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Influence of photoperiodic conditions on the development and content of nitrogenous compounds in the *VRN* NILs wheat *Triticum aestivum* L.

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The influence of a long (16 hrs) LD and short (9 hrs) SD day on the period duration from germination to earing, the content and distribution of free amino acids and total nitrogen on the main stem organs, productivity elements and grain protein content of isogenic lines for genes *VRN* of hexaploid wheat created in gene pool varieties with different photoperiodic sensitivity – Mironovskaya 808 and Olviya were studied in field experiments.

The results showed that the period from germination to earing increased under the influence of short photoperiod in the studied lines, the content and distribution of amino acids and total nitrogen in the main stem organs as well as the individual productivity of plants and changed grain protein content. The level of these changes depends on the genes *VRN* (dominant and / or recessive). It is assumed that genes influence the development and *VRN* formation of the wheat productivity elements in different photoperiodic conditions indirectly, through participation in nitrogen metabolism regulation.

Key words: wheat (*Triticum aestivum* L.), near isogenic lines, genes *VRN*, photoperiod, development, nitrogen metabolism, productivity

INTRODUCTION

Temperature and photoperiod are key environment factors which define prevalence on cultivation zones and the level of agriculturally valuable signs in soft wheat. In the course of evolution and selection this culture has formed two basic genetic systems which determine the growth and development at different temperatures

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and photoperiodic conditions – a system of genes *PPD* (sensitivity to the photoperiod) and a system of genes *VRN* (requirements in vernalization, development type of spring / winter) (Cocram et al., 2007).

Reaction on wheat vernalization is controlled at least by five genes. Three basic genes, *Vrn-A1a, Vrn-B1a* and *Vrn-D1a*, are localized accordingly in chromosomes 5A, 5B and 5D. The winter type of plant development is shown only in the event when these three basic genes are recessive. Thus, the presence of dominant gene *Vrn-A1a* provides full tolerance of plants to vernalization (Loukoianov et al., 2005; Trevaskis, 2010), dominant genes *Vrn-B1a* and *Vrn-D1a* only partially reduce the demand for it. Genes *VRN* are actively investigated at molecular-genetic level (Oliver Sandra et al., 2009), they are cloned and their several allelic variants have been recently described for wheat (Kane et al., 2005; Distelfeld et al., 2009). It has been shown that genes *Vrn-A1a* and *Vrn-B1a* are transcriptional factors (Danyluk et al., 2003; Preston et al., 2008). Reaction of wheat plants to photoperiod is controlled by genes *PPD* localized in chromosomes 2D, 2B and 2A. Gene *Ppd-D1a* is considered the key one among those defining photoperiodic sensitivity of hexaploid wheat. It is related to PRR (Pseudo Response Regulator) family, known regulators of circadian rhythms in Arabidopsis. Phenotypical impact of genes *VRN* and *PPD* systems on development rate in soft wheat has been well studied. Hence, genes *VRN* play the most important role in the definition of the sign "speed of transition to earing"; their contribution to manifestation of this sign is 75% (Potokina et al., 2012). The system of these genes essentially influences the manifestation of agriculturally valuable traits such as productivity, crop structure (Fayt, Suhonosenko, 2005), frost and winter resistance (Dhillon et al., 2010), resistance to diseases (Khotyljov, Kaminskaya, Koren, 2002).

Under natural conditions photoperiod and temperature influence the processes of plants life not individually but in interaction, it is probable that genetic systems *VRN* and *PPD* co-operate in definition of development rate and formation of this culture productivity. However, the question of their interaction has not been practically studied (Kane et al., 2005; Dubcovsky et al., 2006), though such a study is important to improve our ideas about interaction of these genes in control of wheat development rate (Zhmurko, 1999) and formation of economically valuable traits. Besides, a question of physiological-biochemical mechanisms by means of which genes *VRN* and *PPD* are capable to determine growth, development and display level of agriculturally valuable traits in soft wheat remained unclear.

Nitric exchange is one of the central metabolic processes which in many respects define growth, development, productivity and quality of soft wheat grain. Dependence of this process on a genotype of many cultivars of winter wheat has been shown (Zhmurko, 1999). However, these data do not allow to judge about participation of concrete genes in regulation of a nitric exchange in wheat plants. As growth, development, productivity of wheat and protein content in grain depend on genotypic features and ecological factors we have assumed that genetic monitoring systems of wheat development rates (system of genes *VRN* and *PPD*) can indirectly, through a nitric metabolism, influence the formation of these major economically valuable traits. In our opinion, to study this issue, the most adequate models are near isogenic lines (NILs) of wheat differing on condition of genes *VRN* (dominant and / or recessive) which are created in genetic underground of winter grades with a known condition of genes *PPD* (Stelmakh, 1998).

The purpose of our research was to study the influence of different photoperiods on the development of isogenic lines on genes *VRN* of wheat, the content and distribution of free amino acids and total nitrogen on organs, formation of crop structure elements and protein content in grain.

MATERIALS AND METHODS

Plant materials

Objects of research were near isogenic, monogenic dominant by VRN genes of soft wheat lines (*Triticum aestivum* L.) of spring development type given by the Selection and Genetics Institute, the National Centre of Seeds and Sorts Study of NAASU, within the framework of Agreement on Cooperation. We have used the lines created in genetic underground of cultivar Mironovskaya 808 with all genes *PPD* recessive that defines its high photoperiodic sensitivity, and also genetic underground of cultivar Olviya, with dominant gene *PPD-1Da* that defines low sensitivity of this cultivar to the length of the day (Stelmakh, 1998). It is probable that by submitting these lines to influence of different photoperiodic conditions we can reveal joint phenotypical effects of genes *VRN* and *PPD* on the development and productivity of wheat in these conditions.

The growing of plants during field experiments

Field experiments were conducted in 2009–2011 in the experimental site of the Department of Physiology and Biochemistry of Plants of V. N. Karazin National University of Kharkov. Plants grew up in optimum spring terms of sowing. Sowing was manual on the allotments with the area 1 m^2 in triple frequency by each variant of experiment. In a tillering phase (20–25 days after sowing) one part of all lines was subjected to influence of the short photoperiod SD (9 hrs) within 14 days, and the second part grew up during natural long day LD (16 hrs at Kharkov latitude, 50° NL). Short day was created by blackout of plants by lightproof cabins from 6 pm till 9 am.

Phenological observations and morphometric analysis

Phenological observations – the duration of the period from shoots to heading – were determined. After plants yield the productivity elements were calculated: length of an ear, weight of grain from an ear, quantity of grains in an ear and weight of 1 000 grains.

Fixation of plant material

In the earing-flowering phase plant organs: leaves, stems and forming ears were fixed by water vapor (at 120 °C during 30 min) to determine biochemistry analysis – total nitrogen and free amino acids.

Biochemistry analysis

Total nitrogen was defined by the standard method on K’el’dal (Methods…, 1987). Amin nitrogen, content free amino acid, was defined by copper micro method (Methods…, 1987). Protein content in grain was defined on K’el’dal with recalculation factor on protein – 5, 25 (Methods…, 1987).

Statistical analysis

Statistical analysis was performed using average values from three-year measurements. All research and analyses were carried out at 3–5 frequency. The results were processed statistically, tables give average values and their standard deviations. The data are presented as mean ± standard error (SE). Microsoft Excel for Windows version 10.0 software was used for the statistical analysis.

RESULTS AND DISCUSSION

The definition results of transition to earing duration of isogenic lines in conditions of natural long day showed that it was maximum at isoline *VRN-B1a* of both cultivars (Table 1). Among Mironovskaya 808 cultivar isolines lines *VRN-D1* were the first to ear and cultivar of Olviya – plants of line *VRN-D1a*. Irrespective of a genotype on genes *VRN*, all lines of Olviya cultivar eared earlier compared with all lines of Mironovskaya 808 cultivar.

Table 1. Impact of different photoperiodic conditions on duration of shoots–earing period in isogenic by genes *VRN* lines of wheat, days (2009–2011)

Cultivar	Isoline genotype*	Time to heading, days		
		16 hrs**	9 hrs	Increase
Mironovskaya 808	*VRN-A1a*	57 ± 1	65 ± 2	8 ± 1
	VRN-B1a	65 ± 2	78 ± 2	13 ± 2
	VRN-D1a	52 ± 1	60 ± 2	8 ± 2
Olviya	*VRN-A1a*	47 ± 1	50 ± 1	3 ± 1
	VRN-B1a	61 ±2	72 ± 2	11 ± 2
	VRN-D1a	50 ± 1	58 ± 1	8 ± 1

Notes: 1. *) – dominant genes are specified; 2. **) – natural long day

In conditions of short 9-hr-long photoperiod all investigated isolines of both cultivars eared later than in the conditions of a long day (Table 1). However, maximum photoperiodic sensitivity was shown by slowly developing isoline of both cultivars *VRN-B1a.* The delay of earing on the SD of this line of Mironovskaya 808 cultivar was 13 days, and Olviya cultivar – 11 days.

Thus, the investigated lines react to photoperiod reduction as quantitatively LD plants because they slow down the development in the conditions of the adverse photoperiod. The results give basis to assume that among genes *VRN* the leading part in integration of photoperiodic and vernalization ecological signal belongs to gene *VRN-B1a*. In the works of Kane et al., 2010 and Distelfeld et al., 2006 regulatory role of gene TaVRT-2 is shown as key repressor of cereals' flowering sensitive to low positive temperatures (vernalization) and the photoperiod (Kane et al., 2005; Distelfeld et al., 2009).

The study of free amino acids pool distribution (Table 2) on the main shoot organs of wheat isogenic lines showed that its maximum was in leaves of the main photosynthetic bodies of plants. Rather high content of amin nitrogen is revealed in the forming ears, which during the period of earing–flowering phenophase become the main attracting centers of the plant and accept photoassimilants of both nitric and carbohydrate nature. The least content of free amino acids is found in the stems. It is possibly connected with the fact that it carries out mainly transport function and practically does not participate in metabolic processes.

The given picture of free amino acids pool distribution on bodies of the main shoot is characteristic both for Mironovskaya 808 cultivar isolines and Olviya cultivar lines. However, higher content of free amino acids in forming ears was found in Olviya cultivar lines that is probably explained by their faster development in comparison with Mironovskaya 808 cultivar isolines. Distinctive influence of genotype isoline on content of free amino acids is shown only in leaves. Both investigated cultivars slowly develop isoline *VRN-B1a* that was characterized by their minimum content and quickly developing isolines *VRN-A1a* and *VRN-D1a* by maximum. Level of amino acids in ears of slowly developing line *VRN-B1a* of Olviya cultivar was higher than in ears of quickly developing lines of this cultivar *VRN-A1a* and *VRN-D1a* (Table 2). Probably, it is connected with slower involvement of amino acids in protein synthesis in forming cariopses in slowly developing line in comparison with quickly developing ones.

Influence of the short photoperiod on the content and distribution of free amino acids pool on bodies of the investigated isogenic lines is manifested similarly irrespective of cultivar genetic underground and a line genotype on genes *VRN* – the induction by SD increases free amino acids content in all lines. Thus maximum increase of free amino acids pool occurs in the forming ears where there are processes of grains filling and

Table 2. Influence of the short photoperiod on free amino acids content by organs of the main shoot of isogenic by genes *VRN* lines of wheat, mg/g of dry mass (2009–2011)

Isoline genotype*	Leaves		Stems		Forming ears	
	Duration of photoperiod, hrs					
	16**	9	16**	9	16**	9
Mironovskaya 808 cultivar lines						
VRN-A1a	0.97 ± 0.04	1.25 ± 0.07	0.52 ± 0.04	0.53 ± 0.05	0.68 ± 0.06	1.27 ± 0.09
VRN-B1a	0.90 ± 0.03	0.94 ± 0.05	0.43 ± 0.02	0.52 ± 0.04	0.54 ± 0.04	0.80 ± 0.07
VRN-D1a	0.81 ± 0.02	1.11 ± 0.08	0.42 ± 0.02	0.56 ± 0.04	0.49 ± 0.03	0.87 ± 0.06
Olviya cultivar lines						
VRN-A1a	0.91 ± 0.04	1.20 ± 0.09	0.48 ± 0.03	0.61 ± 0.05	0.34 ± 0.02	0.64 ± 0.06
VRN-B1a	0.77 ± 0,03	1.05 ± 0.08	0.49 ± 0.02	0.96 ± 0.08	1.0 ± 0.09	1.36 ± 0.13
VRN-D1a	0.87 ± 0,04	1.09 ± 0.08	0.42 ± 0.02	0.65 ± 0.04	0.82 ± 0.06	1.17 ± 0.10

Notes: 1. *) – dominant genes are specified; 2. **) – natural long day

Table 3. Short photoperiod influence on total nitrogen content in different plant's organs isogenic on genes *VRN* wheat lines, mg/g of dry mass (2009–2011)

Isoline* genotype	Leaves		Stems		Forming ears		Plant	
	Duration of photoperiod, hours							
	16**	9	16**	9	16**	9	16**	9
Isolines of Mironovskaya 808 cultivar								
VRN-A1a	32.0 ± 1.6	29.4 ± 1.1	14.3 ± 0.7	12.5 ± 0.7	23.6 ± 1.2	17.9 ± 0.9	69.9 ± 3.1	59.8 ± 3.2
VRN-B1a	33.7 ± 1.7	35.8 ± 1.6	18.5 ± 0.9	16.5 ± 0.9	23.4 ± 1.2	16.5 ± 0.9	75.6 ± 4.2	68.8 ± 3.8
VRN-D1a	35.8 ± 1.6	30.8 ± 1.4	14.7 ± 0.7	11.1 ± 0.8	23.0 ± 1.2	21.3 ± 1.2	73.5 ± 4.2	62.9 ± 3.3
Isolines of Olviya cultivar								
VRN-A1a	30.1 ± 1.2	27.8 ± 1.2	10.8 ± 0.7	12.6 ± 0.7	21.6 ± 1.1	19.3 ± 1.0	62.5 ± 3.2	59.7 ± 2.2
VRN-B1a	33.3 ± 1.1	40.4 ± 1.9	15.7 ± 1.2	25.2 ± 1.3	22. ± 1.0	23.3 ± 1.2	71.2 ± 3.9	88.9 ± 4.2
VRN-D1a	26.8 ± 1.0	32.1 ± 1.6	11.9 ± 0.7	13.8 ± 0.7	23.4 ± 1.2	18.6 ± 0.9	62.1 ± 3.0	64.5 ± 3.2

Notes: 1. *) – dominant genes are specified; 2. **) – natural long day formation of biologically valuable spare wheat proteins – gliadines and glutenines which monomeasures are amino acids. The increase in free amino acids pool in the conditions of unfavorable for the development of the investigated lines of the short photoperiod, probably, is connected with realisation of the program of a nonspecific stressful adaptation syndrome (Howarth, Parmar, Jones, 2008) in quantitatively long-day plants – intensification of hydrolythic processes and / or synthesis of amino acids *de novo.*

The study of total nitrogen content in various organs of the main shoot of a plant (leaves, stems, forming ears) has shown that in the whole plant among Mironovskaya 808 cultivar isolines and cultivar of Olviya its maximum content was in isoline *VRN-B1a*, both in the conditions of natural LD, and in the conditions of a short photoperiod (Table 3). Nitrogen content in lines of both investigated organs of the main shoot did not differ much, irrespective of genetic underground and genotypes of lines on genes *VRN*. Isolines of Mironovskaya 808 cultivar nitrogen content in leaves and forming ears correlated with rates of their development – fast developing isolines *VRN-A1a* and *VRN-D1a* are characterized by maximum content of nitrogen in organs. In the content of total nitrogen in stems the following feature has been found: in slowly developing isolines *VRN-B1a* of both cultivars its maximum quantity was in the conditions of LD and in the conditions of SD (Table 3). Probably, it is explained by depositing function of a stem during earing-flowering period with subsequent reutilization of nitrogen during grains filling period to be used in protein synthesis. Such feature of participation of stem in regulation of nitrogen metabolites redistribution is shown in a number of works of many researchers, mainly on wheat cultivar with a long vegetation period (Martre et al., 2003; Makino, 2011).

Under the effect of the photoperiodic induction of SD varieties in isolines Mironovskaya 808 in the whole plant and all the organs of the main stem a decrease of total nitrogen is observed which is possible due to a decrease in overall photosynthetic efficiency of the plants of this cultivar as a result of photosynthesis period reduction (Bertheloot, Martre, Bruno, 2008). No such clear dependence was found in Olviya cultivar isolines. Isoline *VRN-A1a* in the whole plant and the majority of organs reduces the amount of total nitrogen in SD conditions, and isolines *VRN-B1a* and *VRN-D1a*, on the contrary, increase the amount of total nitrogen. In the stems of all cultivar of Olviya isolines nitrogen content increases influenced by a short photoperiod, which may indicate enhanced transport and depositing function of that class stem.

Distribution of total nitrogen between the parts of the main stem at earing-flowering stage occurs as follows (Table 4): the maximum percentage of nitrogen was in the leaves (45–52%), lower – in the emerging ears (24–38%), and the minimum – in the stems (17–28%). Distribution of total nitrogen in relation to the whole plant shows that during the 16-hour photoperiod, regardless of genotypic features of the cultivar, isolines that are the first to go earing, manifest maximum in the leaves.

Contrariwise, slow-growing isolines have maximum in the stems, minimal in the emerging ears and leaves that also indicates that the function of the stem is mainly nitrogen depositing, which can be determined by gene *VRN-B1a*.

The influence of short photoperiod on the total nitrogen distribution in organs of plants is related to the cultivars genotype, the investigated lines being created in their gene pool. Under the influence of SD nitrogen content increases in leaves in all sorts of isolines photoperiodically sensitive Minorovskaya 808, but in general, it decreases in the stalk and forming ears. In isolines of photoperiodically neutral Olviya varieties the proportion of nitrogen grows in the stalk but decreases in the leaves and ears.

Decline in the share of total nitrogen in the emerging ears in both cultivars correlates with a slowing down development of wheat under the influence of short days which we found out

Table 4. Influence of a short photoperiod on total nitrogen distribution in various organs of plants isogenic on genes *VRN* wheat lines, % of the index in the whole plant

Isoline* genotype	Leaves		Stems		Forming ears	
	Duration of photoperiod, hours					
	16**	9	16**	9	16**	9
Mironovskaya 808 cultivar lines						
VRN-A1a	45.78	49.16	20.46	20.90	33.76	29.93
VRN-B1a	44.58	52.03	24.47	23.98	30.95	23.98
VRN-D1a	48.70	48.97	20.00	17.64	31.29	33.86
Olviya cultivar lines						
VRN-A1a	48.16	46.57	17.28	21.11	34.56	32.33
VRN-B1a	46.77	45.44	22.01	28.35	31.18	26.21
VRN-D1a	43.16	49.77	19.16	21.40	37.68	28.83

Notes: 1. *) – dominant genes are specified; 2. **) – natural long day

Table 5. Short photoperiod influence on formation of plants' individual productivity elements isogenic on genes *VRN* wheat lines (2009–2011)

Line genotype *	Ear length, cm		Grain weight per ear, g		Number of grains in ear, pcs		Weight of 1 000 grains, g	
	Duration of photoperiod, hours							
	16**	9	16**	9	16**	9	16**	9
Mironovskaya 808 cultivar lines								
VRN-A1a	10.0 ± 0.4	9.1 ± 0.4	0.72 ± 0.04	0.51 ± 0.04	23.7 ± 1.2	22.3 ± 1.2	27.8 ± 1.3	22.3 ± 1.2
VRN-B1a	7.7 ± 0.3	8.7 ± 0.3	0.31 ± 0.02	0.18 ± 0.01	16.2 ± 1.0	16.1 ± 1.0	17.4 ± 1.0	10.6 ± 0.9
VRN-D1a	7.8 ± 0.3	8.8 ± 0.4	0.41 ± 0.03	0.73 ± 0.05	18.0 ± 1.1	23.5 ± 1.2	25.8 ± 1.2	32.6 ± 1.9
Olviya cultivar lines								
VRN-A1a	6.1 ± 0.2	4.9 ± 0.2	0.48 ± 0.03	0.35 ± 0.04	31.7 ± 1.2	17.3 ± 1.0	20.4 ± 1.2	20.4 ± 1.2
VRN-B1a	5.9 ± 0.2	5.5 ± 0.3	0.37 ± 0.02	0.27 ± 0.03	22.4 ± 1.2	18.8 ± 1.0	17.7 ± 1.1	14.5 ± 1.0
VRN-D1a	5.8 ± 0.2	5.9 ± 0.3	0.41 ± 0.02	0.49 ± 0.05	22.6 ± 1.2	20.7 ± 1.8	21.2 ± 1.6	26.5 ± 1.8

Notes: 1. *) – dominant genes are specified; 2. **) – natural long day

Table 6. Influence of short photoperiod on grain protein content in isogenic on genes *VRN* wheat lines, mg/g of dry mass (2009–2011)

Grade	Line genotype *	Protein content during photoperiod	
		16 hours**	9 hours
Mironovskaya 808	*VRN-A1a*	140.3 ± 5.0	144.1 ± 3.1
	VRN-B1a	161.3 ± 4.5	215.9 ± 10.8
	VRN-D1a	155.0 ± 5.1	151.2 ± 3.0
Olviya	*VRN-A1a*	156.6 ± 3.0	148.8 ± 3.0
	VRN-B1a	162.5 ± 4.0	161.2 ± 5.4
	VRN-D1a	159.4 ± 3.2	142.1 ± 3.2

Notes: 1.*) – dominant genes are indicated; 2. **) – natural long day

when determining the length of time before earing (see Table 1).

The study of individual productivity of isogenic lines has shown that in long-day conditions it was maximum in fast growing grades *VRN-A1a* and *VRN-D1a* both varieties under study (Table 5). Performance level of yield structure elements defined varietal (genotype) features: Mironovskaya 808 cultivar compared with the variety of Olviya had longer ears, but fewer grains per ear, and almost the same weight of grain from the ear and weight of 1 000 grains.

Effect of short photoperiod, as a rule, led to declines in individual productivity of isolines *VRN-A1a* and *VRN-B1a* in both cultivars. In isolines *VRN-D1a*, conversely, in a short day all indicators of yield structure increased both in the lines of Mironovskaya 808 cultivar, and the lines of Olviya, which may indicate an indirect effect on the formation of the structural elements in the crop gene *VRN*.

The protein content in wheat grain is the most important economically valuable feature to determine nutritional value of bread. The most important in this respect are glutenine and gliadine fractions (their content and correlation are quite stable), other reserve proteins – albumin and globulins are less valuable and their composition in the grain is more labile (Martre et al., 2003).

The results of protein content determination in the grain showed (Table 6) that all cultivars of Olviya lines have higher content than Mironovskaya 808 cultivar lines at a somewhat lower individual productivity of plants (see Table 5). In Olviya cultivar isolines during a 16-hour photoperiod a clear inverse correlation between the duration of the period before earing and grain protein content was found out. In both cultivar isolines slowly developing lines *VRN-B1a* were characterized by the highest content of protein in the grain. Positive correlation between the protein content in grain and the length of the growing season in different varieties of wheat has been also shown by many researchers (Makino, 2011; Lam et al., 1996).

Under the influence of short photoperiod in the studied isolines grain protein content varied in many ways. In Mironovskaya 808 cultivar isolines *VRN-A1a* and *VRN-B1a* protein content increased and in line *VRN-D1a* – decreased. In the grain lines of Olviya cultivar *VRN-A1a* and *VRN-D1a* protein content decreased under the influence of short-day, and in the line of VRN-B1a it did not change (Table 6).

CONCLUSIONS

Thus, the obtained results show that different photoperiodic conditions affect the development of isogenic lines for genes *VRN* of hexaploid wheat, content and distribution of free amino acids and total nitrogen in parts of plants, individual productivity of plants and grain protein content. This suggests that *VRN* genes are involved into the regulation of photosensitivity of hexaploid wheat. It is likely that the system of *VRN* and *PPD* genes interact in the response of plants to changing photoperiodic and temperature conditions of the environment, which could be a factor in the high plasticity and adaptability of the varieties of this crop. The response level to this action depends on the state of individual *VRN* genes – dominant and / or recessive.

The fact that the studied lines that differ in genes *VRN*, change the development speed, nitrogen metabolism and productivity elements manifest in different ways, suggests possible involvement of these genes in the regulation of the investigated processes. Apparently, the identified influence of these genes on the studied traits can be realized through their participation in the regulation of metabolic processes, such as nitrogen metabolism in plants.

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FOTOPERIODO SĄLYGŲ POVEIKIS KVIEČIŲ *TRITICUM AESTIVUM* L. VYSTYMUISI IR AZOTINIŲ JUNGINIŲ SUDĖČIAI

Santrauka

Lauko eksperimentuose nuo dygimo iki užaugimo buvo tiriamas ilgų (16 val.) ir trumpų (9 val.) dienų poveikis heksaploidinių kviečių veislių 'Mironovskaya 808' ir 'Olviya', pasižyminčių jautrumu įvairiais fotoperiodais, laisvųjų amino rūgščių sudėčiai bei bendrojo azoto pasiskirstymui kamienų organuose, produktyvumo elementams ir grūdų baltymingumui. Rezultatai rodo, kad trumpas fotoperiodas pailgino laikotarpį nuo dygimo pradžios iki užaugimo bei pakeitė amino rūgščių sudėtį ir bendrojo azoto pasiskirstymą pagrindiniuose kamieno organuose, taip pat atskirų augalų produktyvumą ir grūdų baltymingumą. Šių pokyčių mastas priklauso nuo *VRN* genų (dominuojantis ir / ar recesyvinis). Manoma, kad *VRN* genai turi įtakos kviečių produktyvumo elementų formavimuisi ir vystymuisi įvairiais fotoperiodais bei netiesiogiai dalyvauja azoto apykaitos reguliavime.

Raktažodžiai: žieminiai kviečiai (*Triticum aestivum* L.), *VRN* genai, fotoperiodas, azoto metabolizmas, produktyvumas