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## RESPONSE TO VERNALIZATION OF MODERN VARIETIES OF SOFT WHEAT DVURUCHKY

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*The study results of reaction to vernalization of ten genotypes of soft wheat dvuruchky, of which only sort Solomia does not respond to vernalization are given. Seven varieties (Lastochka, Athena, Pallada, Yara, L897YA23, Hutoryanka, Zimoyarka) reacted to the 10-30-daily vernalization by the reduction of period before earing in a moderately shortened and / or elongated days. Two varieties Demir 2000 and Shestopalovka turned to be winter wheat. To access the generative development, they need 30-40 daily vernalization.*

**Keywords:** *soft wheat, the response to vernalization, dvuruchky.*

From the economic and biological point of view, all wheat varieties are divided into two groups: winter and spring. Spring varieties are common in the areas under cultivation where the average January temperature is either above +4°C or below -7°C [1]. In areas of cultivation of soft wheat with average January temperature of -7°C to +4°C winter varieties are common. Winter and spring groups of plants vary considerably according to the degree of reaction to vernalization. Winter wheat have strong responsiveness (15-60 days or more), while the spring can be insensitive or only partially responsive to vernalization [2, 3] The reaction of wheat vernalization is controlled by several genes orthologous series: *Vrn-1*, *Vrn-2*, *Vrn-3*, *Vrn4* and *Vrn-B4* [4]. The basis of wheat division in the spring and winter forms are allelic differences in genes of orthologous series *Vrn-1* gene and *Vrn4*. Presence in genotype varieties of any dominant allele *Vrn-A1A*, *Vrn-B1A*, *Vrn-D1a*, *Vrn4a* or its combinations thereof provides a typical type of spring development [5, 6]. Winter type of development is determined by the presence of only recessive alleles of genes orthologous series *Vrn-1*: *Vrn-A1b*, *Vrn-B1b*, *Vrn-D1b* and gene *Vrn4b*. These dominant alleles are caused by mutations in the promoter or the first intron of the gene regulator [7]. Differences in sensitivity to vernalization may be modified by the effect of ripening genes *per se* [8] and / or genes *Ppd* [9].

The division of wheat in summer and winter is to a certain extent conditional, among F<sub>2</sub> hybrids of spring varieties with winter ones a significant variation in the time of earing was revealed, while the so called transitional forms

are segregated, they are also called alternative, intermedial, facultative or *dvuruchky* [10].

In recent years, due to climate change, the issue of selection of wheat varieties *dvuruchky* has been raised.[11]. In southern Ukraine, the most efficient use of *dvuruchky* are late autumn and winter seeding in years with long dry autumn. Almost every second year (46%) is characterized by a deficiency of moisture during the optimal planting dates, making it difficult to obtain timely and amicable germination [12]. On today in the Register of plant varieties suitable for dissemination in Ukraine a single variety *dvuruchka* *Hutoryanka* is registered.

There are statements that *dvuruchky* is spring wheat with good winter hardiness. [13] M.G. Agayev [14] defines them as typical long-day spring wheat. A.A. Avakian [15] attributes them to the winter forms of late autumn sowing. Some authors have withdrawn to *dvuruchky* the place of independent biological group [16], which has features of both winter and spring [17, 18]. A.N. Berezkin and P.F. Magurov [19] argue that *dvuruchky* is an independent group, occupying an intermediate position between the spring and winter forms. It should immediately be noted that the term "*dvuruchky*" is not genetic and not even the biological but economic. It refers to the genotype capable successfully overwinter in the conditions of relatively mild winters when sown in the autumn, to spire at sowing in the spring and, in both cases, to form an adequate harvest. However, the classification of a particular genotype as *dvuruchky* only on the basis of the principle of a "normally overwinter" in the autumn sowing and "normal ear" during the spring sowing [20] is relative and says nothing about the physiological or genetic nature of the type of such varieties.

Formulation of the problem. Based on the foregoing, the purpose of the work is to determine the response to vernalization of modern varieties soft wheat *dvuruchky* of different origins.

**The method for research.** As the starting material we used nine samples of soft wheat, characterized by the authors of their creation like *dvuruchky*, as well as control samples: Borvy winter varieties [21] and nearly isogenic line *Mironovskaya 808 - Vrn-B1a*, which is *dvuruchka* [10]. Varieties *Athena*, *Lastochka*, L 897YA23 *Pallada*, *Yara* are selected in Krasnodar Research Institute P.P. Lukyanenko (Russia) [22], *Hutoryanka*, *Zimoyarka* – in Institute of Plant Physiology and Genetics of the National Academy of Sciences [18], *Solomia* – in Kherson State Agrarian University [23], *Shestopalovka* – in FHR "BOR". Sort *Demir 2000* was received from the bank of genetic resources of Ukraine (Kharkiv), in this collection it is registered as *dvuruchka*.

To determine the duration of need for vernalization we used temporal vernalization at an interval of 10 days. 20 grains of each sample were laid on moistened filter paper 7 × 19 cm in a row at a distance of 0.7 cm from the top edge

of the paper with notch down. Then the paper was wrapped into a roll. The rolls were placed in a metal box with a water layer of 1 cm and left at room temperature until germination. Five-day seedlings were vernalized in chamber CST-1 at a temperature of 2<sup>0</sup>C, and day-length of 16 hours within 40, 30, 20, 10 days. Following vernalization, seedlings were planted (20.04 and 25.04 2012 2013) in 5 liters volume container 10 plants per pot and grown in a growth area in the natural day length and temperature, as well as in climatic chambers of phytotron in conditions of elongated photoperiod (16 h). At the same time in all three tests five-day seedlings were planted, not subjected to vernalization.

In addition, the seeds of all varieties were seeded with handmade planters in different periods (15.10.2012 and 19.02, 05.03, 19.03 and 04.02.2013 ) on one-row plots with length of 1.25 m, 25 plants in a row with a nutrient area of 5 × 30 cm<sup>2</sup>. Repetitiveness of test in the last experiment was twice.

To determine the length of time before earing in the experimental variants on the growing site and in phytotron we mentioned the date of earing of individual plants, which then was transformed into the number of days before earing. In the field the date of earing was visually observed in the presence of 75% of the eared plants in the plot.

To assess the reliability of the data we used analysis of variance [24].

**Results and discussion.** The comparison of the length of time before earing (MPC) at vernalization of different duration and in the version without vernalization in both years of the study on a growth platform in a moderately shortened natural day witnessed significant differences of dvuruchky varieties on this basis. Varieties of studied set eared in both years in the version without vernalization at almost the same time on the 47.6 - 71.2 and 47.8 - 71.0 days in 2012 and 2013, respectively. The scope for varying by MAC in this variant in the first year of study was 23.6, and in the second – 23.2days. In both years of the study, in this experimental variant the varieties Shestopalovka and Demir 2000 did not ear.. As a rule, longer vernalization contributed to an increase of genetic variation and the reduce of the length of the MPC in all the samples studied. Thus, in the variant of 40-day vernalization the scope of variation by MPC was 27.3 and 32.3 days in 2012 and 2013, respectively, and the duration of the MPC of individual varieties was in the first year 42.7 - 70.0 days, and in the second - 39.4 - 71.7 days. At the same time in both years of study we noted early earing in line L897YA23, and later earing in the variety of genetic variation Demir 2000. Increase of genetic variation in version 40-day vernalization in a moderately shortened natural day can testify to the essential role of genes Eps in controlling the differences by MPC duration in a studied set of varieties.

We analyze the results of the assessment of duration period before earing of control samples (Table.1). Earing of nearly isogenic line of dvuruchka

Mironovskaya 808 - *Vrn-B1a* was noted after the vernalization of varying duration on 55,0-59,9 day, and in the version without vernalization on 61.6 days in 2012, and in 2013 from 58.3 -63.5 and 68.2 days, respectively. Earing of winter varieties Borvy was noted only after a 40-day of vernalization on 49.3 in 2012 and 61.5 days in 2013.

**Table 1**

**The period before earing of varieties *dvuruchky* after vernalization of varying lengths (40, 30, 20, 10 days) and without vernalization (b / np) on a growth platform in 2012 - 2013., days**

Grade	Year	The duration of vernalization, days					
		40	30	20	10	b / np	NDS <sub>0.05</sub>
Miron.. <i>Vrn-B1a</i> *	2012	55.0	56.9	59.9	59.0	61.6	3.3
	2013	58.3	58.5	59.3	61.0	68.2	2.1
Athena	2012	44.7	46.8	47.6	47.3	71.2	6.6
	2013	43.1	46.9	49.5	58.1	65.8	2.6
Lastochka	2012	47.2	48.4	50.4	57.3	58.0	2.4
	2013	45.8	47.4	55.3	76.6	71.0	3.5
Pallada	2012	47.3	48.3	55.5	58.5	61.1	1.7
	2013	45.5	49.8	59.7	57.5	63.3	3.2
Yara	2012	45.5	45.1	52.5	54.7	57.6	1.5
	2013	39.7	46.8	52.0	54.9	62.2	1.2
L897YA23	2012	42.7	45.1	48.9	47.6	56.2	2.4
	2013	39.4	44.4	48.3	60.0	61.2	2.5
Zimoyarka	2012	51.1	52.2	52.5	52.0	51.5	2.8
	2013	51.4	53.7	50.2	51.8	55.5	1.5
Solomia	2012	46.1	43.2	45.2	47.8	50.7	5.0
	2013	44.0	41.1	44.5	46.0	49.6	2.0
Hutoryanka	2012	44.4	45.8	48.3	49.8	47.6	1.5
	2013	46.6	43.2	47.2	45.2	47.8	1.9
Borvy	2012	49.3	n / a**	n / a	n / a	n / a	-
	2013	61.5	n / a	n / a	n / a	n / a	-
Demir 2000	2012	70.0	n / a	n / a	n / a	n / a	-
	2013	71.7	n / a	n / a	n / a	n / a	-
Shestopalovka	2012	51.9	66.0	n / a	n / a	n / a	6.7

	2013	47.6	81.5	n / a	n / a	n / a	17.5
NDS <sub>0.05</sub>	2012	5.8	3.1	1.9	5.8	4.4	
	2013	4.7	2.5	2.7	2.2	3.2	

Note: \* Mir. *Vrn-B1a* - Mironovskaya *Vrn-808 B1a*;

\*\* N / A - plants in this variant of the experiment did not ear.

In other variants of the experiment the indicated sort did not spike, i.e. for the transition to the generative development of varieties Borvy it is needed at least a 40-day vernalization of green seedlings under the used conditions of vernalization. For most modern varieties of GIS - NTSNS it is characteristic 30-40 - daily need for vernalization [25].

If as the criterion for assessing response to vernalization we use data of earing or non-earing of particular genotype after preliminary vernalization of a certain duration, the studied varieties can be divided into two groups. Varieties of the first group Lastochka, Athena, Pallada, Yar L897YA23, Hutoryanka, Zimoyarka, Solomia spiked, as well as a control dvuruchka Mironovskaya *Vrn-808 B1a* after vernalization of varying duration (40-10 days) on 42,7-58,5 in 2012 and on 39,7- and 60.0 day in 2013, and in the version without vernalization on 47,6-71,2 and 47,8-71,0 day, respectively. Wherein the duration of MPC in 2012 was largely correlated ( $r = + 0,51 - +0,94$ ) with that in 2013. The fact of earing of the above mentioned varieties in the version without vernalization allows us to characterize them as dvuruchky. Therefore, varieties Athena, Zimoyarka, Lastochka, Pallada, Solomia, Hutoryanka, Yar L897YA23 must be the carriers of dominant alleles of orthologous series *Vrn-1* genes. However given genotypes differ by vernalization response. Thus, in both years of the study, only two varieties of Solomia and Hutoryanka did not respond to vernalization by accelerated development (reduction in the duration of MPC). Lack of response to vernalization was observed in the control line 808 Mironovskaya *Vrn-B1a* and variety Zimoyarka in 2012 but in 2013 a 10-day vernalization promoted a significant reduction in the duration of MPC in both types. Grades Athena, Lastochka, Pallada, L897YA23 significantly accelerated development after vernalization 10-20 days depending on the year of study. From all grades a sort Yara stands out, which responded in 2013 to 10 daily vernalization, and in 2012 - 30 daily.

Varieties of the second group Shestopalovka and Demir 2000 responded to vernalization like control Borvy winter varieties. The need of latter for vernalization, as shown above, was 40 days. After a 40-day vernalization sort Demir 2000 eared on 70.0 day and on 71.7 day in 2012 and 2013, respectively. After a 30-day vernalization, in both years variety Shestopalovka eared too. Although in both cases a 40-day vernalization more significantly accelerated the earing of the given variety. Therefore, varieties Shestopalovka and Demir 2000 are varieties of winter type development and recessive by genes of orthologous series *Vrn-1* genotypes.

However, the conditions of a moderately shortened natural day negate the differences of varieties by photoperiodic sensitivity largely, but not fully, which may affect the assessment of varieties for the duration of the period before earing. Accordingly, the reaction of varieties *dvuruchky* was evaluated in vitro in phytotron climatic chambers at duration of 16 hours (Table. 2). In general, the results obtained in terms of the day elongated, correspond to those of the day moderately shortened in 2012 ( $r = + 0,57 - +0,98$ ) and 2013 ( $r = + 0,73 - +0,94$ ). All varieties characterized earlier as *dvuruchky* spiked in phytotron without vernalization. Wherein sorts *Zimoyarka* and *Solomia* did not respond to vernalization, similar to the conditions in 2012.

**Table 2**

**The period before earing of *dvuruchky* after vernalization of varying lengths (40, 30, 20, 10 days) and without vernalization (b / np) in elongated day (16 hours), climatic chambers of phytotron, days**

Variety	The duration of vernalization day					NDS <sub>0.05</sub>
	40	30	20	10	b / np	
Miron. <i>Vrn-B1a</i> *	55.2	60.5	70.1	80.4	85.4	2.9
Athena	41.6	43.2	47.0	60.3	65.1	6.6
Lastochka	46.7	49.2	52.6	73.8	68.0	9.0
Pallada	52.4	56.0	56.0	70.7	89.9	4.6
Yara	44.9	45.7	46.3	54.8	71.6	2.2
L897YA23	42.0	41.8	48.0	62.1	74.0	3.9
Zimoyarka	50.8	50.9	54.4	49.8	56.3	1.7
Solomia	44.7	55.9	43.8	42.4	46.8	7.0
Hutoryanka	43.6	47.5	48.1	46.3	53.3	1.8
Borvy	52.1	n / a**	n / a	n / a	n / a	
Demir 2000	78.1	96.5	n / a	n / a	n / a	14.0
Shestopalovka	56.6	86.7	n / a	n / a	n / a	7.8
NDS <sub>0.05</sub>	4.5	4.6	2.7	6.3	5.8	

Note: \* Mir. *Vrn-B1a* - Mironovskaya *Vrn-808 B1a*;

\*\* N / c -plants in this variant of the experiment did not ear.

The remaining varieties were responsive to vernalization, which was observed in 2013. In particular, the five-day seedlings vernalization for 10 days contributed to a significant reduction in time before earing of sort *Hutoryanka*, 20 days - varieties of *Athena*, *Lastochka*, *Pallada*, *Yara*, 30 days - lines *L897YA23* and *Mironovskaya Vrn-808 B1a*. Control winter variety *Borvy* spiked as at the lengthened day as in moderately shortened one only after a 40-day vernalization. Varieties *Shestopalovka* and *Demir 2000* for the transition to the generative development need only 30 days of vernalization. At the same time sort of *Demir 2000* spiked in a moderately shortened days of 2012 and 2013. only after vernalization 40 days.

In the field (Table. 3) sorts *Athena*, *Yara*, *Pallada*, *L897YA23*, *Hutoryanka*, *Solomia*, *Lastochka*, *Mironovskaya 808 - Vrn-B1a* spiked as in winter (15.10), so

at sowing in February (19.02), March (5.03 and 19.03) and early April (2.04). However, despite the reduction in the duration of MPC in the varieties, the calendar dates of earing come much later at sowing in February, March and especially April. Even when sowing in February 19 the earing of these eight genotypes was observed by 13-17 days later compared to that of the autumn sowing, that in conditions of increasing drought, especially during the grain filling, in most years in Odessa will have a negative impact on the formation of the crop. Varieties Demir 2000 and Shestopalovka characterized above as the winter ones did not ear at sowing on 19 February and 5 March respectively and at the earlier timing of sowing. Probably, at a later date of sowing the positivity of vernalization was insufficient for the transition to the generative development of the two varieties. Sort Zimoyarka unlike other varieties of *dvuruchky* responded to different planting dates in the field similar to winter variety Borvy. The first as well as the last eared on 25 and 35 days when sown on February 19 and March 5 respectively. When sowing on 19 March and 2 April Zimoyarka plant varieties did not even form a tube. The reason for such a reaction of this sort should be investigated further.

**Table 3**

**The period before earing (counting from the date of May 1) of *dvuruchky* varieties at different planting dates, 2012/2013., Day**

Varieties	Date of sowing					NDS 0.05
	15.10	19.02	05.03	19.03	02.04	
Miron. <i>Vrn-B1a</i> *	12.0	29.5	35.0	40.0	44.0	0.9
Athena	9.0	22.0	26.5	27.5	35.0	1.4
Lastochka	10.0	24.0	25.0	29.0	36.5	0.9
Pallada	9.0	24.0	27.0	33.0	39.0	0.7
Yara	8.0	22.0	25.0	26.5	35.0	0.7
L 897 I 23	8.0	22.0	26.0	27.0	34.0	5.9
Zimoyarka	11.0	25.0	34.5	n / a**	n / a	1.8
Solomia	8.5	24.5	25.0	28.5	31.0	1.4
Hutoryanka	11.0	25.5	26.0	30.0	34.0	0.7
Borvy	7.0	24.0	34.5	n / a	n / a	1.8
Demir 2000	7.0	33.5	n / a	n / a	n / a	1.9
Shestopalovka	9.0	24.0	30.5	n / a	n / a	1.8
NDS 0.05	0.6	0.9	0.9	1.1	0.5	

Note: \* The Mir. *Vrn-B1a* - Mironovskaya *Vrn-808 B1a*;

\*\* N / c - plants in this variant of the experiment did not ear.

Conclusions: Varieties Lastochka, Athena, Pallada, Yar L897YA23, Hutoryanka, Zimoyarka, Solomia, a control line *dvuruchka* Mironovskaya 808 *Vrn-B1a* spiked after vernalization of varying lengths and without vernalization, which allows us to characterize them as *dvuruchky*. Except variety Solomia that did not respond to vernalization regardless of the study conditions, the other eight

genotypes responded by reduction of period before earing for 10-30-daily vernalization at + 2 ° C, of a five day green seedlings in subsequent cultivation in moderately shortened and / or elongated day .

Two varieties Shestopalivka and Demir and 2000 are winter. For transition to the generative development the first variety requires vernalization for 30 days, the second - 30-40 days, depending on the length of the day.

Characteristics of varieties by the type of development are confirmed by the results of earing or non-earing in the field at different planting dates (October - April). Earing of varieties *dvuruchky Lastochka*, *Athena Pallada*, *Yar L897YA23*, *Hutoryanka*, *Solomia*, *Mironovskaya 808 Vrn-B1a* were noticed at sowing 15.10.2012 and 2.04.2013. Winter varieties *Demir 2000* and *Shestopalovka* spiked at sowing not later than 19 February and 5 March, respectively. Unlike other *dvuruchky* variety *Zimoyarka* responded to different planting dates like winter varieties *Borvy* and *Shestopalovka*.

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#### Аннотация

*Е.Ю. Губич В.И. Файт, В.Ф. Герасименко. Реакция на яровизацию современных сортов двуручек пшеницы мягкой. Представлены результаты изучения реакции на яровизацию десяти генотипов двуручек пшеницы мягкой, из которых только сорт Соломия не реагировал на яровизацию. Семь сортов (Ласточка, Афина, Паллада, Яра, L897Я23, Хуторянка, Зимоярка) реагировали на 10-30-суточную яровизацию сокращением периода до колошения в условиях умеренно укорочённого и/или удлинённого дней. Два сорта Demir 2000 и Шестопаловка оказались озимыми. Для перехода к генеративному развитию им необходима 30-40-суточная яровизация.*

*Ключевые слова: мягкая пшеница, реакция на яровизацию, двуручки.*

#### Анотація

*Е.Ю. Губич В.И. Файт, В.Ф. Герасименко Реакция на яровизацию современных сортов двуручек пшеницы мягкой. Представлены результаты изучения реакции на яровизацию десяти генотипов двуручек пшеницы мягкой, из которых только сорт Соломия не реагировал на яровизацию. Семь сортов (Ласточка, Афина, Паллада, Яра, L897Я23, Хуторянка, Зимоярка) реагировали на 10-30-суточную яровизацию сокращением периода до колошения в условиях умеренно укорочённого и / или удлинённого дней. Два сорта Демир 2000 и Шестопаловка оказались озимыми. Для перехода к генеративному развитию им необходима 30-40-суточная яровизация.*

*Ключевые слова: мягкая пшеница, реакция на яровизацию, двуручки.*