$\log p50 = Kv - C1m - C2t$$

Where p 50 = time required for 50 % of the seed loose viability, m= moisture content, t = temperature (°C), Kv, C1 and C2 = constants.

Harington (1963) has also applied this equation in his investigations and came up with two conclusions which implements until now in order to increase moisture and temperature influence on seed senescence. The first rule reads that for each decreased percent of grain moisture, life of the stored grain gets double. The second rule reads that for each decreased 5 °C of the grain temperature, life of the stored grain gets doubled. The first rule applies if the m.c. is in the range from 14 to 5 %. At higher than 14 % of moisture, development of microorganisms could quickly destroy a grain germination ability, while at lower then 5 % occur reaction which accelerate the destroying speed of grain quality. Besides that conditions, grain germination will depend also on species, cultivar and even on grain categories. It is known that temperature and r.h. in the storage, as the most important factors which are variable, influence on grain stage changes that lead to changes of its quality. Though, less is known how that parameter values, which we could say determine a storage climate, influence on grain of each particular plant species, and sometimes of cultivar. Especially it is less spoken and difficult found results relevant for speed changes in grain when a storage conditions are changing. Knowledge about that is especially relevant for determination of grain storing regime and work in store houses.

Therefore this kind of investigation on species and cultivars, which are the most representative in our region, will give facts about speed changes, and sure help in propagate cognition to those who daily take decisions about parameter changes of the environment in which grain is stored.

Materials and methods

For the bioassay two plant species were used: wheat (cultivar •itarka) and sunflower (cultivar Orion). From each species 8 kg of grain were taken and divided into 32 bags, by four samples for relative air moisture and temperature measurement. Grain samples, prior analysing, were cleaned from mechanical and organic foreign matters and its moisture and temperature were measured. Each sample from 250 g was sealed into linen bag. Four samples from each cultivar were placed into plastic hermetical sealed container. Containers were maintained on four regimes of relative humidity (55 %, 73 %, 80 % and 98 %) and on two regimes of temperature (0 ºC and 20 ºC). So, each bioassay variant included two cultures in four repetitions. Desired r.h. is given with saturated solution of NaCl (73 %) and urea (80 %), and also with desaturated solution of NaCl (98 %) and silica gel (55 %). According to article "Saturated solutions for the control of humidity in biological research" (Winston and Bates, 1960.), saturated solution of urea keeps

under its surface r.h. of 80 % by the temperature of 0 °C and 20 °C, what it was proved as correct. Saturated solution of NaCl by the temperature of 0 °C and 20 °C should keep under its surface r.h. from 75 % to 76 %, but in this case it seamed to be different, that solution keeps r.h. of 73 %. Desaturated solution of NaCl keeps under its surface r.h. of 98 %, and silica gel 55 %. Bioassay was conducted in the Department for grain production and nurseries, during time period from 26. December 2005 to 29 January 2006. During that period, every seven days water absorption and release changes were monitored by the hygrometer Dickey John GAC2100. Results are conducted by analysis of variance and LSD test.

Results

Wheat

Results of grain moisture in wheat under stored temperature at 0 ºC

At the temperature of 0 ºC wheat grain m.c. decreased for 0,5 % and 0,2 % at r.h. 55 % and 73 %, while at r.h. 80 % and 98 %, increased for 0.5 % and 0.7 % after 34 d of storing (Table 1). Analysis of variance show no significant differences of m.c. changes in wheat grain concerning different values of r.h. and 0 ºC air temperature during 34 d of storage (Figure 1).

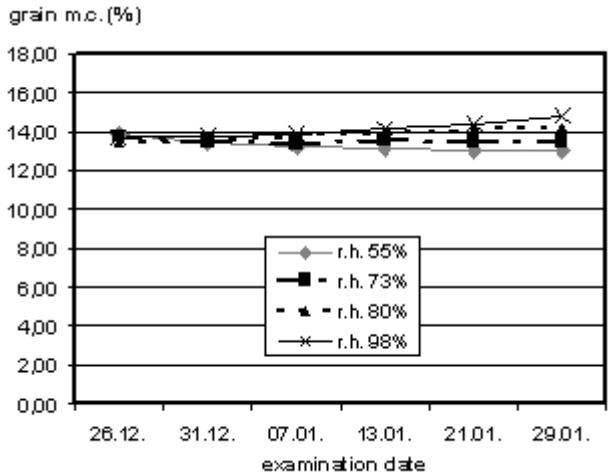

Figure 1. Wheat – grain m.c. (%) at 0 ºC.

Table 1. Wheat moisture content (%) at the storage temperature of 0 ºC and 20 ºC.

r.h. (%)	Treatment (examination date)					
	26.01. 2005.	31.12. 2005.	07.01. 2006.	13.01. 2006.	21.01. 2006.	29.01. 2006.
	Grain m.c. (%) at storage temperature of 0ºC					
55 %	13.45	13.52	13.18	13.10	13.00	12.98
73 %	13.73	13.75	13.40	13.55	13.52	13.52
80 %	14.00	13.75	13.75	14.00	14.13	14.52
98 %	13.57	13.57	13.88	14.18	14.45	14.80
Average	13.69	13.65	13.55	13.71	13.78	13.89
	F test 0.214^{ns}		Lsd test Lsd0.05=0.733		Lsd0.01=1.004	
	Grain m.c. (%) at storage temperature of 20 ºC					
55 %	14.00	13.75	12.57	12.40	12.25	12.35
73 %	13.57	13.57	13.98	13.13	14.20	14.27
80 %	13.98	14.18	14.57	14.80	14.95	14.10
98 %	13.85	13.90	14.80	15.07	15.75	16.48
Average	13.85	13.85	13.98	14.10	14.29	14.55
	F test: 0.23281^{ns}		Lsd test: Lsd0.05=1.690		Lsd0.01=2.315	

Results of grain moisture in wheat under stored temperature at 20 ºC

At the temperature of 20 ºC wheat grain m.c. decreased for 1.6 % at r.h. 55 %, while at r.h. 73 %, 80 % and 98 %, increased for 0.7 %, 1.1 % and 2.6 % (Table 1). Analysis of variance showed no significant differences of m.c. changes in wheat grain concerning different values of r.h. and the air temperature of 20ºC during 34 d of storage (Figure 2).

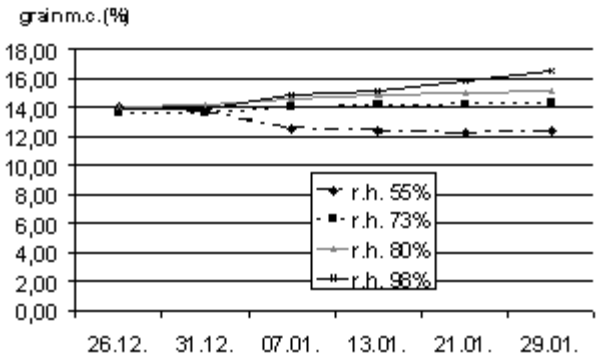

Figure 2. Wheat – grain m.c. (%) at 20 ºC.

Sunflower

Results of grain moisture in sunflower under stored temperature at 0 ºC

During storing time of 34 d, m.c. in sunflower grain decreased for 0.8 % and 0.2 % at r.h. 55 % and 73 % and at the temperature of 0 ºC, while at r.h. 80 % and 98 % increased for 0.5 % and 0.7 % (Table 2). Analysis of variance showed no significant differences of m.c. changes in sunflower grain concerning different values of r.h. and the air temperature of 0 ºC during 34 d of storage (Figure 3).

Results of grain moisture in sunflower under stored temperature at 20 ºC

At the temperature of 20 ºC m.c. in sunflower grain decreased for 1.6 % and 0.1 % at r.h. 55 % and 73 %, while at r.h. 80 % and 98 %, increased for 0.4 % and 1.5 % (Table 2). Analysis of variance showed no significant differences of m.c. changes in sunflower seed concerning different values of r.h. and the air temperature of 20 ºC during 34 d of storage (Figure 4).

Table 2. Sunflower moisture content (%) at the storage temperature of 0 ºC and 20 ºC.

r.h. (%)	Treatment (examination date)					
	26.01. 2005.	31.12. 2005.	07.01. 2006.	13.01. 2006.	21.01. 2006.	29.01. 2006.
	Grain m.c. (%) at storage temperature of 0ºC					
55%	7.88	7.55	7.47	7.32	7.13	7.10
73%	7.90	7.88	7.72	7.60	7.72	7.70
80%	7.60	7.85	8.00	8.05	8.10	8.10
98%	7.50	7.78	7.90	8.15	8.20	8.23
Average	7.72	7.76	7.78	7.78	7.79	7.78
	F test 2.011	Lsd test: Lsd0.05= 0.527		Lsd0.01=0.723		
	Grain m.c. (%) at storage temperature of 20ºC					
55%	7.85	7.28	6.63	6.35	6.25	6.25
73%	7.60	7.35	7.47	7.50	7.38	7.47
80%	7.78	7.55	7.95	7.95	8.10	8.20
98%	7.93	7.60	7.80	8.30	9.07	9.45
Average	7.79	7.44	7.46	7.52	7.70	7.84
	F test 0.165	Lsd test: Lsd0.05= 1.262		Lsd0.01=1.728		

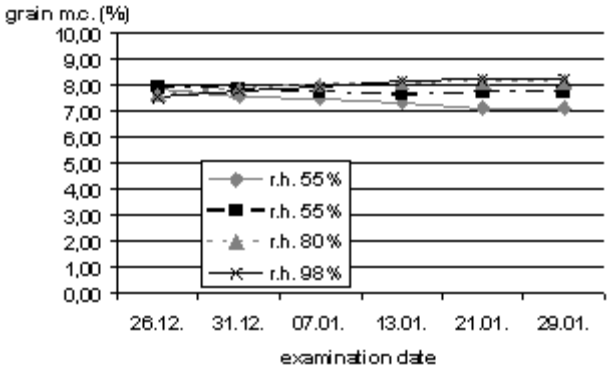

Figure 3. Sunflower – seed m.c. (%) at 0 ºC.

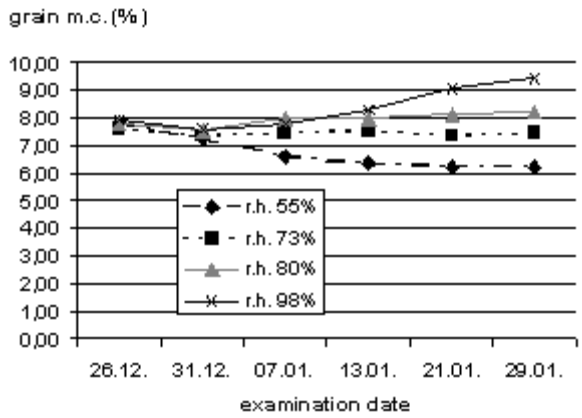

Figure 4. Sunflower – grain m.c. (%) at 20 ºC.

Discussion

The major factors which influence viability of stored grain are temperature, r.h. oxygen content between seed pore space. Many empiric researches had been conducted concerning temperature and r.h. influence on grain viability. In most cases, it has been proved that lower temperature and lower r.h. prolong grain viability. Fewer researches were conducted concerning oxygen influence. However it could be said, that at most species, the higher is oxygen level, the shortest is grain viability. Additionally, by huge numbers of investigation, exceptions to those rules had been affirmed. Some species need high r.h. for longer grain viability period, as for example citrus fruits (Barton, 1943), palms (Rees, 1963), coffee (Huxley, 1964; Bacchi, 1955; 1956). Likewise, it has been affirmed that in cocoa, not only that high m.c. influence better grain viability, but the temperature of 10 ºC is much unfavourable for the grain than the temperature of 30 ºC. Yet, grain viability reactions of those species on storage conditions are incomplete, because in some cases there is a possibility that lower m.c. has been substitute with undesirable effect of rapid grain drying. Concerning that, a research of that kind of species requires additional investigations.

These investigations were conducted only on species that subject to conditions that the grain viability is prolonged at the lower values of air temperatures, r.h. and of oxygen between grain spore space. With the investigated cultures, we proved that grain moisture changes regarding to air temperature and r.h., but those changes are not statistically relevant.

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