Changes in the germinability and vigour of winter triticale seeds with sprouting damage

M. Moś

Agricultural University in Cracow, Poland

ABSTRACT

Changes in the germinability and vigour of seeds with sprouting damage obtained after induced sprouting under laboratory conditions were investigated in winter triticale cultivars: Bogo, Moreno, Vero, in the years 1998–2000. The seeds were tested directly after harvest, at the optimal time for sowing winter triticale and after accelerated ageing test. Average germinability evaluated directly after induced sprouting and at the optimal time for sowing winter triticale ranged from 78.0% to 92.7% and from 70.3% to 81.0%, respectively. Similar results were obtained for the length of the first leaf and the length of the longest root. The estimated components of variance showed that the year variation and interaction of years with seed sprouting damage made the greatest percentage (to 49.2% and to 31.8%, respectively) of the total variation. After accelerated ageing a significant decrease in germinability and vigour of seeds was observed. That decrease was in proportion to sprouting damage which accounted for 57.6% of the total variation. These results point to poor storability of seeds with sprouting damage.

Keywords: winter triticale; sprouting; seed germinability and vigour

The germinability and vigour of seeds are conditioned by genetic traits, which are to a considerable degree modified by agroecological factors affecting the parent plant. After harvest, changes in germinability and vigour can be influenced by the method of storing and ennobling the seeds, however they will depend largely on the initial vigour. In the case of triticale, which displays a considerably strong tendency to sprout, conditioned by high alpha-amylase activity (Masojć and Larson-Raźnikiewicz 1991) and light dormancy (Moś 1994), the initial vigour of seeds can vary, depending on weather conditions during maturation and harvest. According to Belderok (1968), sprouting reduces the quality of seeds and their vigour. The aim of the research was to determine the effect of various sprouting damages of winter triticale seeds on changes in germinability and vigour estimated at various dates. The accelerated ageing test was used to indicate the effect of sprouting on vigour and to determine the storability of seeds with sprouting damage.

MATERIAL AND METHODS

The material for the studies was obtained from observational field experiments carried out in the years 1997–1999 at the Experimental Station in Prusy near Cracow. The testing included three winter triticale cultivars: Bogo, developed at ZDHAR Małyszyn, Moreno and Vero, developed at ZHR Choryń. Spikes were harvested after they had attained full maturity. The spikes were threshed on the day of harvest.

Sprouting of seeds was induced directly after harvest and threshing, under laboratory conditions, on Petri dishes, at the temperature of 20°C. Four degrees of seed sprouting damage were distinguished: seeds with the testa broken near the embryo (1st), seeds with visible primordia of a shoot and an embryonal root (2nd), seeds which developed a shoot and one root (3rd), and seeds which developed a shoot and three roots (4th). The investigation also included control seeds (K), which did not undergo induced sprouting.

Germinability and vigour were determined each year at three dates: directly after induced sprouting (T1), which occurred two weeks after harvest, at the optimal time for sowing winter triticale (T2), i.e. six weeks after harvest, and after the standard accelerated ageing test (AA), carried out according to the ISTA (1995), four weeks after harvest. Germinability and vigour were estimated in Szmal's germinators; 50 seeds were sown into each of the germinators, in four replications. Each of the replicates was in a separate cuvette, so when doing calculations they were treated as blocks. The determinations included germinability (GA), estimated according to ISTA (1999), the length of the first leaf (LFL) and the length of the longest root (LLR) of eight-day-old, normally developed seedlings. For the obtained germinability and vigour results three-factor analyses of variance were done. Analyses of variance for germinability were performed after the transformation of percentage values, according

This study was supported by the State Committee for Scientific Research, project No.5P60B04115.

Table 1. Percentage of variance components and the significance of the *F*-test for the sources of vigour variation estimated after induced sprouting (T1), at the optimal time for sowing winter triticale (T2), and after the accelerated aging test (AA)

Sources of variation	T 1			T 2			AA		
	GA	LFL	LLR	GA	LFL	LLR	GA	LFL	LLR
Blocks	0.1	0.0	0.5	0.1	0.0	0.7	0.2	0.2	0.3*
Years (A)	49.2**	29.8**	35.9**	32.8**	11.4**	28.9**	6.9**	6.9**	9.0**
Degrees of sprouting (B)	5.4	6.3	2.7	0.4	25.0*	4.0	57.6**	44.4**	40.5*
Interaction (A × B)	12.8**	31.8**	22.3**	15.7**	16.3**	15.6**	11.4**	17.5**	19.6**
Cultivars	3.4	0.0	0.0	20.2**	13.4*	9.4	3.6**	2.2	3.4*
Interactions									
A × C	3.3**	6.5**	8.3**	1.6	1.6*	4.2**	1.2**	0.9**	1.2**
B × C	0.7	4.1	3.2	0.0	0.0	0.7	0.0	0.0	0.0
A ×B ×C	5.4*	2.6*	6.9**	6.1*	11.7**	11.7**	14.7**	22.3**	20.9**
Error	19.7	18.9	20.2	23.1	20.6	24.8	5.1	5.6	5.1

* significant at $\alpha = 0.05$, ** significant at $\alpha = 0.01$

GA – germinability, LFL – the length of the first leaf, LLR – the length of the longest root

to Bliss's method. The testing was carried out following the mixed model, in which years were the random factor and degrees of sprouting damage and cultivars were the constant factors. For the separated sources of variation the components of variance were estimated.

RESULTS

The analyses of variance done for germinability and vigour results, obtained at successive dates (Table 1), showed significant interaction between the investigated factors, i.e. years, degrees of sprouting damage of seeds, and cultivars. Significant interactions between years and the degrees of sprouting damage of seeds and between years and cultivars were noted as well. On the basis of the estimated components of variance it was stated that when germinability and vigour were estimated after induced sprouting and at the optimal time for sowing winter triticale, the greatest percentage of the total variation fell to years and their interaction with the degrees of seed sprouting damage. At these two dates no significant effect of sprouting damage of seeds on their germinability and vigour was observed. A lack of significant differentiation of germinability in seeds with sprouting damage resulted from the effect of years and interaction between years and the degrees of sprouting damage (Figure 1). In 1998, at both the dates of estimation (T1, T2) seeds with sprouting damage were characterized by germinability higher by 9–29% as compared with the control. Similarly, in 1999 at the optimal sowing time seeds with sprouting damage germinated better than the control by 6–15%. However, that year, when estimation was done directly after induced sprouting, only the seeds, which developed a shoot and one root (3rd), were characterized by higher 13–19% germinability. Other seeds with sprouting damage and control seeds germinated in the range of 65–71%. In the year 2000 seeds with the highest vigour were developed. Their germinability estimated directly after induced sprouting exceeded 90% for the control and all the sprouting-damaged seeds. However, at the optimal time for sowing winter triticale the seeds with the

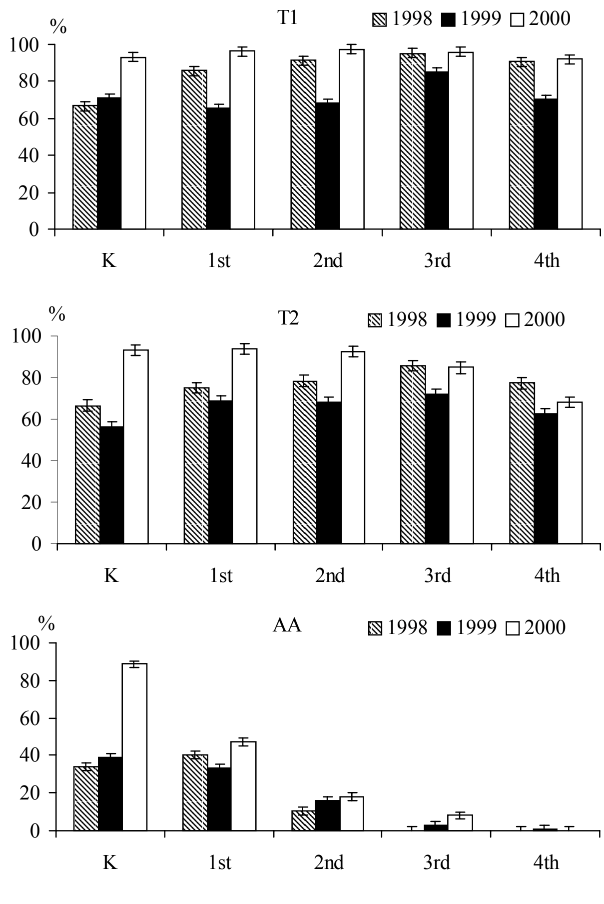

Figure 1. Germinability of seeds (%) with sprouting damage (K, 1st, 2nd, 3rd, 4th), estimated after induced sprouting (T1), at the optimal time for sowing winter triticale (T2), and after the accelerated ageing test (AA)

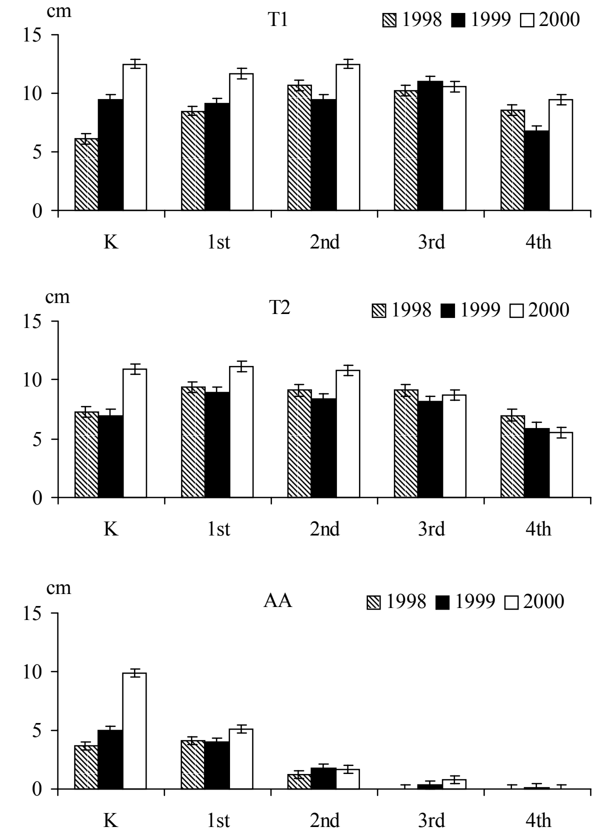

Figure 2. The length of the first leaf of seedlings (cm) developed from seeds with sprouting damage (K, 1st, 2nd, 3rd, 4th), estimated after induced sprouting (T1), at the optimal time for sowing winter triticale (T2), and after the accelerated ageing test (AA)

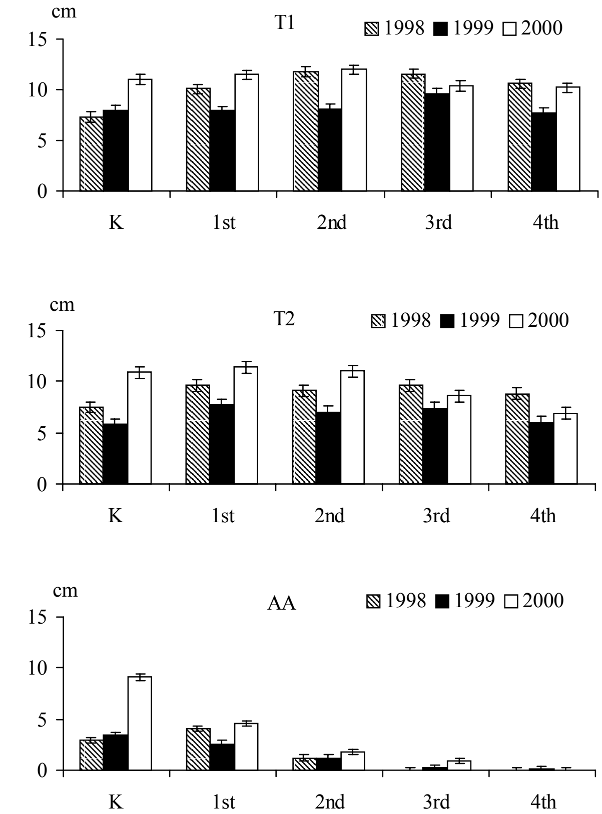

Figure 3. The length of the longest root of seedlings (cm) developed from seeds with sprouting damage (K, 1st, 2nd, 3rd, 4th), estimated after induced sprouting (T1), at the optimal time for sowing winter triticale (T2), and after the accelerated ageing test (AA)

most severe sprouting damage showed a significant reduction in germinability as compared with the control, by 24% on the average. Comparing average germinability values for seeds with the same sprouting damage, estimated directly after induced sprouting and at the optimal sowing time, the greatest reduction was noted in seeds with the most severe sprouting damage (4th). Depending on the year, that decrease ranged from 8 to 24%.

Different germinability and vigour values were obtained when accelerated ageing test was used. The estimated components of variance showed that in that case the greatest influence was exerted by sprouting damage of seeds. A significant decrease in germinability was observed, which became more intense with an increase in the severity of sprouting damage. In 1998 seeds with the damage of the 3rd and 4th degrees did not develop normal seedlings. Similarly, in 1999 and 2000 the most sprouted seeds showed germinability nearing zero. These results point to poor storability of seeds with sprouting damage.

The results similar to those for germinability were obtained for the length of the first leaf and the length of the longest root of eight-day-old, normally developed seedlings. In 1998, when estimation was carried out directly after induced sprouting and at the optimal time for sowing winter triticale, even seeds with the most severe sprouting damage developed longer leaves and roots as compared with the control (Figures 2 and 3). In 1999 only seeds with the most severe sprouting damage (4th) showed a reduction in the length of the first leaf and the longest root. In 2000 a reduction in the length of the first leaf and the longest root was found in seeds with sprouting damage of the 3rd and 4th degrees at the both estimation dates. That reduction was the greatest at the optimal sowing time, amounting to 49.5% of the length of the first leaf and to 37% of the length of the longest root.

In the case of the accelerated ageing test the analyses of variance, carried out for the results obtained for the length of the first leaf and the length of the longest root, showed significant interaction between the investigated factors. The estimated components of variance showed that the greatest influence on the studied vigour factors was exerted by degrees of sprouting damage (Table 1). A reduction in the length of the first leaf and the length of the longest root was observed already in seeds with the broken testa (1st), except for the year 1998, when seeds with the damaged testa developed the longest root and the first leaf that was longer than that in the control. That year a reduction in vigour indices was observed only in seeds, which during induced sprouting, developed primordia of a shoot and an embryonal root (2nd).

A significant effect of cultivars on the studied germinability and vigour indices was found at the optimal sowing time and when the accelerated ageing test was used. Considering the estimated components of variance, the highest percentage of cultivar variation (20.2% of the total variation) was found for germinability at the optimal time for sowing triticale. Considering the cultivars tested at that time, the highest average germinability (86.8%) was found for Bogo.

DISCUSSION

When germinability and vigour were estimated directly after induced sprouting, high values of the investigated indices for the control and the seeds with sprouting damage were found. Only the differences between the results obtained for germinability and vigour when sowing was done directly after induced sprouting, which occurred two weeks after harvest, and those obtained for the optimal time for sowing winter triticale, i.e. six weeks after harvest, made it possible to find the changes in seed germinability and vigour as affected by sprouting damage. Although the period between the harvest and sowing of winter crops is not long, the germinability and vigour changes observed under optimal conditions (T1, T2), under laboratory conditions can be an indication of inferior field emergence. Haastrup Pedersen et al. (1993) found a significant negative correlation between average germination time, determined under laboratory conditions, and field emergence in winter wheat. The greatest changes between the results obtained after induced sprouting and those for the optimal sowing time were noted in seeds with the most severe sprouting damage. In the year 2000, when seeds with the best vigour was developed, in the case of the most sprouted seeds the differences resulting from various estimation dates amounted to 24%. These results correspond with those of earlier research works of Moś (1999), in which vigour of induced seeds and of seeds showing the 1st and 4th degrees of sprouting was determined two and six weeks after harvest and after keeping them for 6–8 and 12 months under warehouse conditions. Already at the optimal sowing time a significant decrease in germinability of the most sprouted seeds was noted. Similar results were obtained by Elias and Copeland (1991), who in two-year studies proved the effects of sprouting damage of seeds and storing time on the germinability of white and red wheat cultivars. Sprouted seeds of red cultivars maintained high germinability up to the sixth week after harvest. In the case of white cultivars a more rapid decrease in germinability, already after three weeks of storing was found, which was explained by a weaker resistance to sprouting of these cultivars.

In the case of seeds with lesser sprouting damage the differences between the results obtained directly after induced sprouting and those for the optimal sowing time ranged from 10.5% to 12.9% only in 1998. In successive years no such differences were observed. The induction of sprouting was probably a treatment similar to hydroconditioning, especially in 1999, when seeds with weak vigour developed. Similarly, Aschermann-Koch et al. (1992) obtained a significant increase in germinability and vigour in wheat seeds induced under oxygen.

The use of the accelerated ageing test made it possible to observe the phenomenon of irreversible vigour changes, which in seeds with evident sprouting was the most intense. Significant interaction between years, degrees of sprouting damage and cultivars can point to seasonal and varietal conditioning of the rate of seed ageing. At the same time it points to poor storability of these seeds, because of decreased germinability and vigour (Stahl and Steiner 1996, Narkiewicz-Jodko and Schneider 1988, Moś 1999, 2000), which in consequence causes a reduction in field emergence (Elias and Copeland 1991, Chastain et al. 1994, Moś and Wójtowicz 2002) and yield (Haastrup Pedersen et al. 1993).

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Received on October 3, 2002

ABSTRAKT

Změny v klíčivosti a vitalitě porůstáním poškozených obilek ozimého tritikale

Byly sledovány změny klíčivosti a vitality obilek ozimého tritikale poškozených porůstáním. Porůstání bylo indukováno v laboratorních podmínkách v letech 1998 až 2000 u odrůd Bogo, Moreno a Vero. Obilky byly hodnoceny ihned po sklizni, v době optimální pro výsev a po vystavení vzorků urychlenému stárnutí. Průměrná klíčivost, hodnocená ihned po indukovaném porůstání a v termínu setí tritikale, se pohybovala v rozmezí hodnot od 78,0 do 92,7 % a od 70,3 do 81,0 %. Shodné výsledky byly získány u délky prvního listu a délky nejvyvinutějšího kořínku. Vypočtené složky variability ukazují, že ročníková variabilita a vztah ročníku k poškození porůstáním měly nejvyšší podíl na celkové variabilitě (do 49,2 % a do 31,8 %). Po urychleném stárnutí se klíčivost a vitalita průkazně snižovala. Pokles klíčivosti a vitality se podílel na poškození porůstáním hodnotou 57,6 % z celkové variability. Výsledky potvrzují špatnou skladovatelnost osiva poškozeného porůstáním.

Klíčová slova: ozimé tritikale; porůstání; klíčivost a vitalita obilek

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Corresponding author:

Prof. dr. hab. Maria Moś, Department of Plant Breeding and Seed Science, Agricultural University in Cracow,
ul. Łobzowska 24, 31-140 Cracow, Poland
tel.: + 48 126 333 606, fax: + 48 126 333 606, e-mail: rrmos@cyf-kr.edu.pl

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