Physiological nature of overwintering oats forms

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ABSTRACT

We evaluated the need for low temperatures (vernalization) and the photoperiodic reaction of three collections of winter oats (1. Pedarn, Maris Quest, Peniarth; 2. Gerald, Solva, Kymon, Pendragon; 3. Pewi, Silwi, Wiskas) in a comparison with spring oats varieties. All three collections of varieties showed little need for low temperatures, mostly as few as 10–20 days, which does not represent an obligatory need; this influence is only quantitative and constitutes no precondition for a passage of plants into the generative stage. Only in the case of the Maris Quest variety, the need for vernalization approached 30 days. As compared with the reaction of winter barley varieties that had and in some cases still have worse overwintering in the Czech Republic, the length of vernalization is equal. In the photoperiodic experiment, the reaction to a short autumn day turned out to be the critical condition for a possibility of autumn sowing and overwintering; in the case of these varieties, a short day inhibits the development until arrival of winter. We evaluated this reaction according to the length of the induction period. This period was only 10–15 days in the case of the spring oats Český žlutý, 30 days in the case of winter oats Maris Quest, 25 days for Pedarn, 20 days for Peniarth and 21 days for Pendragon; the induction period was 14–21 days in the case of varieties Gerald, Kymon and Solva. When compared with figures for winter barley, it had the longer photoperiodic induction period. The evaluated varieties of winter oats do not reach such a degree of a reaction to a short day, which manifests itself in their lower frosthardiness than that of winter barley. We verified that in provoking tests for frosthardiness, and also by lower critical values of temperatures for dying out of 50% of plants, the so-called LT 50.

Keywords: oat *Avena sativa* L.; winter oats varieties; overwintering; vernalization; photoperiodic reaction

Since the middle of the last century, the share of winter crops has been growing at the expense of spring ones in Europe. In the case of wheat, it has come up to more than 90%, in the case of rye up to nearly 100%. Other examples of expansion of winter crops are winter rape and winter barley, in the last decades even distichous, winter varieties of which had not been known for a long time. From Great Britain, we know winter forms of oats (*Avena sativa* L.) providing there yields by 10% higher than spring ones. Winter oats are cultivated widely also in the USA and in Australia, where their breeding for winterhardiness has made a considerable progress. During the last twenty years, we can meet winter oats more and more also on the European continent, e.g. in Greece, Turkey, in the countries of former Yugoslavia, and in Bulgaria (Hetzler and Dambroth 1990, Dimitrova-Doneva and Tanchev 1999), but also in Switzerland, Italy and Germany, where they have already bred several domestic varieties. Their expansion is being ascribed to a period of mild winters. However, successful breeding of these forms of oats is also obvious. As for the USA and Canada, the progress in breeding of winter oats is described in a paper by Livingston and Elwinger (1995), who pointed out that winterhardiness was increasing by 0.26% annually in the period 1935–1992.

The tendency towards winter forms of cereals is determined by their higher yields caused by a longer vegetation period, a possibility of utilizing of winter moisture and nutrients, and better rooting and tillering. Due to autumn and early spring temperatures and the length of a day, formation of yield components, above all number of ears and ear productivity is more favorably influenced in the case of winter cereals. Since 1969, when we learnt about cultivation of winter oats and winter field beans (*Vicia faba* L.) in Great Britain, we have been interested in the nature of the winter character of these species. However, varieties of those days did not overwinter under the conditions of Central Bohemia in the years 1970–1972. This corroborated the well-known fact that the winter character is a relative notion, dependent on conditions of the winter period in the place of cultivation.

There are several hypotheses about the possibility of overwintering. Very often, the level of progress of plant development by the arrival of winter is mentioned. It is regulated either by a need for low temperatures for a definite period – vernalization, or by a sensitivity to a short day inhibiting the development.

In the case of winter oats (*Avena sativa* L.), the need for vernalization has not been usually stressed in literature (McDaniel and Barr 1994). But the results from Loskutov (2001), the majority of wild oats species, cold temperature requirements had a greater effect on heading date, them daylenght. More often, a rather greater sensitivity to a short day was established (Oquist and Huner 1991). The speed of development by the arrival of frosts is demonstratively connected with a resistance to winter conditions (Petr et al. 1960). The development

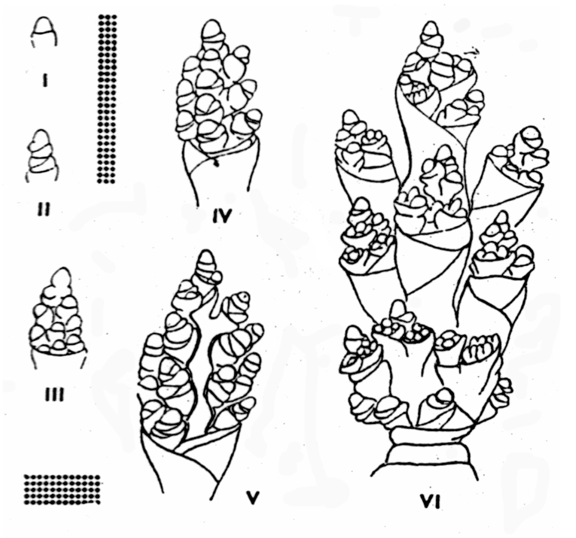

Figure 1. Differentiation stages of a shoot apex of oats

I-st, II-nd, III-rd stage – non-differentiated shoot apices in the vegetative period of oats, IV-th stage – spikelet bumps, V-th stage – apparent first nodes, VI-th stage – stalk shooting plants

should be slow so that it did not overrun a critical limit by the arrival of winter; it is given by the end of the vegetative period and the passage into the generative one. According to differentiation stages of a shoot apex, this is represented by the III-rd organogenesis stage, the so-called double ridge stage (Figure 1). It is supposed that, in the case of typical winter crops, there is a need for low temperatures during a longer period, i.e. the so-called vernalization type, or that the development is inhibited by the reaction to a short autumn day, which is a general element of a biological clock, determining preparation of plants for winter conditions. Also morphological, hormonal and biochemical changes caused by shortening days have been described (Livingston 1996). There are also varieties combining a certain need for vernalization with a reaction to a short day, or a manifestation of vernalization under short-day conditions, too. The aim of this work was to clarify the nature of overwintering oats forms.

MATERIAL AND METHODS

Oats varieties (*Avena sativa* L.) Pedarn, Maris Quest and Peniarth, cultivated as winter forms in Great Britain in the sixtieth and seventieth, were used for the trials, they were obtained from the Welsh Plant Breeding Station Aberystwyth.

The variety description states about the Peniarth variety that it is one of the oldest varieties of winter oats in Great Britain and should be quite winter-hardy under conditions of Britain. However, it showed bad overwintering under the conditions of Central Bohemia during several years, similarly as the other evaluated varieties, and it would not be possible to utilize them in practical farming. The spring oats variety Český žlutý was used as a check variety. We observed the reaction of these four varieties to vernalization and in a photoperiodic experiment also the length of the photoperiodic induction period and the level of development inhibition by a short day.

Later, we got new varieties of winter oats from Switzerland, originating mostly in Great Britain, though: Gerald, Solva, Kymon and Pendragon. We investigated the reaction to vernalization and the length of a day for these varieties. These varieties did not overwinter under the conditions of Central Bohemia.

The methodology of vernalization was the classic one, i.e. after germination of 50 grams of grains in water during 36 hours, the grains were placed into dishes with a filter paper, covered with a wet paper, and moved into a refrigerator with a temperature of 3–6°C. Water for keeping the moisture was supplemented regularly. The interval in a refrigerating box was 10 days; the whole exposition to low temperatures was 40 days. The control, unvernalized plants had grains only dipped in water, and they were geminated during 36 hours under the room temperature. Germinated grains of all variants were sown on the same day, and only grains with germs of the same length were selected for sowing. The pots contained 15 plants in two replicas. The effect of vernalization was observed according to the start of growth stages, plant length and stages of shoot apex organogenesis (passage into the generative period), and first of all, according to the time of plant earing (50% plants).

Table 1. Effect of the length of vernalization to the time of earing of the plants

Variant		Control	1	2	3	4
Length of vernalization (days)		0	7	14	21	29
Maris Quest	date of earing	–	–	1. 9.	24. 8.	3. 8.
	number of days	0	0	81	73	52
Pedarn	date of earing	–	24. 8.	24. 8.	14. 8.	3. 8.
	number of days	0	73	73	63	52
Peniarth	date of earing	–	24. 8.	20. 8.	11. 8.	1. 8.
	number of days	0	73	69	60	49
Český žlutý (spring oats)	date of earing	9. 8.	7. 8.	7. 8.	5. 8.	3. 8.
	number of days	58	56	56	54	52

Table 2. Effect of the length of vernalization to the differentiation stage of a shoot apex

Variety	Variant vernalization (days)	Control 0	1 7	2 14	3 21	4 29
Maris Quest	stage of organogenesis	II.	II.	III.	IV.	VII.
	shoot apex length (mm)	0.6	0.5	0.8	1.0	7.0
	height of shoot apex setting (mm)	0.4	0.4	0.5	0.5	2.5
Pedarn	stage of organogenesis	II.	III.	IV.	V.	VII.
	shoot apex length (mm)	0.4	0.7	0.9	1.8	15.0
	height of shoot apex setting (mm)	0.4	0.4	0.4	0.6	3.3
Peniarth	stage of organogenesis	II.	III.–IV.	IV.	V.	VII.
	shoot apex length (mm)	0.4	0.8	1.0	1.6	20
	height of shoot apex setting (mm)	0.3	0.4	0.4	0.6	3.6
Český žlutý	stage of organogenesis	VII.	VII.	VII.	VII.	VII.
	shoot apex length (mm)	9.0	9.5	9.5	11.0	46.0
	height of shoot apex setting (mm)	2.8	4.3	6.5	7.0	6.0

The photoperiodic experiment was based on a stepwise putting the plants to another mode of day lengths, from a long day to a short one, or from a short day to a long one. In the first experiment, the interval was 7 days, so that individual variants were exposed to a long day for a period of 7, 14, 21, 28, 35 and 42 days, and after that they were planted in a short 8-hour day (from 7:30 a.m. to 3:30 p.m. of the summer time) until the end of the experiment.

The short day was achieved by carrying the pots on a cart into a darkened house. The plants were watered and water relations equalized in cases of night rainfall, when some variants were in the darkened house. The growth was evaluated by a measurement of plant length, the start of growth stages after Feekes, and newly according to a decimal scale of growth stages (DC) and stages of shoot apex organogenesis according to a scale by Kuperman (Petr et al. 1988). Furthermore, the time of plant earing was identified.

RESULTS

Vernalization of the first collection of winter oats varieties – Maris Quest, Pedarn and Peniarth with a control spring oats variety Český žlutý – was based on the effect of low temperatures during 7, 14, 21 and 29 days, with control unvernalized plants. The effect on the time of earing and number of days until earing is given in Table 1.

A more precise evaluation of the effect of vernalization on plant development is enabled by observing the stage of shoot apex differentiation, a future base of the spike, together with a measurement of its size and the height of apex setting inside the stalk (Table 2).

It is obvious from the results, that there is an impact of the length of vernalization on an acceleration of plant development, reducing the time before plant earing. The effect of vernalization was stronger in the case of the Maris Quest variety, where the treatment under low temperature conditions for 29 days accelerated the develop-

Table 3. Date of earing and number of days from emergence until earing

Variety	Variant	KD	10	9	8	7	6	5	4	3	2	1	KK
	number of long days		45	40	35	30	25	20	15	10	5	0	0
	number of short days		28	33	37	42	47	52	58	63	68	73	73
Pedarn	date of earing	20. 7.	23. 7.	23. 7.	29. 7.	31. 7.	–	–	–	–	–	–	–
	number of days	62	65	65	71	73							
Peniarth	date of earing	20. 7.	20. 7.	20. 7.	29. 7.	31. 7.	31. 7.	–	–	–	–	–	–
	number of days	62	62	62	71	73	73						
Maris Quest	date of earing	29. 7.	29. 7.	29. 7.	–	–	–	–	–	–	–	–	–
	number of days	71	71	71									
Český žlutý	date of earing	3. 7.	3. 7.	3. 7.	8. 7.	20. 7.	29. 7.	31. 7.	31. 7.	–	–	–	–
	number of days	45	45	45	50	62	71	73	73				

KD – control on a long day for the whole time
KK – control on a short day for the whole time
Number of days = number of days from emergence till earing

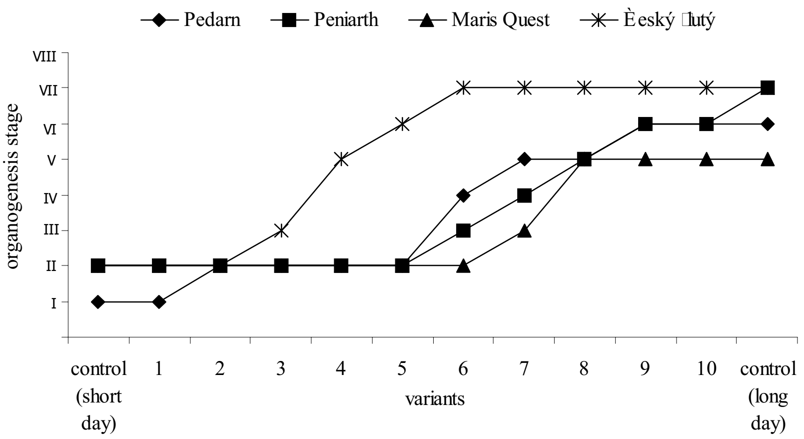

Figure 2. Organogenesis stages of a shoot apex as measured on 1 July

KK = control short day
KD = control long day

ment most, and probably corresponds to the need of plants of this variety for the length of low temperature exposition. The other varieties had a lower need for low temperatures 21 days, or 21–29 days. The spring oats variety showed no provable acceleration of the development, and low temperatures affected only its growth processes.

Oats is a long-day plant – the development is the quickest under long-day conditions. A short day inhibits its development, delays its passage into the generative period, and the plant start earing later or show no earing at all.

The photoperiodic experiment, carried out on the same varieties of winter oats, was based on a stepwise transfer of plants from a long (natural 15–16 hour) day to a short, 8-hour one. In this experiment, unvernalized and germinated grains were sown; they emerged on 18 and 19 May, when we started on their transfer to a short day. The experiment was finished on 31 July; the plants were exposed to a short day until then (with the exception of the control permanently on the long day). The results are presented in Table 3 and Figures 2 and 3.

In the case of the spring oats variety that has a weak reaction to the length of a day, 15–25 long days were enough for the passage into the generative stage, and later also to earing of panicles. The influence of 35–40 short days caused a deceleration of the development; nevertheless, the plants passed to the generative stage even under these conditions (Figures 2 and 3).

It follows from both evaluations, i.e. according to the time of earing and according to differentiation stages of a shoot apex, that 25–30 long days were enough for passing into the generative stage and earing of plants in the case of the Pedarn variety. A strong inhibition of the development appeared after 42–47 short days. In the case of the Peniarth variety, the plants passed into the generative stage after 20–25 long days, and 47–52 short days caused an inhibition of development. In the case of the Maris Quest variety, plants needed 35–40 long days to pass into the generative stage, and short days inhibited development of plants after an exposition to 33–37 short days. Number of long days necessary for the passage into the generative stage is a so-called induction period. The longer it is, the higher the sensitivity to a short day that inhibits the development to a stronger measure shows to be.

If short days operate in the period of the photoperiodic induction, a demonstrable delay in the development of plants appeared during differentiation of a shoot apex, the future base of an panicle, and hence a delayed earing appeared as well. In the case of the Pedarn variety, plants of the check permanently on a short day showed no earing until 31 July. Similarly, plants of the 2nd to 6th variants

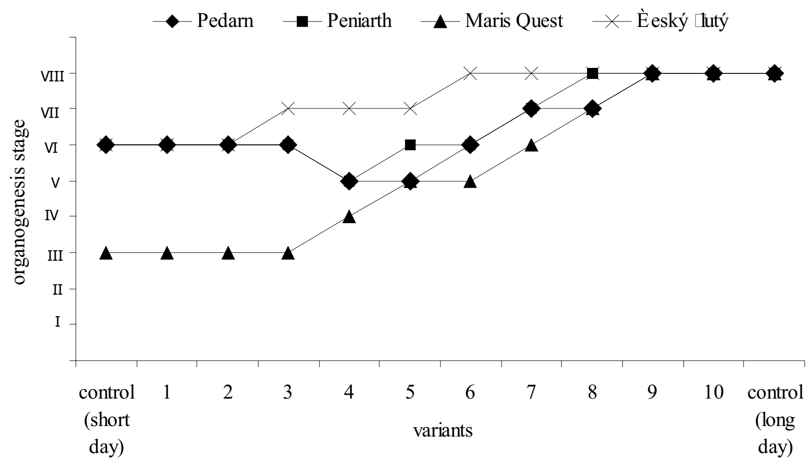

Figure 3. Organogenesis stages of a shoot apex as measured on 31 July

Table 4. Time of earing and number of days until end of earing

Variety	Variant	Date of earing when vernalized					Length of vernalization
		0 days	10 days	20 days	30 days	40 days	
Gerald	date of earing	10. 8.	6. 8.	6. 8.	16. 7.	16. 7.	
	number of days	82	78	78	58	58	20–30 days
Kymon	date of earing	12. 8.	6. 8.	23. 7.	16. 7.	16. 7.	
	number of days	84	78	64	58	58	10–20 days
Pendragon	date of earing	6. 8.	30. 7.	16. 7.	16. 7.	16. 7.	
	number of days	78	72	58	58	58	10 days
Solva	date of earing	6. 8.	6. 8.	23. 7.	23. 7.	16. 7.	
	number of days	78	78	64	64	58	10–20 days

exposed to 5–25 long days after their emerging, and to 47–73 short days after that.

A similar result was obtained in the case of the Peniarth variety, where no earing was observed for plants up to the 5th treatment with 5–20 long and 52–73 short days.

The strongest photoperiodic sensitivity was proved in the case of the Maris Quest variety, where no earing was observed for plants up to the 8th variant exposed to 35 long days and 37–73 short days. A short day significantly slowed down the development in this period, both according to the time of earing and according to the differentiation of a shoot apex. This plant shows the longest period of the photoperiodic induction, and the strongest reaction to a short day manifested by an inhibition of the development.

The reaction to vernalization was rather weak in the case of the next collection of winter oats – Gerald, Kymon, Pendragon and Solva. This was betrayed by the fact that even unvernalized plants finished their earing. The unvernalized plants showed earing on 12 August in the case of the Kymon variety, on 10 August in the case of the Gerald variety, on 6 August in the case of the Pendragon and Solva varieties. We verified that temperatures were not so low as to allow the plants to complete their vernalization. Nonetheless, we recorded acceleration in the development, and a speeded-up time of earing (Table 4).

According to the above-stated results, it is possible to attach to the evaluated varieties a wider temperature range for effective vernalization, and thus to deduce a thought about little sensitivity to vernalization that does not constitute a significant control element for the winter character, as it is in the case of regular winter crops.

We observed the photoperiodic reaction again by means of a transfer of plants from a long day to a short one. In the case of this collection, the photoperiodic induction is not delimited so distinctly as in the case of the former collection (Table 5). This period lasted 21 days in the case of the varieties Gerald, Kymon and Pendragon, and 14 days in the case of the Solva variety.

Under conditions of a long day, earing appeared at first at the Pendragon and Solva varieties (9 July), later at the Kymon variety and the last was the Gerald variety. An early-maturity character of particular varieties can be concluded from this. In the case of the Gerald variety, the greatest delay in the time of earing due to a short day – as late as after 80 days – can be proved, while the Kymon and Solva varieties showed earing after 74 days, and the

Table 5. Date of earing and number of days from emergence until earing

Variety	Variant	KD	6	5	4	3	2	1	KK
	number of long days	80	42	35	28	21	14	7	0
	number of short days	0	39	46	53	60	67	74	81
Gerald	date of earing	23. 7.	23. 7.	23. 7.	30. 7.	6. 8.	12. 8.	–	–
	number of days	52	52	60	60	74	74	0	0
Kymon	date of earing	15. 7.	15. 7.	23. 7.	23. 7.	6. 8.	6. 8.	–	–
	number of days	52	52	60	60	74	74	0	0
Pendragon	date of earing	9. 7.	9. 7.	9. 7.	9. 7.	23. 7.	–	–	–
	number of days	46	46	46	46	60	0	0	0
Solva	date of earing	9. 7.	9. 7.	15. 7.	15. 7.	23. 7.	6. 8.	–	–
	number of days	46	46	52	52	60	74	0	0

KD – control on a long day for the whole time
KK – control on a short day for the whole time

Pendragon variety after 60 days. The last variety had the most delimited period of photoperiodic sensitivity, though.

DISCUSSION

In the case of the first collection of winter oats varieties (Maris Quest, Pedarn and Peniarth), the length of vernalization was in the range of 21–29 days, the check spring oats variety Český žlutý did not show any reaction to vernalization.

In the case of the second collection of varieties (Gerald, Kymon, Pendragon and Solva), it was quite difficult to prove a manifestation of vernalization, and that only in the range of 10–20 days. Such temperatures can be considered only for quantitative effect of low temperatures influence only on the growth, but not for a precondition for a passage into the generative period. Such a reaction was recorded for five varieties of winter oats by McDaniel and Barr (1994), and for 25 varieties in the USA by King and Bacon (1992). When we to compare these figures with other varieties of winter or overwintering varieties, they are closest to winter barley varieties. For examples, winter barley varieties cultivated in the Czech Republic in the sixtieths – six-row varieties Stupický and Pavlovický – had the length of vernalization 22–24 days (Petrová and Petr 1959). In addition, two row varieties of winter barley cultivated later had short vernalization (Alraune 20–30 days, Danilo 20–30 days, Famosa 20–30 days, Marinka 20–30 days, new breeding KM 948 30 days, and the multi-row variety Borwina 30–40 days) (Štolcová and Capouchová 1995).

A direct study of vernalization of English varieties of winter oats was carried out by Hugh and Naqui (1991), who also determined a weak reaction to vernalization, and even permitted that the evaluated varieties Solva, Lustre, Kymon, Sun II and Trafalgar can reach earing under conditions of a long day without vernalization. They also refer to Sampson and Burrows (1972) that the requirement of vernalization in the case of winter oats is more facultative than obligatory. We tested the reaction to vernalization of the above-mentioned varieties Solva and Kymon in the next collection, together with the varieties Gerald and Pendragon, and a very low effect of low temperatures was proved again – for the Pendragon variety 10 days, for the Kymon and Solva varieties 10–20 days, and for the Gerald variety 20–30 days. Moreover, we can add results of the last experiment with winter oats varieties Silwi, Pewi and Wiskas, already originating in continental breeding of the Lochow Petkus company (Federal Republic of Germany) that overwintered well in Central Bohemia in the last years 1997–2000. Nonetheless, neither of these varieties have a significantly longer vernalization, just 10–20 days, which is inefficient from the point of view of the development.

To summarize these facts, the need for low temperatures – vernalization is not a control factor for slowing down the development until an arrival of winter and overwintering in the case of the evaluated varieties. Thus, we can assume that it will be the second important factor – an inhibition effect of a short day – that will take part in the control. We investigated it by means of a photoperiodic experiment determining the length of the induction period, i.e. the time of exposition to a long day necessary for the passage into the generative stage, expressed by a degree of differentiation of a shoot apex and by earing. Ten to fifteen long days were enough for the spring oats variety to pass into the generative stage; there were differences for winter varieties. The Maris Quest variety had the longest period 30 days, Pedarn 25 days, Peniarth 20 days. The development of plants was inhibited at most in the case of the Maris Quest variety, followed by the Peniarth variety, and at least in the case of the Pedarn variety. This could point out to an order according to winterhardiness, since there are correlations between the sensitivity to a short day and frosthardiness (Oquist and Huner 1991).

As concerns the second collection of varieties, the induction period was not delimited so explicitly. It was 21 long days in the case of the Pendragon variety, and it amounted to just 14–21 long days in the case of varieties Gerald, Kymon and Solva. The Gerald variety showed earing as the latest, which could betray a greater sensitivity to a short day.

The above-stated figures concerning the induction period were rather short, and the level of sensitivity to a short day was rather weak in this experiment. Again, a comparison with winter barley varieties is on hand; this period amounted to 24 and 36 days in the case of the originally cultivated varieties of multi-row barley Stupický and Pavlovický, where Pavlovický was winter-hardier (Petrová and Petr 1959). Similarly, relatively short induction periods were recorded for two row winter barley, too – 21 days in the case of the varieties Alraune, Danilo and Famosa, 28 days in the case of the Marinka and Borwina varieties. This comparison shows some similarity in the reaction to the length of a day with winter oats varieties, However, even so it is obvious that winter oats varieties have not reached such a reaction to the length of a day as winter barley that, due to their frosthardiness and winterhardiness, compare favorably in mass farming under conditions of the transient climate of Bohemia and Middle European countries. We must add that winter conditions of the last ten years are in question, substantially milder than in the previous decades.

Eventually, we can compare it in the case of the last collection of winter oats varieties from Germany – Silwi, Pewi and Wiskas. In the winters 1998,1999 and 2000, these varieties proved good overwintering in variety trials as well as on larger experimental areas. An evaluation (in points 9–1) of winterhardiness in two-year provoking experiments when sown into wooden boxes placed at the surface and in the height of 1 m, gave the following results: Pewi 3, Silwi 3.5, Wiskas 4; winter rye Daňkovské nové 8.5, winter barley Marna 4, and winter wheat Samanta 8.

A further evaluation of frosthardiness was done by means of the lethal temperature LT 50, which is a temperature that causes dying off of 50% of plants (Prášil et al. 1989). The critical temperature was observed on 12 February 1997, namely –8.8°C for the Wiskas variety, –6.5°C for the varieties Pewi and Silwi, while LT 50 for rye was –14.2°C, for wheat –13.2°C, and for barley –12.1°C. In 1998, LT 50 was –7.3°C for Wiskas, for Pewi –9.1°C, and for Silwi –6.5°C. In 1999 (sampling on 16 December), LT 50 was –8.8°C for Silwi, –10.7°C for Wiskas, and –10.1°C for Pewi. Marschal et al. (1998) evaluated winter oats varieties in a similar way in the USA, searching for varieties that would resist to –12°C. They found only three varieties out of a whole collection of cultivated ones. To compare these LT 50 figures with those for two row barleys, a 9-variety (Lunet, Labela, Pastoral, Famosa, Marinka, Monaco, Kira, Magie and Colombo) mean value of LT 50 proved to be in the range from –10.0°C to –12.0°C in a 3-year trial (Štolcová and Capouchová 1995). It follows that not even the above-mentioned new varieties of winter oats reach the figures of frosthardiness of distichous winter barley that is showing rapid spread in Central Europe. However, frosthardiness of varieties in the beginning of two row winter barley breeding was also low, and hence, we can expect a progress in breeding of winter oats forms as well.

From the point of view of control factors conditioning overwintering, we determined little need for low temperatures – vernalization that has only a quantitative nature and does not precondition the passage into the generative stage. However, some sensitivity to a short day showed; we evaluated it according to the degree of a development inhibition by a short day and according to the length of the induction period. Again, the same reaction as in the case of two row winter barley varieties manifested itself. It indicates that breeding of winter oats varieties can proceed in the same direction as in the case of distichous winter barley.

We presume some future for winter oats in European grain production, too, since it is more productive than spring forms, has some health qualities, we determined a higher content of proteins and a lower share of glumes than in a case of control spring varieties cultivated under the same conditions. In foreign papers, some other qualities in the content of nutritionally significant compounds are mentioned, e.g. a lower content of beta glucans.

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Received on September 17, 2001

ABSTRAKT

Fyziologická podstata přezimujících forem ovsa

U tří souborů odrůd ozimého ovsa (1. Pedarn, Maris Quest, Peniarth; 2. Gerald, Solva, Kymon, Pendragon; 3. Pewi, Silwi, Wiskas) jsme ve srovnání s odrůdami jarního ovsa sledovali potřebu nízkých teplot (jarovizaci) a fotoperiodickou reakci. U všech tří souborů odrůd byla potřeba nízkých teplot malá, většinou jen 10–20 dní, což nepředstavuje obligatorní potřebu, a tento vliv je jen kvantitativní a není podmínkou pro přechod rostlin do generativního období. Jen u odrůdy Maris Quest se blížila potřeba jarovizace 30 dnům. Při srovnání s reakcí odrůd ozimého ječmene, které měly a v některých letech mají horší přezimování v ČR, se shoduje délka jarovizace. Ve fotoperiodickém pokuse se ukázalo, že rozhodující podmínkou možnosti podzimního výsevu a přezimování je reakce na krátký podzimní den, který u těchto odrůd inhibuje vývoj do nástupu zimy. Tuto reakci jsme posuzovali podle délky indukčního období. U jarního ovsa odrůdy Český žlutý bylo toto období jen 10–15 dní, u odrůd ozimého ovsa Maris Quest 30 dní, Pedarn 25 dní, Peniarth 20 dní a Pendragon 21 dní, u odrůd Gerald, Kymon a Solva bylo indukční období 14–21 dní. Ve srovnání s hodnotami zjištěnými u ozimých ječmenů měly fotoperiodické indukční období delší. Zkoumané odrůdy ozimého ovsa nedosahují takového stupně reakce na krátký den, což se projevuje v jejich menší mrazuvdornosti než u ozimých ječmenů. To jsme také potvrdili v provokačních zkouškách na mrazuvzdornost a též nižšími hodnotami kritických teplot pro uhynutí 50 % rostlin, tzv. LT 50.

Klíčová slova: oves *Avena sativa* L.; ozimé odrůdy; přezimování; jarovizace; fotoperiodická reakce

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