Changes in requirements on vernalization of winter wheat varieties in the Czech Republic in 1950–2000

J. Petr, F. Hnilička

Czech University of Agriculture in Prague, Czech Republic

ABSTRACT

The need for vernalization of winter wheat varieties cultivated in the Czech Republic in 2000 was studied in comparison with the need for vernalization in the past decades since 1950. In 2000, many foreign varieties were cultivated in the Czech Republic, mostly West European. Varieties with a vernalization of 40–50 days and 50–60 days show the highest representation in the assortment (47.3% and 31.6%, resp.). The share of varieties with a long vernalization over 60 days is 15.8%. In around 1990, when varieties of domestic breeding were mostly grown, there were, next to the largest group with a vernalization of 40–50 days, 21.7% of varieties with a vernalization of 30–40 days and the same amount with a vernalization of 50–60 days. During the last ten years, the share of varieties with a longer vernalization has risen, not only due to foreign varieties, but also due to new domestic varieties. It is apparent from a 50-year overview that what has predominated are varieties with a vernalization of 40–50 or 40–60 days, which is a range usual for winter varieties of wheat in Middle and West Europe. After 1950, a departure from original domestic varieties appeared; those were represented by original alternative varieties (in Czech pøesívky, in German Wechselweizen, in Russian dvuručki) and half-winter varieties with a shorter vernalization, strictly speaking with a vernalization fixed to a short day, and a strong photoperiodic reaction. Representation of varieties as related to their length of vernalization has changed in the course of the decades following utilization of foreign varieties; this was affected above all by varieties from Russia (the former USSR), Germany, but also Yugoslavia. Varieties from these countries were utilized also as parent components in domestic breeding.

Keywords: winter wheat; *Triticum aestivum* L.; varieties; vernalization; individual development; winter character

Among many characteristics and features of winter wheat varieties, the character of their individual development, studied mainly in relation to their need for vernalization and their reaction to the length of a day, plays also its role. It is related to the level of their winter character, which is known from the theory of a stage development that widely stimulated a study of these problems in the 1950th. The above-stated result was proved by many authors also in the recent years, e.g. Miao-GY et al. (1993). These studies proved also a conclusive relation to the length of a vegetative period and to the earliness of the variety, which is again documented in results of a number of authors, e.g. Košner and Pánková (1997a), Slafer and Rawson (1995), Slafer (1996), and many others. The relation of development processes to the winter-hardiness has manifested itself for some varieties directly, e.g. through a correlation with the tendency to winter killing Schmütz (1977), and for some varieties indirectly, e.g. Mahfoozi et al. (2000), who stress the regulative effect of a short day in the relation to over wintering. Also a relation to the time of restoring of spring vegetation, when varieties with a finished vernalization and a specific sensitivity to a short day restore the spring vegetation earlier, they can form the base of the ear for a longer time, and they are more demanding of early regenerative fertilization, which is already connected with forming of yield elements. However, there is also the role of a short day for forming of a larger number of tillers (Petr 1975, Petr et al. 1983, Knighst et al. 1993). All these manifestations of relationships are determined geneticall-y and controlled by respective genes, proved by numerous studies in recent years, e.g. those of Miura and Worland (1994), Worland et al. (1996), and Košner and Pánková (1997b).

As concerns agronomy, deviations in development can reflect in requirements for the sowing time, which was described in this country earlier by Foltýn et al. (1970), and in Australia by Penrose et al. (1991), further in the system of separated nutrition, to an exact application of pesticides and growth regulators, and mostly in the relationship to indicators of the speed of development (Petr et al. 1983).

The knowledge of the character of development manifested in a vernalization and photoperiodic reaction can serve a background for recognizing varieties in relation to their relationship to geographic conditions of their origin, as described for the first time by Razumov (1965), and recently by Worland et al. (1996). These data improve the description of varieties and enable to derive their behavior in the mentioned areas and in agronomy. They can provide important information also for practical breeding, namely for a successful selection of parent components. In Czech sources, important results in this field can be found in papers by Košner (1992), and Košner and Pánková (1997a, b).

In this paper, we introduce results of a study of the need for vernalization of registered varieties of wheat

Table 1. Vernalization length of winter wheat varieties in the Czech Republic in 1990

Variety	Vernalization length (days)	Variety	Vernalization length (days)
Agra	44	Odra	35–44
Blava	44–53	Regina	44–53
Branka	44–53	Roxana	44
Danubia	44	Selekta	44–53
Hana	44–53	Senta	35–44
Iris	35	Simona	44–53
Ilona	44	Slavia	53
Košútka	35–44	Sofia	44
Livia	35–44	Sparta	53
Mara	44–53	Vala	53
Mironovská 808	49–53	Viginta	44–53
		Zdar	50–53

cultivated in the Czech Republic about 1990 and 2000. We also provide an overview of changes in the need for vernalization of the winter wheat assortment cultivated since 1950, from the paper by Teltscherová (1964), and from studies of the Czech University of Agriculture in Prague (Petr 1966, Balková 1973, Petr et al. 1983).

MATERIAL AND METHODS

In 5-year and later 10-year intervals since 1951, we have studied the length of vernalization of registered winter wheat varieties in the former Czechoslovakia and (since 1990) in the Czech Republic. The methods for determining the necessary length of vernalization were classic ones, and over the whole period basically the same, as described in detail in the paper by Balková (1973). Germinated grains were, for a definite interval, exposed to the vernalization temperature of 3–5°C. The grains were moistured in water for 24 to 36 hours under the temperature of 20°C, and then, evidently springing up, placed into a refrigerator with the above-mentioned temperature registered by a thermo hygrograph. The interval for putting into the refrigerator was seven days, and the total vernalization time was 56–63 days. After that time, grains vernalized for 7, 14 up to 56 or 63 days were sown on the same day together with an unvernalized control. Its grains were moistured and germinated under the room temperature for 48 hours. Germinated grains were planted, usually in the last decade of May, into growing pots, originally Mitscherlich, later plastic pots of the same size, and in field conditions into rows of 1 m each. Twenty plants were planted into a pot in two replicas. In each experiment, 20–25 varieties of the cultivated assortment were studied.

During the vegetation, plants were regularly watered and measured, and growth stages, or organogenesis stages of a shoot apex, and above all the time of earing were recorded. In some years (1960 and 1970), the vernalized varieties were kept also under a short day. Data in this paper are generated under the conditions of a long day (15–16 hours). Occurrence of minimum temperatures under 5°C was minimal during the experiment, and it could not terminate vernalization of the plants.

RESULTS AND DISCUSSION

The length of vernalization for varieties cultivated in about 1990 is given in Table 1. Varieties of Czech and Slovak breeding still prevail, when Soviet varieties were widely used as parent components (70% of varieties). Hence, the length of vernalization prevails in the range of the Soviet varieties, i.e. 40–50 days. To remind, Mironovska 808 had 49–53 days, Kavkaz 35, Jubilejna 42–44, Aurora 42, and Iljichovka 44.

In Table 2, there are results of varieties cultivated in 2000. We stress again that the main goal of the trial was screening of the length of vernalization to complete the 50-year overview of requirements on vernalization.

Table 2. Number of days until earing for different vernalization length of varieties in 2000

Variety	Vernalization length				Variety	Vernalization length			
Weeks	8	6	4	2	Weeks	8	6	4	2
Alana	62	81	0	0	Niagara	85	101+	0	0
Apache	64	78	95	0	Samanta	50	60	89	0
Brea	101	0	0	0	Sepstra	64	92	0	0
Contra	78	0	0	0	Siria	60	78	101	0
Drifter	70	101	0	0	Sulamit	92	0	0	0
Ebi	64	92	101	0	Šárka	57	0	0	0
Elpa	50	57	95	101	Tower	64	78	85	0
Estica	53	78	85	0	Versailles	60	70	78	0
Ludwig	101+	0	0	0	Vlasta	64	0	0	0
Nela	85	0	0	0					

+ less than 50% of plants showed earing

Table 3. Vernalization length of winter wheat varieties in the Czech Republic in 2000

Variety	Vernalization length (days)	Variety	Vernalization length (days)
Alana	40–50	Niagara	50–60
Apache	40–50	Samanta	40–50
Brea	> 60	Sepstra	50–60
Contra	50–60	Siria	40–50
Drifter	50–60	Sulamit	> 60
Ebi	50–60	Šárka	40–50
Elpa	30–40	Tower	40–50
Estica	40–50	Versailles	40–50
Ludwig	> 60	Vlasta	50–60
Nela	50–60		

First, an overview of number of days necessary from sowing to earing (until 50% of plants has eared in the experimental pot) is shown. The length of vernalization is given in weeks as usual in contemporary literature.

According to the time from sowing to earing, we can name varieties that showed earing at first and then step-by-step, after a full vernalization of 8 weeks:

1. The following varieties were earing after 50–60 days: Elpa, Estica, Samanta, Šárka and Siria
2. The following varieties were earing after 60–65 days: Alana, Apache, Ebi, Sepstra, Tower, Versailles and Vlasta
3. The following varieties were earing after 70–85 days: Drifter, Contra, Nela and Niagara
4. The following varieties were earing after more than 90 days: Brea, Ludwig and Sulamit

Further, we can name varieties with an obligatory (strong) need for a full vernalization, when one to two-week deficit in vernalization does not allow the plants to reach earing. The following varieties belong to this category: Brea, Contra, Ludwig, Nela, Niagara, Sulamit and Vlasta.

Varieties with a wider range of the need for vernalization follow: Apache, Ebi, Estica, Versailles, Samanta, Siria, Šárka and Tower. The Elpa variety showed a peculiar result, when plants with a 2-week vernalization eared, which is to be verified.

According to the previous sorting of varieties based on the length of vernalization in days, when representation of varieties in a particular collection is expressed in percentage, the Elpa variety had the shortest vernalization. Most of the varieties (47.3%) had their vernalization in the range 40–50 days, one third in the range 50–60 days, and almost 15% of varieties had a very long vernalization over 60 days (Table 3).

We may suspect that the shift was caused by a larger number of foreign varieties that fulfilled the conditions for an entry into the State Variety Book in the state variety trials, and that brought many changes in characteristics and features. However, also new varieties from domestic breeding seem to be characterized by a long vernalization. As compared with the year 1990, a shift has appeared from the group of varieties with a vernalization of 40–50 days to the group of varieties with a vernalization longer than 50 days (Nela, Niagara and Vlasta), and even over 60 days (Brea and Sulamit). Out of the collection examined, already up to 50% of varieties is classified in this category. The proportion of varieties with a vernalization of 30–40 days has decreased.

From these data, we can derive some practical knowledge. Above all we can mention the relationship between the length of vernalization and the tendency to winter killing, when Schmütz (1977) found significant correlations in 2-year trials: for 64 varieties a correlation $-0.69^{++,}$ and for 66 varieties a correlation -0.82^{++}. Thus, the longer the vernalization, the lower the tendency to winter killing. This relationship did not show in the collection of our varieties in all experimental periods. Above all not in the case of original varieties of alternative and half-winter forms, but also not in further periods of study of the relationship between vernalization and winter hardiness, and we do not expect it in the case of the current assortment, where number of varieties with a long vernalization has grown. Hence, it should be stressed that there is a significant relationship between the length of a day and over wintering for many varieties, which was discovered by Schmalz (1957) a long time ago, and confirmed recently by other authors. Today, it rather holds that the reaction to the length of a day may play a role in the stability of winter hardiness, which is important particularly under our conditions.

The length of a day is a stronger factor than the temperature, and it inhibits the development until the arrival of winter. Under a slower development, plants or their tillers do not overstep the critical limit of a shoot apex differentiation, and so they are not damaged by frost. This was observed also by Fujita (1997). In spring, a short pre-spring day does not enable a premature transition into the generative stage, and hence, plants are not damaged by frost. Mahfoozi et al. (2000) even presents that a short day raises the level of the lethal temperature, or it maintains resistance values attained for a longer time. To be a winter crop does not automatically mean frost hardiness or winter hardiness. The winter character is based genetically and controlled by definite genes (Košner and Pánková 1997a). Over wintering is, however, a relative notion depending on individual conditions of the winter in the place of cultivating. After all, in the last decade of mild winters, many spring forms of cereals, oil plants, and legumes have over wintered also in Bohemia.

As we have already mentioned above, varieties with a long vernalization should belong rather to late ones; however, this does not agree for all varieties according to their description. Similarly as above, the influence of the day length may manifest itself here, or the manifestation of vernalization under different lengths of a day, or a series of other characteristics of varieties, which we also had observed earlier (Petr 1966) and which are mentioned by Košner and Pánková (1997b), too.

Another practical relation derived from the length of vernalization is a recommendation of earlier sowing of varieties with a long vernalization, as stated by Foltýn et al. (1970). Earlier sowing is recommended in the case of West-European varieties that have a longer vernalization; however, the reasons are not related to the longer vernalization. Earlier sowing makes for changes in coming of individual growth stages, and thus forming of yield elements and the final yield (Slafer and Rawson 1995, Slafer 1996).

When early sown, varieties create tillers that are more productive; they may be sown with a lower sowing rate. Formation of the ear base is transferred into the period of a shorter pre-spring day and a lower temperature; hence, it longs longer, which results in a higher productivity of ears. Just the new varieties create their yield usually by the productivity of ears. It was stated also by Metho et al. (1999), when a higher number of grains in the ear and larger grains were reached under a lower temperature and the length of a day of 11–13 hours. Knowledge of variety's development distinctness as related to conditions for yield element formation shows to be important for productivity of plants.

Changes in the length of vernalization in the assortment of winter wheat varieties

Changes in representation of varieties according to their length of vernalization in the variety composition since 1950 until 2000 are given in Figure 1 and Table 4.

Varieties with a short vernalization but a strong sensitivity to a short day were cultivated in the first monitored period. These were alternative forms that might be sown both in autumn and in spring, originating in regional varieties cultivated in the transition climate of Bohemia since the 17th century. They show the need for a low temperature only under conditions of a short day. Similar properties could be found also in the case of so-called half-winter varieties, as Chlumecká 12, Stupický Bastard or Dobrovická 10 used to be.

Another wider group of that time were Moravian varieties – awned and bare wheats with a vernalization of 32–40 days. Original Slovak varieties (Slovenská B, Slovenská intenzívná, Slovenská 777, Slovenská 200) had all a vernalization of 30–35 days, just some of them, e.g. Viglášská, Radošínská Karola and Košútská had a longer vernalization of 40–42 days.

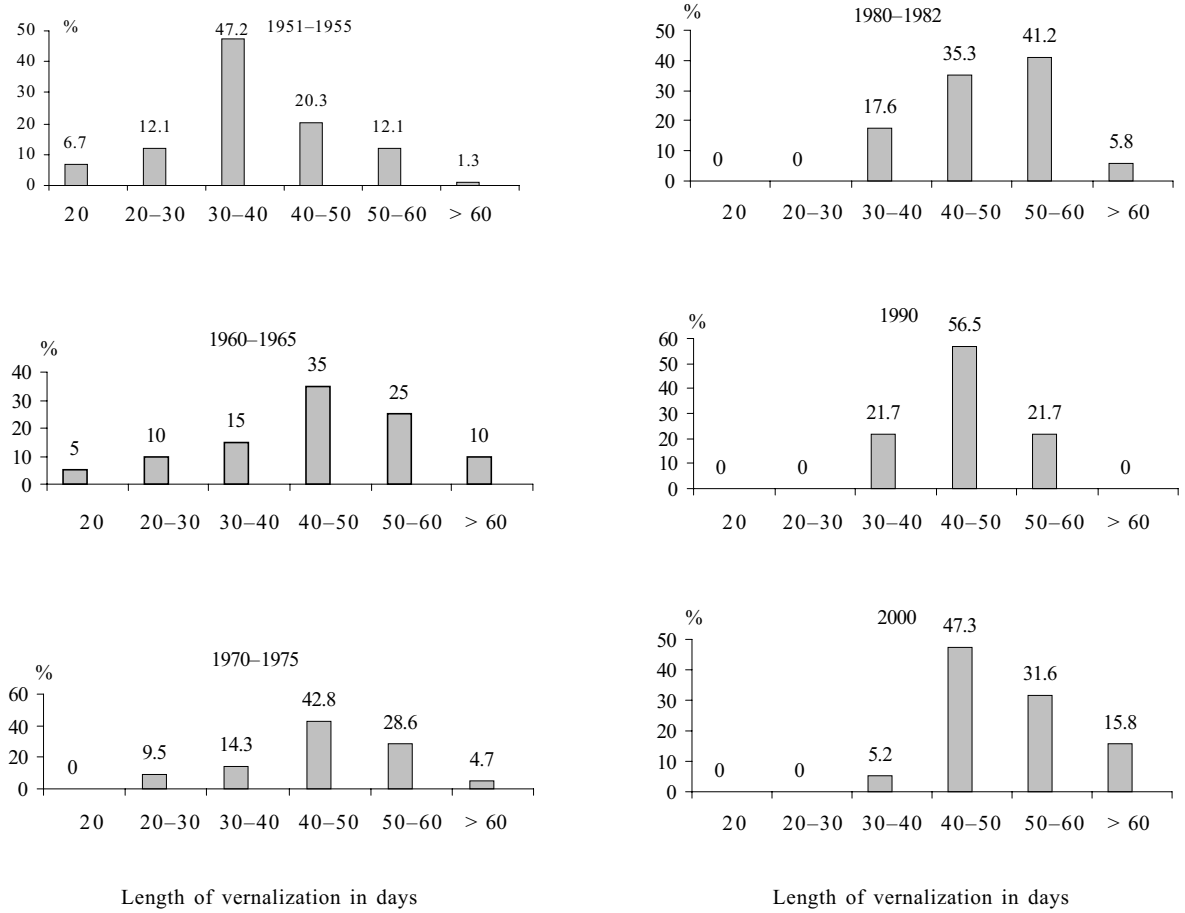

Figure 1. Length of vernalization in days (percentage representation of wheat varieties according to the length of a vernalization of varieties cultivated 1950–2000)

Table 4. Representation of winter wheat varieties in % according to the length of vernalization in the years 1950–2000

Period of evaluation		Representation of varieties according to vernalization length					
Days		< 20	20–30	30–40	40–50	50–60	> 60
1951–1955	No.	5+	9++	35	15	9	1
	%	6.7	12.1	47.2	20.3	12.1	1.3
1960–1965	No.	1+	2++	3	7	5	2
	%	5	10	15	35	25	10
1970–1975	No.	0	2	3	9	6	1
	%	0	9.5	14.3	42.8	28.6	4.7
1980–1982	No.	0	0	3	6	7	1
	%	0	0	17.6	35.3	41.2	5.8
1990	No.	0	0	5	13	5	0
	%	0	0	21.7	56.5	21.7	0
2000	No.	0	0	1	9	6	3
	%	0	0	5.2	47.3	31.6	15.8

+ alternative forms, ++ half-winter forms

In 1959–1962, a principal restriction of these original varieties took place, and varieties of post-war breeding appeared; out of them, Kaštická osinatka with a vernalization of 44 days and Diana I. with a vernalization of 50 days should be mentioned. At the same time, some foreign varieties have been introduced, such as Fanal, and Hadmerslebener Qualitas with a vernalization of 50–60 days.

In the 60th and 70th, Soviet varieties made a significant change in the composition of varieties, above all Mironovská 808 with a vernalization of 49–53 days, cultivated for a long-time, and further Jubilejná and Ijichovka with a vernalization of 44 days. The collection of varieties of Krasnodar breeding – Kavkaz, Aurora and Bezostá 1 had a shorter vernalization of 35–42 days.

For a short time, Yugoslavian varieties with a vernalization of 35–44 days (Super Zlatna and Baranjka) were also represented in our assortment. In the end of the 70th and the beginning of the 80th, varieties of domestic breeding come across next to Soviet varieties, although again with Soviet varieties background. The length of vernalization in the years 1980–1982 we have studied in seventeen varieties: Amica, Baranjka, Grana, Hela, Istra, Jubilar, Juna, Košutka, Lena, Mirela, Mironovská zlepšená, Odra, Regina, Slavia, Solaris, Super Zlatna and Vala (Petr et al. 1983). One should remind the variety Slavia with a vernalization of 53 days that was excellent also in foreign variety trials. Since 1985, a series of domestic varieties from Stupice were registered (Selekta, Sofia, Simona, Senta, Samanta, Sida, Siria and others), with a vernalization of 44–53 days, Sulanit even over 60 days. Similarly, varieties from Uhřetice had a vernalization of 44–53 days, e.g. Regina, and the famous variety Zdar had a vernalization of 50–53 days.

Varieties of Moravian breeding (Branišovice and Hrubčice) constituted an important contribution for our grain production; varieties with a high baking quality came from there. The length of a vernalization is in the range 44–53 days; varieties of recent years have a longer vernalization of 50–60 days, and the variety Brea even more than 60 days.

As compared with the previous period, there is a shift towards a longer need for vernalization in the collection of varieties, not only in the case of foreign varieties, but also in the case of varieties of domestic breeding. This shift towards typical winter forms does not guarantee higher winter hardiness and frost hardiness, however, these qualities tend to be connected.

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ABSTRAKT

Změny v požadavcích odrůd ozimé pšenice v ČR na jarovizaci v období 1950–2000

Délka jarovizace a reakce na délku dne patří mezi významné vlastnosti odrůd ozimé pšenice. Souvisí se stupněm ozimosti, délkou vegetační doby, raností odrůdy, průběhem fází růstu a formováním výnosových prvků. Práce přináší výsledky sledování potřeby jarovizace registrovaných odrůd ozimé pšenice kolem roku 1990 a 2000, a doplňuje tak údaje o požadavcích odrůd na jarovizaci od roku 1950 v desetiletých intervalech. Byla použita klasická metodika jarovizace, kdy se naklíčené obilky vystavovaly teplotě 3–5°C v sedmidenních intervalech od 0 do 56–63 dní. Pokus byl veden ve vegetačních nádobách po 20 rostlinách a ve dvou opakováních za dlouhého dne 15–16 hodin. Hlavním kritériem byla doba metání (50 % rostlin ve variantě), podle které se určila příslušná délka plné jarovizace, která je uvedena u jednotlivých odrůd v tab. 1 až 3. Okolo roku 1990 byl rozhodující podíl odrůd domácího českého, moravského a slovenského šlechtění, kdy převažovaly odrůdy s jarovizací 40–50 dní, a vedle nich ve stejném poměru (21,7 %) byly odrůdy s jarovizací 30–40 dní a 50–60 dní. V roce 2000, kdy bylo registrováno mnoho zahraničních odrůd, zůstává sice největší podíl odrůd s jarovizací 40–50 dní, ale zvětšil se podíl odrůd s delší jarovizací, tj. 50–60 dní a dokonce i více než 60 dní, a to nejen u odrůd zahraničních, ale i odrůd domácího šlechtění. Z padesátiletého sledování délky jarovizace u odrůd pěstovaných v Československu a později v České republice převažovaly v sortimentu odrůdy s jarovizací 40–50 dní, resp. 40–60 dní, což je rozmezí pro ozimé formy pšenice ve střední a západní Evropě. Po roce 1960 nastal odklon od původních odrůd pšenice, které v Čechách představovaly odrůdy přesívek a poloozimů, s krátkou jarovizací, resp. s jarovizací jen za krátkého dne a obecně se silnou reakcí na krátký den. V jednotlivých desetiletích se do změn délky jarovizace sortimentu odrůd promítaly vstupy zahraničních odrůd, např. ruských (z bývalého SSSR), německých, jihoevropských a západoevropských.

Klíčová slova: ozimá pšenice; *Triticum aestivum* L.; odrůdy; jarovizace; individuální vývoj; charakter ozimosti

Corresponding author:

Prof. Ing. Dr. h. c. Jiří Petr, DrSc., Česká zemědělská univerzita v Praze, 165 21 Praha 6-Suchdol, Česká republika,
tel.: + 420 2 24 38 25 46, fax: + 420 2 24 38 25 35, e-mail: jpetr@af.czu.cz