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Alleles of *Ppd-1* genes that control sensitivity to photoperiod in a number of bread winter wheat genotypes

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Purpose. Analysis of the allelic state of *Ppd-1* genes, which control sensitivity to photoperiod, in varieties and lines of bread winter wheat, and comparison of the results obtained with field observations on the duration of periods before heading and flowering, whose originators were the Nosivska Breeding and Research Station of the V. M. Remeslo Myronivka Institute of Wheat National Academy of Agrarian Sciences of Ukraine and Poltava State Agrarian Academy of the Ministry of Education and Science of Ukraine. **Methods.** The following methods were used in the work: DNA extraction, allele-specific PCR, agarose and polyacrylamide gel electrophoresis, analysis of variance. **Results.** It was revealed that 'Yuvivata 60' variety has a recessive *Ppd-1* genotype and belongs to the III haplotype by a combination of mutations in the structure of *Ppd-D1* gene. Line 'L41/95' was heterogeneous by alleles of *Ppd-D1* gene, which corresponded to the presence of haplotypes III and VII. All other tested cultivars and lines were characterized by alleles *Ppd-A1b*, *Ppd-B1b* and *Ppd-D1a*, and assigned to haplotype VII. According to the results of statistical data processing, the duration of the period from May, 1 to heading was the smallest for the variety 'Donskaya polukarlikovaya' in the conditions of both the Forest-Steppe and Polissia-Forest-Steppe regions of Ukraine, the longest – in the varieties 'Yuvivata 60', 'Myronivska 61' and 'L41/95'. The differences between these groups were significant and amounted to 10 days. **Conclusions.** A breeding material with a high adaptive ability for growing conditions in Polissia-Forest-Steppe zone was studied by the allelic state of the *Ppd-1* genes. A low level of polymorphism in the studied varieties and lines was revealed by the alleles of *Ppd-1* genes [12.5% – *Ppd-D1b* (III), 12.5% – *Ppd-D1a/b* (III/VII), 75% – *Ppd-D1a* (VII)], that agrees with the hypothesis that breeders gave a greater preference for the photoperiod-insensitive wheat genotype under Ukrainian conditions. The genotypes with the dominant *Ppd-D1a* (VII) gene almost completely dominate in the south of Ukraine. At the same time, in northern latitudes, weather conditions negate the advantages of the genotypes with *Ppd-D1a* gene.

Keywords: *Triticum aestivum L.; photoperiod-sensitivity genes; allele-specific PCR.*

Introduction

Varieties and lines of bread winter wheat are characterized by different growth rates, which enable them to adapt to different climatic and geographical conditions. Global and regional climate changes make it required to increase the adaptive potential of winter wheat plants. The purpose of breeding winter wheat in the Polissia-Forest-Steppe zone is to create varieties adapted mainly for this ecological niche. High adaptability of polyploid wheat is explained by its complex genome characterized by allelic variations and variations in the number of gene copies, which significantly affect the regulation of plant growth and development [1]. The duration of the "sprouts-heading" period of *Triticum aestivum* L. determines the flowering time, indirectly affects the yield, and thus is one of the most important agronomic traits.

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The onset of heading largely depends on photoperiod sensitivity of wheat plants – the response to the length of daylight hours. In *T. aestivum*, photoperiod sensitivity is determined by *Ppd-1* genes located on homeologous chromosomes 2A, 2B, and 2D [2]. Dominant alleles of these genes shorten the duration of the "sprouts-heading" period due to a decrease in the response of plants to the photoperiod under conditions of short daylight hours. Such alleles appeared in the wild-type wheat genotype as a result of mutations (deletions or insertions) in the promoter regions of *Ppd-A1*, *Ppd-B1*, *Ppd-D1* genes or an increase in the number of copies of *Ppd-B1* gene [3–6]. *Ppd-1* genes belong to pseudo-response regulator family and play an important role in the control of circadian rhythms due to the increased expression of the CONSTANS (CO) proteins during long daylight hours. CO proteins interact with proteins encoded by the locus that controls FLOWERING TIME (FT), thereby enhancing their expression and inducing flowering. Alleles of *Ppd-1* genes, which cause a neutral reaction to photoperiod, activate the genes for vernalization and trigger early flowering at short daylight hours, in some cases even when the requirements for vernalization are not met [7].

The aim of the research is to revealed the alleles of *Ppd-1* genes, which control sensitivity to photoperiod, in the varieties and lines of bread winter wheat of the the Nosivska Breeding and Research Station of the V. M. Remeslo Myronivka Institute of Wheat of NAAS of Ukraine (NBRS MIW) and Poltava State Agrarian Academy of the Ministry of Education and Science of Ukraine (PSAA), and comparison of the data of molecular genetic analysis with the data of period of heading and flowering obtained in the field experiments.

The varieties and lines analyzed in the work were tested at the National Centre for Plant Genetic Resources of Ukraine, approved, registered and used in the breeding programs of the PSAA, V. M. Remeslo Myronivka Institute of Wheat of NAAS of Ukraine (MIW), The Plant Production Institute named after V. Ya. Yuriev of NAAS. The study of the molecular genetic characteristics of this bread winter wheat material will enable to characterize its alleles and further conduct marker assisted selection (MAS) for the effective breeding of genotypes with certain combinations of alleles and haplotypes that determine sensitivity to photoperiod.

Materials and methods

We analyzed varieties and lines of bread winter wheat NBRS MIW ('Yuvivata 60', 'KS1', 'KS22-04', 'L59-95', 'Zoriana Nosivska', 'KS14', 'L41/95'), PSAA ('Ariivka') and control varieties 'Donskaya polukarlikovaya', 'Myronivska 61', provided by V. V. Moskalets, an employee of the Institute of Horticulture of the NAAS. The pedigrees of the used lines are shown in Table 1. Varieties 'Yuvivata 60', 'Zoriana Nosivska' belong to the semi-intensive type for low and medium agronomic background. Variety 'Ariivka' and lines 'L41/95', 'L59-95', 'KS1' are of the universal type, suitable for growing after various predecessors. One of the main parental and maternal components in hybridization variety 'Donskaya polukarlikovaya' is of an intensive type, well-selected, balanced, early maturing, winter and drought-resistant with large-grain size, productive high and stable grain quality.

DNA was isolated from etiolated seedling by the modified method [12]. Nested allele-specific PCR were carried out on a Flax Cycler Amplifier (Analytik Jena, Germany), the PCR conditions are described in publications [3–6]. The nucleotide sequences of primers for the detection of alleles of genes of photoperiod sensitivity are described in detail in the article by Bakuma et al. [13]. Amplification fragments obtained in PCR were fractionated by horizontal and vertical electrophoresis in 1% agarose gel or in 7% polyacrylamide gel.

The dates of heading and flowering onset of wheat plants were recorded during field experiments on the basis of the NBRS MIW (Polissia-Forest-Steppe zone) and the Bila Tserkva National Agrarian University of the Ministry of Education and Science of Ukraine (Forest-Steppe of Ukraine) for seven years (2010–2017). The experimental field of the Nosivska Breeding and Research Station is located within a specific ecotone of the Dnipro lowland, in the sphere of influence of two physical and geographical zones – Polissia and Forest-Steppe. The soil of the experimental site is leached chernozem, low humus, light loamy.

The experimental field of the Bila Tserkva NAU is located in the central part of the Right-Bank Forest-Steppe – in the Buzko-Serednodniprovskyi district of the Dnister-Dnipro Forest-Steppe province. The soil is typical black one. The placement of the plots is randomized, the repeatability of the experiment is 3–6 times and in different ecological zones varied depending on the homogeneity of the field in terms of soil and relief features, the predecessor, the quality of preparation of the area for sowing, the volume of seed material. The total area of the experimental plot was 12 m^2. The predecessors of bread winter wheat were annual cereals and legumes; the cultivation technology is generally

Table 1

Pedigree of the studied varieties and lines of bread winter wheat

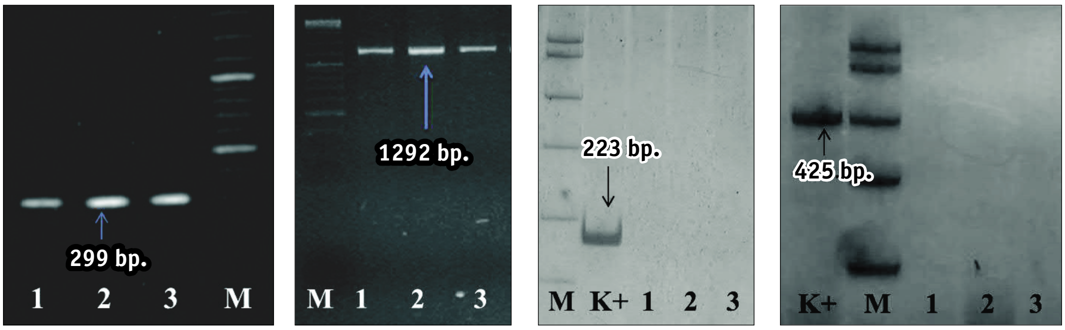
No.	Variety / line (national catalog number, certificate)	Pedigree	Year of creation	Originator
1	'Ariivka' (No. 171136)	'Donskaya polukarlikovaya' × 'K6477/91'	2007	PSAA [8]
2	line 'KS1' (38-95, UA0107961)	'Donskaya polukarlikovaya' × 'K6477/91'	1995	NBRS MIW [9]
3	line 'KS22-04' (UA0108019)	'Zoriana Nosivska' × 'Myronivska 61'	2004	NBRS MIW [9]
4	line 'L59-95' (UA0108016)	♀' Donskaya polukarlikovaya' × ♂ [♀(♀ 'Maris Malder' × ♂ 'Pony') × ♂ 'Donskaya polukarlikovaya']	1995	NBRS MIW [9]
5	'Zoriana Nosivska' (UA 0110603, No. 521)	('Obrii' × 'Maris Hunstman') × 'Maris Hunstman'	1998	NBRS MIW [10]
6	'Donskaya polukarlikovaya'	('Rusalka' × 'Severodonskaya')	1983	All-Russian Research Institute of Grain Crops named after I. G. Kalinenko
7	line 'KS14-05' (UA0123342, No. 1913)	♀ 'Maris Hunstman' × ♂ ('Kyianka' × 'Pony')	2005	NBRS MIW / Institute of Horticulture NAAS [9]
8	line 'L41/95' (UA010803, No. 757)	'Mirleben' × 'Poliska 92'	1995	NBRS MIW [9]
9	'Yuvivata 60' (line 'L4639/96') (UA0108163, No. 1102; variety in the State Register since 2014)	('Poliska 90' × 'Mirleben') × ('Holger' × 'PPH296')	1996	NBRS MIW [9]
10	'Myronivska 61'	intraspecific hybridization with subsequent individual selection from the hybrid population 'Illichivka' × 'Hadmersleben 6508-74'	1987	MIW [11]

accepted for the conditions of Forest-Steppe zone [14]. To reveal the beginning of heading and flowering periods the corresponding dates, when we observed flowering and heading in about 50% of the plants of each plot of a specific wheat genotype, were marked according to the generally accepted method [15, 16].

The climate of the transitional Polissia-Forest-Steppe and Forest-Steppe zones is moderately continental, warm, mild, with sufficient moisture. Growing conditions during 2010–2017 were varied. The increased temperature in May (which is indicated for the period 2010–2014, compared to the long-term norm) and June (2010–2013) did not allow wheat plants to use their maximum potential for heading and flowering phenophases (accumulate the required amount of assimilates) and caused thermal drought, which can negatively affect grain formation and, as a result, yield. October 2013 and 2014 were very dry, only 6–15 mm of precipitation fell in the Forest-Steppe, and 6–24 mm in the Polissia-Forest-Steppe. In 2017, the amount of precipitation during the growing season was lower than the average annual indicators – only 56 mm of precipitation fell in April, May and June. The data were statistically processed using the Statistica 10 software by one- and two-way analysis of variance (ANOVA) [17]. The reliability of the influence of the "Line", "Cultivation zone" factors and their interaction are determined by Fisher's F-criterion for the corresponding factor or interaction.

Results and Discussion

The breeding material of bread winter wheat analyzed in the article, was created at the Nosivska Breeding and Research Station, located in the conditions of the southern ecotone of Polissia, or Polissia-Forest-Steppe zone. Long-term field studies allowed this material to be differentiated into stable, narrowly and broadly adaptive varieties / lines. The latter group ('Yuvivata 60', 'L4639/96', 'L41/95', etc.) is characterized by a wide range of ecological plasticity, the varieties referred to it have a high mass of 1000 grains, large-grain, and multiflorous. And it should be noted that the use of multiflorous forms of wheat in the breeding process reliably leads to an increase in the number of grains per spike in the following hybrid populations [18, 19]. They are the ones who most fully realize their genetic potential in the indicated growing zone, based on what they were selected into the Polissia-Forest-Steppe ecotype among the studied varieties and lines of wheat. Alleles of *Ppd-A1*, *Ppd-B1*, *Ppd-D1* genes were investigated in the genotypes of the studied varieties and lines. No polymorphism was found in *Ppd-A1* locus. According to results of the electrophoresis of the amplification fragments obtained by allele-specific PCR, the presence of *Ppd-A1b* allele was revealed, what means the absence of 1085 bp deletion in the promoter region (Fig. 1a). In addition, the recessive allele *Ppd-B1b* was detected in all studied varieties and lines. The resulting PCR product was 1299 bp, what indicates the absence of 308 bp insertion in the promoter region (Fig. 1b). At the same time, fragments of 223 bp and 425 bp, which define three and four copies of *Ppd-B1* in the genotype, respectively, and which presence lead to decrease in sensitivity to the photoperiod were not found. (Fig. 1c, d).

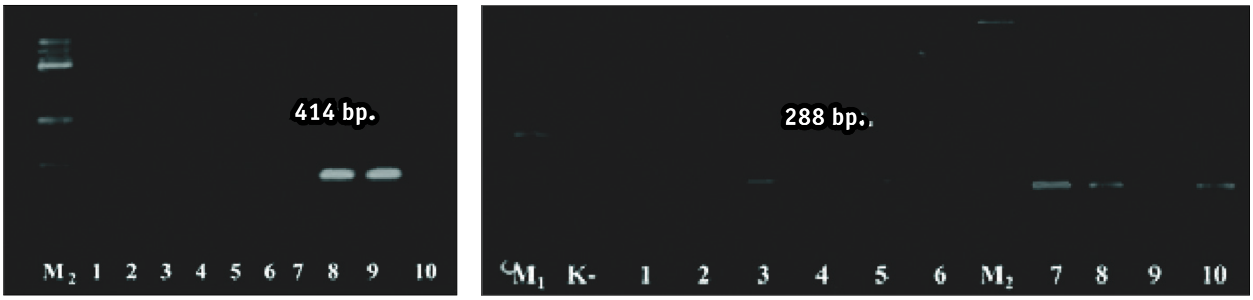


a b c d

Fig. 1. Electropherogram of amplification fragments obtained by PCR of DNA of varieties / lines with allele-specific primers:

a) *Ppd-A1b*: 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; M – molecular weight marker *ladder mix*; b) *Ppd-B1b*: 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; M – molecular weight marker *ladder mix*; c) three copies *Ppd-B1* type of 'Sonora 64': 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; K+ – 'Elehiia Myronivska'; M – molecular weight marker *pUC19/MspI*; d) four-copy *Ppd-B1* type 'Chinese Spring': 1 – 'Ariivka', 2 – line 'KS1', 3 – line 'KS22-04'; K+ – 'Struna Myronivska'; M – molecular weight marker *pUC19/MspI*.

The recessive allele *b* was identified in the genotype of 'Yuvivata 60' variety by *Ppd-D1* gene. Line 'L41/95' turned out to be heterogeneous at this locus. In other varieties and lines of bread wheat, the dominant allele *Ppd-D1a* was detected (Fig. 2).



a b

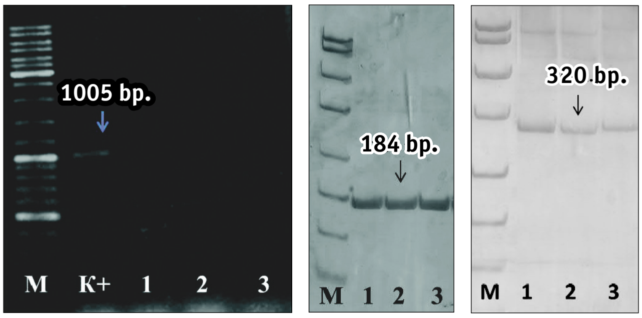
Fig. 2. Electropherogram of amplification fragments obtained by PCR with a pool of DNA isolated from five kernels of varieties / lines, with allele-specific primers:

a) *Ppd-D1b*: 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; 4 – line 'L59-95'; 5 – 'Zoriana Nosivska'; 6 – 'Donskaya polukarlikovaya'; 7 – line 'KS14'; 8 – line 'L41/95'; 9 – 'Yuvivata 60'; 10 – 'Myronivska 61'; M_2 – molecular weight marker *ladder mix*; b) *Ppd-D1a*: 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; 4 – line 'L59-95'; 5 – 'Zoriana Nosivska'; 6 – 'Donskaya polukarlikovaya; 7 – line 'KS14'; 8 – line 'L41/95'; 9 – 'Yuvivata 60'; 10 – 'Myronivska 61'; M_1 – molecular weight marker *pUC19/MspI*; M_2 – molecular weight marker *ladder mix*.

Ppd-D1b allele in 'Yuvivata 60' variety and in 'L41/95' line was most likely inherited from the 'Mirleben' donor variety, where this allele was found earlier [20]. In addition, the second parental form of 'Yuvivata 60' cultivar is 'Poliska 90', which carries allele *b* of the *Rht8* dwarfing gene [21]. This suggests that the cultivar is recessive in *Ppd-D1* gene, since the dominant *Ppd-D1a* allele is usually inherited together with allele *c* of the *Rht8* dwarfing gene. 'Donskaya polukarlikovaya' variety was also studied and involved in the pedigree of 'Ariivka' variety, 'KS1' and 'L59-95' lines. It has the *Ppd-D1a* allele in the genotype, which causes a neutral reaction to photoperiod. Analysis of the origin of 'Zoriana Nosivska' variety suggests that *Ppd-D1a* allele is inherited from 'Obrii' variety [22].

Currently, on the basis of the molecular structure of *Ppd-D1* gene, ten functionally distinctive haplotypes are distinguished. They control different levels of gene expression and have different effects on the duration of the "sprouts-heading" period [23]. Using allele-specific markers in the genotypes of the studied plants, the presence of mutations in the nucleotide sequence of *Ppd-D1* gene-insertions of 24 bp and 15 bp, separated by 105 bp in the intact promoter region (Fig. 2a), insertion of MLE (*mariner*-like elements) type transposons in intron 1 (Fig. 3a), no 5 bp deletion in the seventh exon (Fig. 3b) and deletion of 16 bp in the eighth exon (Fig. 3c) was detected.

The combination of these mutations with a key deletion of 2089 bp, which causes a neutral reaction to photoperiod, allowed the genotype of 'Yuvivata 60' to be assigned to haplotype III, and line 'L41/95' heterogeneous at the *Ppd-D1* locus, to haplotypes III and VII. Other varieties and lines are assigned to haplotype VII (Table 2). According to Guo et al. [5], haplotype III is characterized by a lower level of expression of *Ppd-D1* gene compared to haplotypes I–VI, which leads to a later heading of plants and can be an advantage when grown in northern latitudes, since it will allow plants to avoid the effect of low temperatures in case of flowering in late spring – early summer. Currently, no studies of the expression level of haplotype VII of *Ppd-D1* gene have been carried out.



а б в

Fig. 3. Electrophoregram of the distribution in 7% PAG of amplification fragments obtained by PCR with DNA of varieties / lines and allele-specific primers:
a) *Ppd-P5* (TE *insertion located in intron* 1): 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; K+ – 'Zymoiarka'; M – molecular weight marker *ladder mix*;
b) *Ppd-P7* (deletion of 5 bp in exon 7): 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; M – molecular weight marker *pUC19/MspI*; c) *Ppd-P3* (insertion of 16 bp in exon 8): 1 – 'Ariivka'; 2 – line 'KS1'; 3 – line 'KS22-04'; M – molecular weight marker *pUC19/MspI*.

As a result of one-way analysis of variance of field experiment data on heading and flowering rates, a significant influence of the "Line" factor ($P = 0.01$) on the investigated traits was revealed. The earliest heading under the conditions of the Forest-Steppe and Polissia-Forest-Steppe of Ukraine was typical for the variety 'Donskaya polukarlikovaya', the latest for varieties 'Yuvivata 60', 'Myronivska 61' and line 'L41/95' (Table 3). The difference between the indicated groups was significant – about 10 days. But in terms of yield, the studied lines differed among themselves within the margin of error.

Among the varieties and lines with 'Donskaya polukarlikovaya' variety in the pedigree, only line 'L59-95' did not significantly differ from the parent variety in flowering time, which may indicate the presence of other genes in the genotype of these samples that affect the rate of phenophase duration which we do not test in this work. Also of interest is the rather late heading and flowering of 'Mironivska 61' variety plants (which is characterized by the presence of *Ppd-D1a* allele), practically at the level of the photoperiod-sensitive variety 'Yuvivata 60' and line 'L41/95'. The differences may be due to other genetic systems or epigenetic factors. In general, samples with the recessive allele of *Ppd-D1* gene tended to later heading and flowering than varieties and lines with a dominant allele. According to two-way ANOVA (Table 4), the factors "Line" and "Growing area" significantly influenced the DH and DF, but not on the yield. In the conditions of Forest-

Table 2

***Ppd-D1* haplotypes of the studied wheat varieties and lines**

Allele *Ppd-D1*	Variety, line	*Ppd-D1* haplotype	Number of varieties	24 bp + 15 bp insertion in the promoter	2089 bp deletion in the promoter	TE insertion in intron 1	5 bp deletion at exon 7	16 bp insertion at exon 8
b	'Yuvivata 60'	III	1	absent	absent	present	absent	absent
a	'Ariivka', 'KS1', 'KS22-04', 'L59-95', 'Zoriana Nosivska', 'Donskaya polukarlikovaya', 'KS14', 'Myronivska 61'	VII	8	absent	present	present	absent	absent
b/a	line 'L41/95'	III/VII	1	absent	absent / present	present	absent	absent

Table 3

Characteristics of the studied varieties and lines of bread winter wheat according to agronomic traits

Variety, line	Average for 2010–2017 (Forest-Steppe)			Average for 2010–2017 (Polissia-Forest-Steppe)		
	DH	DF	Yield, g/m²	DH	DF	Yield, g/m²
'Ariivka'	23.13	27.13	637.5	25.13	30.25	687.09
'KS1'	23.25	27.25	624.3	25.13	29.63	623.35
'KS22-04'	21.50	26.38	590.6	23.88	28.25	632.68
'L59-95'	20.63	25.00	577.8	22.50	26.63	536.36
'Zoriana Nosivska'	24.25	28.75	555.3	26.13	31.00	595.44
'Yuvivata 60'	27.25	31.88	661.4	30.25	34.50	640.54
'KS14'	22.63	26.75	578.6	24.13	29.75	556.00
'L41/95'	26.75	31.88	597.9	29.13	34.00	577.23
'Donskaya polukarlikovaya'	17.25	21.50	530.0	19.00	23.00	519.59
'Myronivska 61'	26.13	30.50	591.0	28.38	33.00	579.48
$LSD_{0.05}$	3.92	3.74	–	3.82	3.36	–
$LSD_{0.01}$	5.2	5.1	–	5.06	4.47	–

Note. DH – date of heading (starting from the first of May); DF – date of flowering (starting from the first of May).

Table 4

Influence of factors "Line" and "Growing area" factors on the studied traits

Signs	Source of variation, mS			
	"Line"	"Growing area"	"Line" × "Growing area" interaction	Accuracy
df	9	1	9	140
DH	164.92***	174.31***	0.72	15.17
DF	179.0***	211.6***	1.2	13.2
Yield	29222	5	4074	22268

*** – valid for p = 0.001.

Steppe flowering and heading occurred approximately two days earlier than in the conditions of the Polissia-Forest-Steppe zone (Fig. 4).

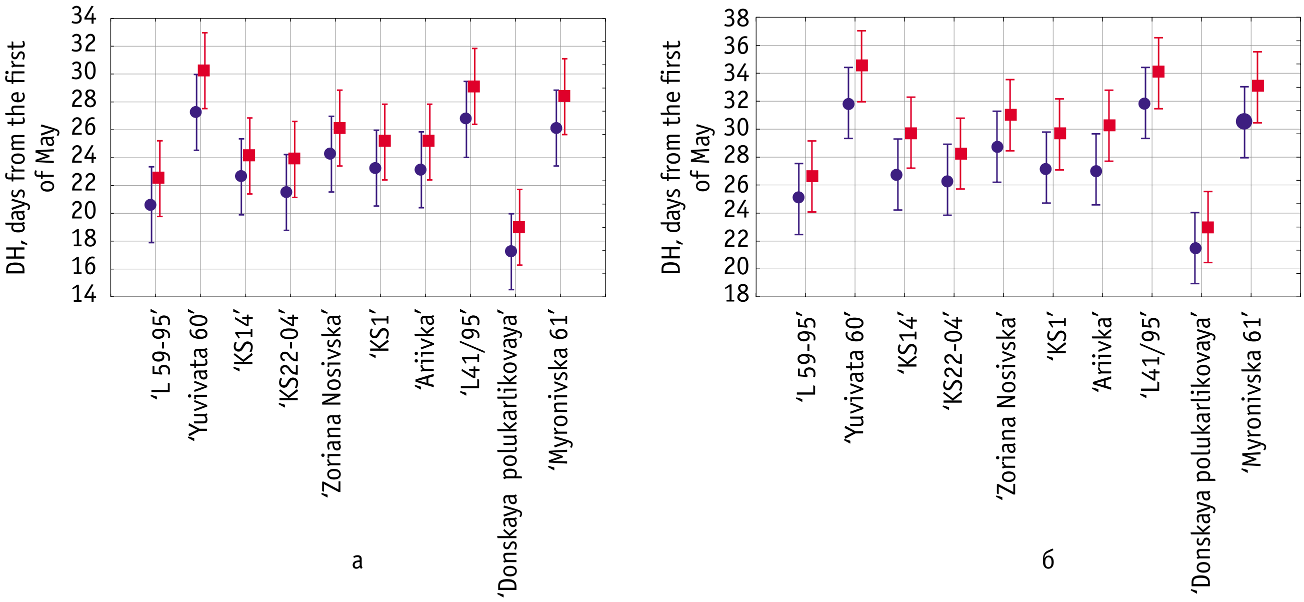


Fig. 4. Time of heading (a) and flowering (b) of the studied lines in the conditions of the Forest-Steppe (blue circle) and Polissia-Forest-Steppe zone (red square)
Note. ■, ● – average value; I – variance.

Lines with (*Ppd-D1a*) and absence of deletion of 2089 bp upstream of the coding region (*Ppd-D1b*), regardless of the cultivation zone, did not significantly differ among themselves in yield, which can be explained by selective breeding, aimed at creating high-yielding varieties. Also, the absence of differences can be influenced by the presence of only one sample with *Ppd-D1b* and *Ppd-D1a/b* in groups and a fairly high variance in terms of yield (Fig. 5).

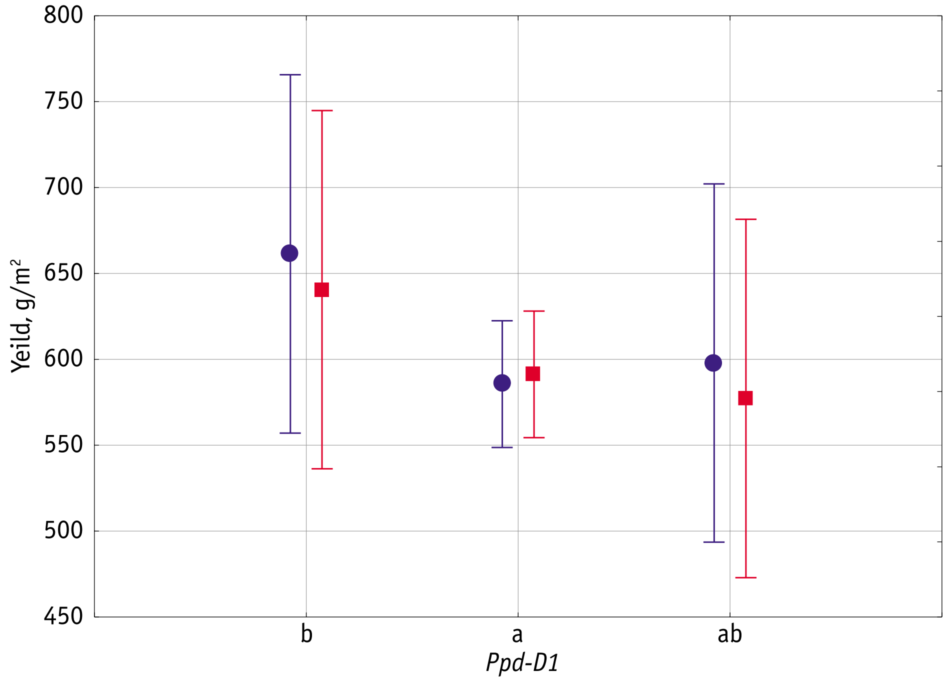


Fig. 5. Productivity of the investigated lines depending on the alleles of the *Ppd-D1* gene under the conditions of the Forest-Steppe (blue circle) and Polissia-Forest-Steppe (red square)

Note. ■, ● – average value; Ɪ – variance.

Conclusions

The new varieties and lines analyzed in the work fully correspond to the direction of bread winter wheat breeding for the conditions of Polissia and Forest-Steppe, since they combine high adaptability to unfavorable abiotic factors, productivity, including large grain, multiflowering, 1000-grain weight, etc. In these agroclimatic zones, varieties with *Ppd-D1a* gene (VII haplotype) prevail. As we have shown earlier, all varieties of the Steppe ecotope [13] assigned to haplotype VII, but among other varieties belonging to the Forest-Steppe ecotope there were carriers of *Ppd-D1b* allele [24, 25] assigned to haplotypes II, III, and IV, however their percentage was quite small, especially among winter varieties.

During cultivation of new wheat genotypes in Forest-Steppe and Polissia-Forest-Steppe zone, similar trends regarding earlier heading and flowering of plants with reduced sensitivity to photoperiod are observed. So an interesting question remains: What genetic mechanism allows 'Donskaya polukarlikovaya' variety to be the earliest among all the studied samples (even among the varieties with the same *Ppd-D1a* gene).

However, for the conditions of Polissia and Polissia-Forest-Steppe transition zone there is no need to create varieties with early heading, typical for the variety 'Donskaya polukarlikovaya', because for this ecological niche May conditions are occasionally accompanied by low and negative air temperatures, which causes a complete or partial white spike, sterility of the ear, an increase in the formation of underdeveloped shoots and, as a result, uneven maturation, and decrease in crop productivity.

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Бакума А. О.[1], Чеботар Г. О.[1], Ткачук А. В.[1], Чеботар С. В.[1,2*], Москалець Т. З.[3], Москалець В. В.[3] Алельний стан *Ppd-1* генів, що контролюють чутливість до фотоперіоду, у низки генотипів пшениці м'якої озимої. *Plant Varieties Studying and Protection*. 2020. Т. 16, № 3. С. 253–261. https://doi.org/10.21498/2518-1017.16.3.2020.214926

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Мета. Визначення алельного стану генів *Ppd-1*, що контролюють чутливість до фотоперіоду, у сортів та ліній пшениці м'якої озимої Носівської селекційно-дослідної станції Миронівського інституту пшениці ім. В. М. Ремесла НААН (НСДС МІП) і Полтавської державної аграрної академії МОН України (ПДАА), та зіставлення отриманих результатів молекулярно-генетичного аналізу з даними польових спостережень щодо строків колосіння та цвітіння. **Методи.** Виділення ДНК, алель-специфічна ПЛР, електрофорез фрагментів ампліфікації в агарозних та поліакриаламідних гелях, дисперсійний аналіз. **Результати.** Визначено, що сорт 'Ювівата 60' має рецесивний генотип *Ppd-1* та належить до III гаплотипу за комбінацією мутацій у структурі *Ppd-D1* гена. Лінія 'Л41/95' виявилася гетерогенною за алелями гена *Ppd-D1*, що відповідало наявності гаплотипів III і VII. Усі інші досліджені зразки характеризувалися алелями *Ppd-A1b*, *Ppd-B1b* та *Ppd-D1a* та належали до гаплотипу VII. За результатами статистичної обробки даних тривалість періоду від першого травня до колосіння була найменшою в сорту 'Донская полукарликовая' в умовах як Лісостепу, так і Полісся–Лісостепу України, найбільшою – у сортів 'Ювівата 60', 'Миронівська 61' та лінії 'Л41/95'. Відмінності між зазначеними групами були достовірними й становили приблизно 10 діб. **Висновки.** За алельним станом генів *Ppd-1* досліджено селекційний матеріал з високою адаптивною здатністю для умов вирощування в перехідній зоні Полісся–Лісостеп. За алелями генів *Ppd-1* досліджені сорти та лінії виявили невисокий рівень поліморфізму [12,5% – *Ppd-D1b* (III), 12,5% – *Ppd-D1a/b* (III/VII), 75% – *Ppd-D1a* (VII)], що узгоджується з гіпотезою надання селекціонерами більшої переваги слабкочутливим до фотоперіоду генотипам пшениці в умовах України. Генотипи з домінантним алелем *Ppd-D1a* (VII) в умовах Півдня України практично повністю домінують. Водночас у північніших широтах погодні умови нівелюють переваги, що мають генотипи з *Ppd-D1a*.

Ключові слова: *Triticum aestivum L.; чутливість до фотоперіоду; алель-специфічна ПЛР.*

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