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GERMINATION OF BUCKWHEAT SEEDS SUBJECT TO STORAGE TIME AND ELECTROMAGNETIC STIMULATION METHODS

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Key words: buckwheat, storage time, physical stimulating factors.

Abstract

This paper presents the results of research on the influence of storage time, laser beam and magnetic field stimulation on the final number of germinated buckwheat cv. "Kora" seeds. Germination tests were carried out in a controlled environment chamber at a stable temperature of 21°C, stable humidity and without a source of light. Significant differences were reported in respect of values determining the percentage of germinated seed subject to the year of harvest. The impact of physical stimulation factors on seeds (harvested in 1993 and 2002) did not increase the final number of germinated seeds in those groups.

PRZEBIEG PROCESU KIEŁKOWANIA NASION GRYKI W ZALEŻNOŚCI OD CZASU PRZECHOWYWANIA ORAZ ELEKTROMAGNETYCZNYCH METOD STYMULACJI

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Słowa kluczowe: gryka, czas przechowywania, fizyczne czynniki stymulacyjne.

Streszczenie

W pracy przedstawiono wyniki badań nad wpływem czasu przechowywania oraz działania światła laserowego i pola magnetycznego na końcową liczbę wykiełkowanych nasion gryki odmiany Kora. Testy kiełkowania przeprowadzono w komorze klimatycznej w stabilnej temperaturze 21°C, stałej wilgotności i bez dostępu światła. Stwierdzono znaczne różnice w wartościach określających procent wykiełkowanych nasion w zależności od lat zbioru. Poddanie badanych nasion (roczniki 1993 i 2003) działaniu fizycznych czynników stymulacyjnych nie miało wpływu na zwiększenie końcowej liczby wykiełkowanych nasion w tych grupach.

Introduction

Seeds are stored to keep them in a state of anabiosis until the moment when the right environmental conditions (adequate hydration level, access to air, adequate temperature) allow for the germination process to begin. The period of storage and the storing conditions are also important factors which affect germination. The process of seed aging is accompanied by (usually irreversible) degenerative changes in the structure and physiological and biochemical functions of the protoplast (LITYŃSKI 1977). Seeds lose their viability for various reasons, mainly due to the loss of enzymatic activity, depletion of reserve substances, changes in the structure of embryo cytoplasm, disturbances in protein metabolism, degree of degeneration of embryo's cell nuclei, accumulation of toxic metabolites and changes in the structure of nucleic acids (ZURZYCKI, MICHNIEWICZ 1985). Numerous research studies (LITYŃSKI 1977) have shown that seeds stored under adequate conditions maintain their germinating capacity at a level similar to the initial value for around three years, after which seed viability is subject to a sudden and irreversible drop. Those irreversible degenerative changes are directly responsible for decreasing crop yields. Various substances and methods are presently applied to stimulate the seed germination process and, consequently, increase the yield. The application of pre-sowing chemical agents, such as seed dressings, growth regulators and physical stimulants, supports the germination process and contributes to yield increase. The beneficial effect of a variable magnetic field as a factor which supports other processing methods was observed by ROCHALSKA (2002) in respect of soybean and maize seeds germinated under temperature stress. Physical stimulation factors (magnetic and electric field, ionizing, microwave and laser radiation) have already been applied to various vegetables, pulse crops and cereals, including tomatoes (GŁADYSZEWSKA 1998, GŁADYSZEWSKA, KOPER 2002a, b, KOPER i in. 2001) onions (PIETRUSZEWSKI 2000, PROKOP i in. 2001, PROKOP i in. 2002), cabbage (PIETRUSZEWSKI i in. 2002), radishes (PIETRUSZEWSKI i in. 2002, PROKOP i in. 2002), spinach (PIETRUSZEWSKI i in. 2002), sugar beets (KOPER i in. 2002, PIETRUSZEWSKI 2000), faba beans (PODLEŚNY 2001, PODLEŚNY, PODLESNA 2004, PODLEŚNY i in. 2001), wheat (KORDAS 2002, KORNARZYŃSKI i in. 2004, PIETRUSZEWSKI 1999), barley (RYBIŃSKI i in. 2002, RYBIŃSKI i in. 2004), oat (DROZD i in. 2004), maize (ROCHALSKA 2002), flax (OLCHOWIK, GAWDA 2002) and plants of the family Brassicaceae, including thale cress (QIN i in. 2006) and woad (YI-PING CHENA i in. 2005). In general, research results indicate that the impact of the above factors differs subject to the applied parameters which determine their properties.

The objective of this study was to analyze the effect of laser light stimulation and variable magnetic field stimulation on the percentage of germinated buckwheat cv. Kora seeds, subject to the period of seed storage.

Materials and methods

The experimental material comprising seeds harvested in 1993 and 2003 was subjected to laser stimulation (in 3 series during the free fall of seeds from the charging hopper chute) with a He-Ne laser beam with a wavelength of λ=630 nm and density power of 4 mW/cm^2 (group L) (CIUPAK i in. 2006) or magnetic field stimulation with an intensity of 30 mT and frequency of 50 Hz (group M) with exposure time of 8 seconds. A combination of the above stimulating factors was also applied to form group LM (laser + magnetic field). The control group in the experiment were non-stimulated buckwheat seeds (group C). Every group was represented by 400 seeds sown on Petri dishes (on stimulation day) in 4 samples of 100 seeds each. The prepared seeds were placed in a controlled environment chamber at a stable temperature of 21^{o}C, stable humidity and without a source of light. The above temperature (which was within the optimum range for buckwheat seed germination (HRYNCEWICZ 1992) enabled to obtain results within a shorter time and created a more favorable environment for the germination of older seeds (1993). Germinated seeds (showing germs with a minimum length of 2 mm) were counted every 1–2 hours beginning from the appearance of the first germ (when germination was most intense). The time intervals in which germs were counted were gradually extended due to decreasing germination intensity. Germination rate S_k, the final number of germinated seeds N_k (indicated in %) and the time required for the germination of 50% of all sown seeds (t_{50}) were calculated based on the obtained results.

Results and discussion

The data defining the final number of germinated buckwheat seeds N_k (standard deviation values are indicated in parenthesis), subject to storage time and the applied stimulation factors, are presented in Table 1. Figure 1 additionally presents curves which represent the number of germinated seeds (in %) as a function of time. When analyzed, the obtained results indicate significant differences in N_k values of seeds harvested in 1993 and

Table 1

Number of germinated seeds N_k (in %) subject to the harvest year and the applied stimulation method

Number of germinated seeds (%)			
1993			
K	L	M	LM
69 (5.9)	64.75 (7.37)	62.5 (9.54)	71.25 (13.96)
2003			
83.25 (3.3)	84 (8.6)	81 (2.2)	85 (8.7)

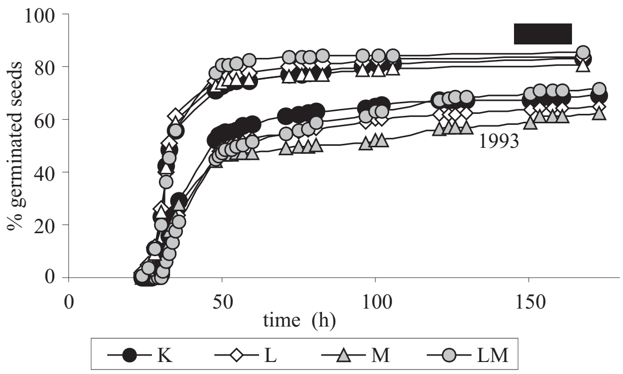

Fig. 1. Final number of germinated seeds N_k (%) harvested in 1993 and 2003, subject to stimulation method

2003. A comparison of control groups (C) representing both harvest years shows that N_k values were more than 14% lower in older seeds.

The greatest difference between stimulated groups (more than 19%) in the final N_k value was observed with regard to seeds which were subjected to laser simulation. None of the applied physical stimulation factors contributed to an increase in the number of germinated seeds from both harvest years. The above was confirmed by a statistical analysis based on testing the hypothesis of the difference between two means with the use of Student's *t*-test (at a significance level of α=0.05). Statistically significant negative effects of stimulation were observed in older seeds (1993) which were subjected to a variable magnetic field (group M).

The data for the beginning of the germination processes in every seed group are presented in Table 2, and significant differences in the time of the beginning of germination are illustrated by Figure 1. The obtained results

Table 2

Time of the beginning of germination process t_p and time of germination of 50% of all sown seeds t_{50}

Time of germination beginning t_p (h)			
K	L	M	LM
1993			
28	28	27	31
2003			
24	24	24	24
Time of germination of 50% of all sown seeds t_{50} (h)			
K	L	M	LM
1993			
48	53	78	57
2003			
34	33	33	34

indicate that regardless of the applied stimulation method, the germination of the seeds harvested in 2003 began at the same moment (hour 24 after sowing). Older seeds (1993) germinated later (Table 2). As regards group LM, the germination process started in hour 31 after sowing, i.e. 7 hours later than the group of seeds harvested in 2003.

Table 2 also indicates the time required for 50% of all sown seeds to germinate. An analysis of the above data indicates that the seeds harvested in 2003 needed 33 hours from sowing to germinate. Older seeds (1993) needed more than twice that time to attain the same germination level. As regards magnetic field stimulation, the time required for the germination of 50% of buckwheat seeds harvested in 1993 was more than five times longer than that observed in the group of seeds from 2003. The data obtained from the observation of the initial germination phase was used to set the value of the relative germination rate coefficient W_k (against control) of buckwheat seeds with the use of the below formula:

$$W_k = \frac{n(t)}{n_{\text{control}}}$$

where:
$n(t)$ – number of seeds germinated in time t,
$n_{control}$ – number of control group seeds germinated in given time t, and the corresponding change in the number of germinated seeds N_k as per the below formula:

$$N_k = \frac{n_k}{n_c} \cdot 100\%$$

where:
n_k – number of germinated seeds,
n_c – total number of sown seeds.

The comparative diagrams in Figure 2 indicate the germination rate S_k of buckwheat seeds, subject to the applied stimulation method and harvest time. The germination rate S_k (seed/h) of buckwheat seeds was calculated based on the below formula:

$$S_k = \frac{n_{\max}}{\Delta t}$$

where:
$n_{\max}$ – maximum number of germinated seeds recorded during the count,
Δt – time interval between two successive counts.

The curves representing 1993 harvest groups differ significantly from the curves which illustrate the 2003 harvest group. This difference is most likely due to a longer period of storage. The curves in Figures 2 also present the maximum germination rate by indicating the number of seeds which germinated within 1 hour after sowing.

Table 3

Value of relative germination rate coefficient W_k and number of germinated seeds N_k

1993							
	K	L		M		LM	
Time from sowing (h)	N_k (%)	W_k	N_k (%)	W_k	N_k (%)	W_k	N_k (%)
28	0.5	0.5	0.25	0.5	0.75	0	0
29	0.75	0	0.25	1	1	0	0
30	1.25	0.5	0.5	5	3.5	0	0
31	5.25	0.56	2.75	0.56	5.75	0.56	2.25
32	10.5	0.67	6.25	1	11	0.71	6
33	15.5	0.75	10	1.3	17.5	0.65	9.25
34	19.8	0.65	12.8	0.53	19.8	1	13.5
35	24	1.18	17.75	0.7	22.75	1	17.75
36	29	1.15	23.5	1	27.75	0.75	21.5
48	52.25	0.96	45.75	0.72	44.5	1.01	45
49	53.75	1.33	47.75	1.33	46.5	0.83	46.25
50	54.5	1.67	49	0	46.5	1	47
	K	L		M		LM	
Time from sowing (h)	N_k (%)	W_k	N_k %)	W_k	N_k (%)	W_k	N_k (%)
26	3.5	1.09	4.75	1	3.3	1.09	3.8
28	11	0.87	11.3	0.8	9.3	0.97	11
30	23	1.23	26	1.31	25	0.77	20
32	42.5	0.73	40.3	0.87	42	0.83	37
33	48.25	1.83	50.8	1.17	49	1.52	45
35	55.75	1.37	61	1.3	59	1.43	56
48	71	0.9	74.8	0.93	73	1.43	78
50	72.75	0.43	75.5	0.57	74	1.57	81

A detailed analysis of the obtained curves indicates that the highest germination rate of seeds harvested in 2003 was observed in hour 8–9 of the process (hour 32–33 after sowing). Maximum S_k values for seeds harvested in 1993 were reported from hour 5 to 9 of the germination process (hour 32–36 after sowing) The highest S_k values for older seeds (1993) were nearly half the maximum germination rate values reported for seeds with a shorter storage period (2003 harvest).

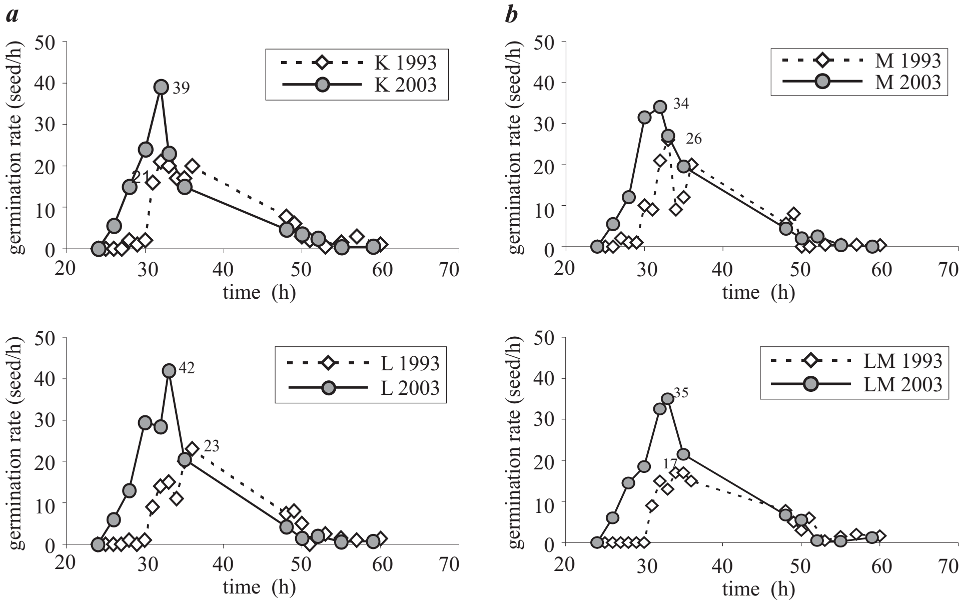

Fig. 2. Seed germination rate subject to harvest year and the applied stimulation method

Conclusions

1. Considerable differences were observed in the final number of germinated seeds which were harvested in 1993 and 2003.
2. The applied stimulating factors did not increase the final number of germinated buckwheat seeds.
3. A statistically significant, negative effect of stimulation was reported for the group of seeds harvested in 1993 which were stimulated with a magnetic field.
4. A longer storage period (for seeds harvested in 1993) extended the time required for the germination process to begin and it reduced the germination rate of seeds.

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