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Physiological and genetic features of the rate of development of modern varieties of soft wheat (Triticum aestivum L.)

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Goal. Assessment of levels of vernalization demand, photoperiodic sensitivity, frost resistance, and identification of alleles of Vrn1 and Ppd1 genes of two-handed varieties of soft wheat. **Methods.** Field: growing plants in the conditions of shortened and extended days of phytotron and vegetation site; hybridological analysis by photoperiodic sensitivity genes (Ppd1) and type of development (Vrn1); analysis of variance and correlation; criterion c2; multiplex STS-PCR with specific primers to the PpdD1 gene. **Results.** Phenotypic differences of the studied varieties in response to vernalization and sensitivity to the photoperiod were revealed. 5 groups of varieties with different Vrn1 and 2 groups of varieties with different Ppd1 genotypes were identified. Winter and frost resistance of two-handed varieties in the tillering and seedling phase, as well as the reaction of two-handed varieties for the duration of the period before earing to winter and spring sowing dates, were assessed. **Conclusions.** Varieties Demir 2000, Shestopalivka are winter varieties with low sensitivity to the photoperiod, others are typically spring with weak (Solomiia, Pallada, Afina, Yara, L897Я23) or strong (Lastivka, Khutorianka, Zimoiarka) sensitivity to the photoperiod. Weak reaction to the photoperiod of Afina, Pallada, Solomiia, Shestopalivka, Yara, Demir 2000, L897Я23 varieties is caused by the PpdD1a gene. Varieties Lastivka, Khutorianka, Zimoiarka are carriers of only recessive alleles of 3 genes of the orthological series Ppd1. The spring type of development of Zimoiarka and Khutorianka varieties is caused by 2 genes VrnA1a and VrnB1a, Afina, Lastivka, L897Я23 — by genome VrnD1a, Solomiia — by VrnA1a, Pallada and Yara — by VrnB1a. The presence in the genotype of varieties at once of two genes — VrnA1a and VrnB1a, or only one — VrnA1a, and in some cases — only VrnD1a, contributes to a significant reduction in frost resistance of seedlings and winter hardiness of two-handed plants. Winter and spring sowing dates cause the shift of earing time to much later calendar dates compared to sowing in autumn, which can negatively affect the formation of the yield of two-handed varieties.
Key words: *Vrn1 and Ppd1 genes, vernalization, photoperiod, earing, winter, frost resistance.*
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The response of plants to low positive temperatures (vernalization) and the duration of lighting (photoperiodism) are the basic mechanisms of the regulation process of wheat ontogenesis [1]. The response to vernalization in the initial ontogenesis period for the subsequent passage to generative development is the main feature that allows distinguishing typically winter wheat genotypes from typically spring. Winter wheat has a significant need for vernalization, while the spring may be non-sensitive or partially sensitive to vernalization. Both spring and winter genotypes can be sensitive or non-sensitive to the photoperiod. Qualitative differences in type of development are controlled by the genes of the orthologous series *Vrn-1*. The winter type of development is caused by the presence in the genotype only recessive alleles of these genes: *Vrn-A1b, Vrn-B1b, Vrn-D1b*. The presence in the genotype any dominant allele *Vrn-A1a, Vrn-B1a, Vrn-D1a* determines the spring type of development [2, 3]. The differences in photoperiodic sensitivity are due to the action of three *Ppd-1* genes located on the chromosomes of the second homeological group: *Ppd-A1, Ppd-B1, Ppd-D1*. The dominant alleles of these genes contribute to a decrease in sensitivity to the photoperiod, and a significant response to the photoperiod is inherent in genotypes with recessive alleles of all three genes [4, 5]. Transitional, alternative, facultative spring or facultative winter varieties are the genotypes that can develop and pass on to the generative development at both spring and autumn sowing. Alternative wheat is grown mostly in areas with mild winters. In the south of Ukraine, alternative varieties are suitable for late autumn and winter crops, in years with prolonged dry autumn [6]. The peculiarity of alternative varieties is a high sensitivity to shortening the day length and a spring type of development, that is, a inexpressive reaction to the vernalization [7, 8]. The significant delay in the development of alternative varieties in the autumn is due to the interaction of the *Vrn-1* and *Ppd-1* genes, in particular the dominant *Vrn-B1a* gene with recessive alleles *Ppd-A1b, Ppd-B1b* and *Ppd-D1b* [7]. At the same time, some authors [8] note the possibility of controlling the spring type of development of alternative varieties by dominant alleles of genes *Vrn-D1* or even *Vrn-A1*. Genotypes with dominant *Vrn-A1a* gene that do not respond to the photoperiod are typically spring varieties [9]. All other combinations of *Vrn-1* and *Ppd-1* genes effect on differences in spiking times [10] and resistance to frost [11]. Such genotypes can only be assigned to alternative in mild winters. However, hardening in both extended and shortened day duration provided a higher frost resistance of alternative varieties with the dominant *Vrn-B1a* gene [8, 12].

In numerous recent scientific and promotional publications on alternative wheat in Ukraine, unfortunately, there is no complete research on the physiology of development (ontogenesis) and the genetics of alternative genotypes [13, 14, 15]. This often does not determine the difference between true alternative and short-term winter varieties or spring cold-resistant genotypes.

The purpose of the study was to assess the levels of vernalization needs, photoperiodic sensitivity, frost resistance, and identification of bread wheat by alleles of *Vrn-1* and *Ppd-1* genes.

Materials and methods of researches. Varieties Afina, Lastochka, Pallada, Yarka, L897Я23 (Krasnodar Scientific Research Institute of Agriculture named after P.P. Luk'ianenko, Russia), Khutorianka, Zymoiarka (Institute of Plant Physiology and Genetics National Academy of Sciences of Ukraine, Kyiv), Solomiia (Kherson State Agrarian Univercity, Kherson), Shestopolivka (farm "BOR") were used as starting breeding material which are described by their authors as alternative [16-19]. Also were used variety Demir 2000 (which, according to the description of the Center for Genetic Resources of Ukraine, is alternative) and F_2 populations from the diallelic crossings of this varieties and crossing with almost isogenic monogeneously dominant by the *Vrn-1* genes of the Mironovskaya 808 or Skorospelka 3b populations. In various experiments, the winter variety Borvii of the PBGI-NCSCI breeding and alternative almost isogenic breeding line of the Mironovskaya 808 variety according to the *Vrn-B1a* gene (hereinafter Mironovskaya 808 Vrn-B1a) were used as a controls.

Seeds of varieties and F_2 populations from diallelic crossing were germinated at room temperature. Five-day seedlings were vernalized in the special chamber at + 2 °C and for a duration of day 12 hours: for varieties – 40, 30, 20, 10 days; for F_2 populations – 40 days. After the end of the vernalization, the seedlings were planted under artificial conditions in light phytotron chambers, ten plants in 5-liter vessels and one part of each variety was grown under a 16-hour prolonged day and the rest and F_2 populations – under a 12-hour shortened day. At the same time, not vernalizated five-day seedlings were planted under prolonged and shortened days. The reaction to the vernalization of a particular sample was determined by comparing the average date of its earing in two adjacent variants of the previous vernalization. The difference between the average duration of the period before earning of the variety after the vernalization under growing on the shortened and elongated day characterized its level of photoperiodic sensitivity.

Genetic analysis of half-diallelic F_2 hybrids by photoperiodic sensitivity was performed by this method [20]. The distribution of F_2 populations into the phenotypic classes of plants, which sooner and later earned under shortened day, was carried out according to the date of earning of the first plant of the Mironovskaia line 808 *Vrn-B1a*. Multiplex PCR with gene-specific primers was used to determine alleles of *Ppd-D1a* and *Ppd-D1b* [21].

Hybridological analysis by type of development and distribution of F_2 populations into the phenotypic classes of spring and winter plants was performed by the this method [22], with the only difference being that the plants were grown in 5-liter pots (ten plants per pot) at the growing area.

Frost resistance was assessed by freezing seedlings at -12^0C and using the "beams" method at -16^0C [23] in the freezing chamber. Winter hardiness was assessed in the field by accounting for plants in autumn and in spring season. Seeds of alternative varieties Demir 2000, Afina, Zymoiarka, L-897Y23, Lastivka, Pallada, Solomiia, Khutorianka, Shestopolivka, Yara and control samples winter variety Borvii and alternative line Mironovskaya 808 *Vrn-B1a* were sowned in autumn 2012, 2014 and 2015 (October 15, 9 & 20, respectively), as well as in different calendar terms during the winter and spring of 2013 (19.02, 05.03, 19.03 and 02.04) and 2014 (24.12.2014 and 25.02.2015) by manual planting on the experimental area of the General and Molecular Genetics Department of of PBGI - NCSCI on two row sections with length of 1 m by 20 grains per row with plant feeding area of 30x5 cm^2. Repeat the experiment - two to three times.

Dates of spiking of individual plants were marked in the phytotron and at the vegetation area during the growing season for determine the period before earning. In the field, the date of spiking was marked visually in the presence of 75% of the spiked plants in the area.

Statistical processing of the obtained results was carried out according to conventional methods of variance and correlation analysis, criterion χ^2 [24].

Research results. Comparison of the period duration before the spiking of alternative varieties plants after vernalization of different duration (term) under prolonged (PD) and shortened (SD) day of the climatic chambers of the phytotron indicated a significant influence of the genotype on the specified trait (Table 1). If as a criterion for evaluating the reaction to vernalization use the fact of earning or not earning a specific genotype after pre-vernalization of a certain duration, then the studied varieties can be divided into two groups. Varieties of the first group Afina, Zymoiarka, Lastivka, Pallada, Solomiia, Khutorianka, Yara, L897Я23 and control alternative line Mironovskaya 808 *Vrn-B1a* spiked by 41.6 days (Afina) - 89.9 days (Pallada) in conditions of PD regardless of the previous vernalization of different duration (40-10 days) and even in its absence. In the conditions of SD, the earning of the varieties Afina, Zymoiarka, Lastivka, Pallada, Solomiia, Khutoryanka, Yara, L897Y23 were noted at 43.1 days (Afina) - 97.5 days (Lastivka) both in the variant without vernalization, and after 10-40 days of the previous vernalization. However, in the absence, as well as in the vernalization of 10 and 20 days, the spiking of plants of the almost isogenic line Mironovskaya 808 *Vrn-B1a* (alternative genotype, control) was not observed in the conditions of SD. The gradual reduction of the vernalization duration to 30, 20, 10 days and to its complete absence contributed to the increase in the duration of the spiking period by 2.1 days (Solomiia) - 37.5 (Pallada) days in the variance without vernalization compared to the 40-day vernalization in the conditions PD and 8.3 days (Solomiia) - 41.3 (Yara) days in the conditions of SD. However, these genotypes differ in response to vernalization. Thus, in the artificial conditions of the phytotron chambers, the variety Solomiia almost did not respond to the vernalization by the acceleration of development (shortening the duration of the period to the earning). Zymoyarka and Khutoryanka varieties are smaller, and Lastivka - to a greater accelerated the development after 10 days of vernalization. The Afina and Yara varieties and the L897Я23 line responded significantly even to the 20-day vernalization. Of all the genotypes, the Pallada variety and the Mironovskaya 808 *Vrn-B1a* control line, which responded for 30 days of vernalization with the acceleration of the ear, are slightly different.

The varieties of the second group - Shestopalivka and Demir 2000 - responded to the vernalization similar to the control winter variety Borvii. The need for vernalization of the Borvii was 40 in the conditions of PD, and 30 days – of SD . Earning of varieties Shestopalivka and Demir 2000 were noted both in the PD and in the SD only after 30 days of vernalization. At the same time, in both cases, the 40-day vernalization significantly accelerated the spiking of these varieties by 16.9 - 21.3 and 18.4 - 19.7 days, respectively.

1. ***The duration of the period before spiking of alternative varieties in the conditions of prolonged (PD) and shortened (SD) days after temporal vernalization, days***

Varieties	Day	Duration of vernalization, days				Without vernali-zation	Slightest Signi-ficant Difference $_{0,05}$
		40	30	20	10		
Afina	PD	41,6	43,2	47,0	60,3	65,1	6,6
	SD	43,1	49,6	56,9	67,9	76,5	2,6
Zymoiarka	PD	50,8	50,9	54,4	49,8	56,3	1,7
	SD	59,8	68,3	96,0	86,6	96,4	6,6
Lastochka	PD	46,7	49,2	52,6	53,8	68,0	9,0
	SD	56,3	68,4	74,0	80,0	97,5	7,0
Pallada	PD	52,4	56,0	66,0	70,7	89,9	4,6
	SD	51,3	54,2	73,8	76,8	88,4	4,0
Solomiia	PD	44,7	55,9	43,8	42,4	46,8	7,0
	SD	44,7	56,8	52,6	52,3	53,0	4,6
Khutorianka	PD	43,6	47,5	48,1	46,3	53,3	1,8
	SD	54,9	74,0	82,2	77,5	80,7	8,9
Yara	PD	44,9	45,7	46,3	54,8	71,6	2,2
	SD	45,5	49,0	55,7	71,7	86,8	3,1
L897Я23	PD	42,0	41,8	48,0	62,1	64,0	3,9
	SD	45,2	47,6	57,0	64,7	69,9	2,8
Myronivska 808 *Vrn-B1a*	PD	55,2	60,5	70,1	80,4	85,4	2,9
	SD	94,4	105,8	n/s	n/s	n/s	8,2
Shestopalivka	PD	56,6	73,5	n/s	n/s	n/s	7,8
	SD	65,4	86,7	n/s	n/s	n/s	11,1
Demir 2000	PD	78,1	96,5	n/s	n/s	n/s	14,0
	SD	76,3	96,0	n/s	n/s	n/s	8,0
Borvii	PD	52,1	n/s	n/s	n/s	n/s	-
	SD	67,1	96,3	n/s	n/s	n/s	6,8
Slightest Signi-ficant Difference $_{0,05}$	PD	4,5	4,6	2,7	6,3	5,8	
	SD	4,4	6,8	4,5	6,3	6,6	

Note: n/s - plants did not spike in this version

So the varieties Shepopalivka and Demir 2000 are winter. For the passing to generative development of these varieties requires 30-40-day pre-vernalization by low temperatures. The varieties of Afina, Zymoiarka, Lastivka, Pallada, Solomiia, Khutorianka, Yara, L897Я23 and the control Mironivska 808 *Vrn-B1a* spiked in the conditions of PD in the absence of artificial pre-vernalization, so is spring.

Hybridological analysis of F_2 populations from test-cross alternative varieties with monogeneously dominant *Vrn-A1a* or *Vrn-B1a* or *Vrn-D1a* genes by type of development (spring and winter) revealed five groups of varieties with different genetic control of type development (Table 2). In particular, in the genotypes Khutorianka and Zymoiarka, two genes *Vrn-A1a* and *Vrn-B1a* of type development were identified. The alternative type of development of other varieties that have been spiked in the previous experiment without vernalization is controlled by a single gene. Solomiia has only the dominant allele *Vrn-A1a*, Pallada, Yara, as well as the control line Mironivska808 Vrn-B1a, – only the allele *Vrn-B1a*, Lastivka, Afina and line L897Я23 – only the allele *Vrn-D1a*. The Shestopalivka and Demir 2000, as well as the winter Borvii, which spiked only after 30-40 days vernalization, are carriers of only recessive alleles of all three genes of the orthologous series *Vrn-1* (genotype *Vrn-A1b Vrn-B1b Vrn-D1b*).

Reducing the day duration to 12 hours led to an increase in the period duration of the spiking of all varieties, regardless of the duration of the pre-vernalization (Table 1). In Demir 2000 and Pallada varieties, the conditions of the shorted day even contributed to acceleration of the development rate by 0.5 - 1.8 days with 40-, 30-day vernalization. According to the degree of spiking delay in the conditions of SD compared with PD varieties can be divided into two groups. Afina, L897Y23, Pallada, Solomiia, Yara, which did not respond or spiked under conditions of SD with a delay up to 3.2 days with 40 days vernalization and up to 15.2 days in the variant without vernalization can be characterized as low sensitive to the photoperiod [25].

Shepopalivka and Demir 2000 can also be included to this group of varieties, as well as control winter Borvii. The differences between PD and SD variants for these three genotypes after 40 days vernalization were 8.8, 1.8 and 15 days, respectively. The varieties of the second group (Lastivka, Khutorianka, Zymoiarka) showed significantly higher photoperiodic sensitivity.

2. ***The need for vernalization (NV), photoperiodic sensitivity (PhPS) and genotypes of modern alternative varieties by genes of the orthologous series Vrn-1 and Ppd-1***

Varieties	phenotype		genotype		Type of evelopment
	NV, діб	PhPS	*Vrn-1*	*Ppd-1*	
Myronivka - *Vrn-B1a* (control)	0	high	*Vrn-B1a*	*Ppd-D1b*	alternative
Zymoiarka Khutorianka	0	high	*Vrn-A1a Vrn-B1a*	*Ppd-D1b*	spring
Lastochka	0	high	*Vrn-D1a*	*Ppd-D1b*	
Afina L897Я23	0	low	*Vrn-D1a*	*Ppd-D1a*	
Yara Pallada	0	low	*Vrn-B1a*	*Ppd-D1a*	
Solomiia	0	low	*Vrn-A1a*	*Ppd-D1a*	
Demir 2000 Shestopalivka	30-40	low	recessive	*Ppd-D1a*	winter
Borvii (control)	30-40	low	recessive	*Ppd-D1a*	

The difference in the duration of the period before spiking between the variants of PD and SD of these genotypes after 40 days vernalization was 9.0 - 11.3 days. With the decrease in the duration of the pre-vernalization, the response to the 12-hour day increased in variety Lastivka up to 21.4 - 29.5; Khutorianka - up to 27.4 - 34.1 and Zymoiarka - up to 36.8 - 41.6 days. This value is like to that in the highly sensitive line Mironivska 808 *Vrn-B1a*, whose developmental delay in the conditions of SD compared to PD at 40-30 days vernalization was 39.2 - 45.7 days.

Genetic analysis of photoperiodic sensitivity (early : late plants) of F_2 populations derived from crossing alternative varieties according to the half-diallellic scheme confirmed the absence of differences in the genetic control of photoperiodic sensitivity, as in the group of low sensitive to photoperiod and also in group of high sensitive to photoperiod. However, splitting in F_2 populations into earler or later spiking plants in most combinations of the crossing of 4 high sensitive to the photoperiod varieties (Lastivka, Khutorianka, Zymoiarka and Mironivska 808 *Vrn-B1a* control line) on the one hand, with 8 varieties sensitive to the photoperiod (Demir 2000, Solomiia, Pallada, Yara, Afina, Shestopalivka, L897Y23, and winter Borvii), on the other hand, significantly corresponded to that with differences of parents by one gene.

According to DNA analysis the varieties Afina, L897Y23, Pallada, Solomiia, Yara, Shestopolivka and Demir 2000 are carrier of gene allel *Ppd-D1a,* the varieties Lastivka, Zymoiarka, Khutorianka and Mironivska 808-*Vrn-B1a – Ppd-D1a*.

The diversity of alternative varieties by alleles of *Vrn-1* and *Ppd-1* genes did not significantly affect on differences in winter-hardiness genotypes under field conditions in 2015/2016 (Table 3). Overall, the wintering level of alternative varieties was high – 87.6%. Most varieties wintered by 90-97%. Only the monogenouslly dominant by *Vrn-D1a* gene variety Lastivka (83%) and the dominant by two *Vrn-A1a* and *Vrn-B1a* genes Zymoiarka (75%) and Khutorianka (45%) observed a decrease in this indicator. At the same time, during freezing at –16^{0}C plants in the phase of tillering, which were selected from the field on 15.02.2016, alternative varieties, regardless of the presence of dominant gene *Vrn-1*, as well as winter Demir 2000 completely died. Only 30% of living plants of winter varieties Shestopalivka and Borvii and of alternative Mironivska 808 *Vrn-B1a* control line survived under these freezing conditions.

The freezing of seedlings at –12°C revealed significant differences between frost varieties. The duration of the day during quenching has a significant impact on the formation of frost resistance of the two hands. In general, the level of frost resistance of varieties during hardening under PD conditions (33% of living plants) is lower than that under hardening under DM conditions (47% of living plants). The freezing of seedlings at –12°C revealed significant differences between alternative varieties by frost resistance. The duration of the day during quenching has a significant impact on the formation of frost resistance for alternative varieties. In general, the level of frost resistance of varieties during hardening under PD conditions (33% of live plants) is lower than that under hardening under SD conditions (47% of live plants).

3. ***Winter hardiness and frost resistance of plants in the tillering phase at –16 ° C and seedlings at –12 °C during quenching of alternative varieties under prolonged (PD) and shortened (SD) days, % of living plants***

№	Varieties	Hardiness 2015/2016	Frost resistance		
			tillering	seedlings; SD	seedlings; PD
1	Afina	91	0	32	43
2	Zymoiarka	75	0	0	0
3	Lastochka	83	0	44	23
4	Pallada	94	0	45	51
5	Solomiia	90	0	13	0
6	Khutorianka	45	0	0	0
7	Yara	97	0	33	33
8	L897Y23	97	0	28	51
9	Myronivska 808 *Vrn-B1a*	92	29,2	71	41
10	Shestopalivka	97	24,3	62	65
11	Demir 2000	93	0	44	31
12	Borvii	97	33,9	85	61
	Slightest Significant Difference $_{0,05}$	-	-	15	18
	Average	87,6	7,3	47,3	33,3

Estimates of frost resistance of alternative varieties in the two hardening variants do not significantly coincide (r = + 0.71). As a result, some varieties (L897Y23, Afina, Pallada, Shestopalivka) formed higher frost resistance by 3 - 23% during the hardening of plants under PD conditions. Other varieties (Solomiia, Demir 2000, Lastivka, Mironivska 808 *Vrn-B1a*), on the contrary, showed a higher resistance to negative temperatures by 13 - 30% when hardened under conditions of SD. Regardless of the day duration during hardening, higher frost resistance is inherent in winter varieties Borvii and Shestopolivka. Spring varieties with *Vrn-B1a* or *Vrn-D1a* genes were lower in winter by 10 - 42%, and the carriers of the *Vrn-A1a* gene or *Vrn-B1a* gene were completely died. High level of frost resistance (71%) of the control line Mironovskaya 808 *Vrn-B1a* is close to the level of the control winter variety Borvii (85%) when hardening in the conditions of SD (actually in the field conditions of Ukraine autumn and winter day is less than 12 hours), so only the interaction of the dominant *Vrn-B1a* gene with the recessive alleles *Ppd-A1b, Ppd-B1b* and *Ppd-D1b* contributes to significant delay in the development under shortened natural day of autumn and winter and, as a consequence, the formation of better winter hardeness and frost resistance of alternative varieties.

Alternative varieties differ significantly in the duration of period before spiking, both in autumn sowing and in sowing in December, February or March (Table 4). At the same time, this feature was significantly influenced by the sowing period in the conditions of 2012/2013 and 2014/2015. Afina, Yara, Pallada, L897Я23, Khutorianka, Solomiia, Lastivka, Mironivska 808 *Vrn-B1a* spiked in both years of study regardless of the sowing period. However, under the shortening of the duration of the period before the spiking of the varieties under sowing in December, February, March and, especially, in April, compared with the autumn sowing, the calendar dates of spiking in winter and spring sowing come much later. Even with sowing in February (19-25), the spiking of these genotypes was observed in 2013 with early warm spring by 13-17, and in 2015 – with late cold spring – by 8.3 - 13.0 days later in compared to autumn sowing.

The main reason for this is the fact that all these genotypes are selected for and under the conditions of autumn sowing, perhaps even slightly later than optimal, but not in spring. Eating late will have a negative impact on the formation of elements of the crop structure and grain filling in the face of increasing drought in most years in the steppe. Spiking late will have a negative impact on the formation of elements of the crop structure and grain formation under increasing drought in most years in the steppe.

Demir 2000 and Shestopalivka varieties, as well as control winter Borvii, were sown on February 25, 2015, and the plants were spiked. In 2013, the aforementioned three varieties did not spiked at sowing on March 19 and later sowing dates, and Demir 2000 did not spiked at sowing on March 5. Probably, in these variants of the experiment, the duration of natural vernalization was insufficient to move to the generative path of development of these three genotypes. Unlike other spring varieties, the Zymoiarka responded to the spring 2013 sowing time, similar to winter Borvii. Under the sowing date March 19 and April 2, the plants of the variety Zymoiarka did not even form a tube, although in the phytotron its were spiked without prior vernalization both in the conditions of prolonged and shortened days.

4. ***The duration of the period before earning (counting from the date of May 1) alternative varieties at different sowing dates in 2012/2013 and 2014/2015, days***

Varieties	2012/2013						2014/2015			
	15.10	19.02	05.03	19.03	02.04	Slightest Significant Difference 0,05	9.10	24.12	25.02	Slightest Significant Difference 0,05
Afina	9,0	22,0	26,5	27,5	35,0	1,4	24,3	28,3	37,3	1,3
Zymoiarka	11,0	25,0	34,5	n/s**	n/s	1,8	27,3	36,0	40,0	1,5
Lastochka	10,0	24,0	25,0	29,0	36,5	0,9	28,0	29,3	38,7	1,7
Pallada	9,0	24,0	27,0	33,0	39,0	0,7	27,3	30,7	39,7	2,6
Solomiia	8,5	24,5	25,0	28,5	31,0	1,4	30,0	29,3	38,3	1,7
Khutorianka	11,0	25,5	26,0	30,0	34,0	0,7	27,3	31,3	38,7	1,3
Yara	8,0	22,0	25,0	26,5	35,0	0,7	25,0	28,7	37,0	2,0
L897Ya23	8,0	22,0	26,0	27,0	34,0	5,9	25,0	31,0	37,0	2,3
Myr. *Vrn-B1a**	12,0	29,5	35,0	40,0	44,0	0,9	28,7	38,3	41,7	2,6
Demir 2000	7,0	33,5	n/s	n/s	n/s	1,9	26,0	29,3	n/s	3,2
Shestopalivka	9,0	24,0	30,5	n/s	n/s	1,8	24,0	28,3	n/s	1,6
Borvii	7,0	24,0	34,5	n/s	n/s	1,8	26,0	28,3	n/s	1,6
Slightest Significant Difference 0,05	0,6	0,9	0,9	1,1	0,5		0,5	0,5	0,6	

Примітка: * Myr. *Vrn-B1a* - Myronivska 808 *Vrn-B1a* ;
**n/s - the plants in this variant of the experiment did not spiked

Conclusions

Summarizing of the results of the Vrn-1 and Ppd-1 identification of genotypes, that characterized by their authors as alternative, we can deside that none of them respond to the criteria of "typical" alternative. The varieties studied are either winter (Demir 2000, Shestopalivka) with low sensitivity to the photoperiod or typically spring with low (Solomiia, Pallada, Afina, Yara, L897Ya23) and high (Lastochka, Khutorianka, Zymoiarka) sensitivity to photoperiod.

The low reaction to the shortening of the day length of the varieties Afina, Pallada, Solomiia, Shestopolivka, Yara, Demir 2000, L897Ya23 is due to the presence in their genotype of the dominant allele Ppd-D1a. Lastochka, Khutorianka, Zymoiarka varieties are highly sensitive to the photoperiod genotypes and carriers of only recessive alleles of three genes of the orthologous Ppd-1 series.

The spring type of development of Zymoiarka and Khutoryanka varieties is caused by two genes Vrn-A1a & Vrn-B1a, Afina, Lastochka and line L897Ya23 - gene Vrn-D1a, Solomiia - gene Vrn-A1a. Only two varieties Pallada and Yara are monogenically dominant genotype by the Vrn-B1a.

In the south of Ukraine, alternative varieties have a rather high level of overwintering 87.6%. Hardening in the conditions of a shortened day helps to increase the level of frost resistance of seedlings of alternative varieties. The presence in the genotype of the varieties of two genes at once, Vrn-A1a and Vrn-B1a (Khutorianks, Zymoiarka) or only Vrn-A1a (Solomiia), and in some variants, only Vrn-D1a contributes to a significant reduction of frost resistance of seedlings and winter hardiness of alternative varieties.

Alternative varieties differ significantly in the duration of the period before spiking, regardless of the sowing period (October, December, February, March and April). At the same time, winter and spring sowing periods contribute to the shifting of spiking to much later calendar times compared to autumn sowing, which may negatively affect on yield formation of the alternative varieties.

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