

Enhancing elite wheat variety adaptability using genome editing

A.A. Kiseleva^{1,2*}, E.M. Timonova^{1,2}, A.A. Berezhnaya¹, A.E. Kolozhvari^{1,2}, E.A. Salina^{1,2}

¹ Institute of Cytology and Genetics, SB RAS, Novosibirsk, Russia

² Kurchatov Genomic Center of the Institute of Cytology and Genetics, SB RAS, Novosibirsk, Russia

* antkiseleva@bionet.nsc.ru

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Improving the adaptability of high-yielding wheat cultivars is a key strategy for advancing sustainable crop production. One effective approach is to shorten the growth cycle, as early-flowering varieties typically exhibit higher daily productivity than medium- or late-flowering counterparts. Therefore, tuning heading time is a critical breeding objective.

In this study, we focused on the elite spring wheat line Velut, which combines high yield potential, disease resistance, and strong regenerative capacity. However, its late heading limits its adaptability to the agroclimatic conditions of the Urals and Western Siberia – major regions for spring wheat cultivation in Russia.

Using CRISPR/Cas9-mediated genome editing, we introduced targeted mutations into the promoter regions of *PPD-1* genes. A total of 46 T0 plants carrying diverse promoter variants were obtained. Phenotypic evaluation of T1 progeny revealed a significant reduction in heading time compared to wild-type Velut. The advancement ranged from 2.1 to 5.4 days. Seven mutant lines with distinct promoter deletions were selected and advanced to the T2 generation, where stable homozygous mutations were confirmed in the absence of vector. These plants were used to confirm the effect of the introduced mutations on phenotype.

Targeted deletions within the promoter region encompassed binding sites of the transcriptional repressor CHE. Plants with such mutations exhibited accelerated heading. Diurnal expression profiling demonstrated altered *PPD-1* transcriptional rhythms in the edited lines, consistent with the loss of repressor binding. Moreover, differential expression patterns among the edited lines suggest that additional regulatory elements or transcription factors may contribute to *PPD-1* regulation.

As a result, we generated a set of wheat lines harboring defined promoter mutations in *Ppd-B1* and *Ppd-D1*. These lines represent valuable genetic material for dissecting the cis-regulatory architecture of photoperiod response genes and for developing early-flowering, climate-adapted wheat cultivars.

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