V.S. Pustovoit All-Russian Research Institute of Oil Crops,

# Molecular markers for the detection of photoperiod-related genes in soybean

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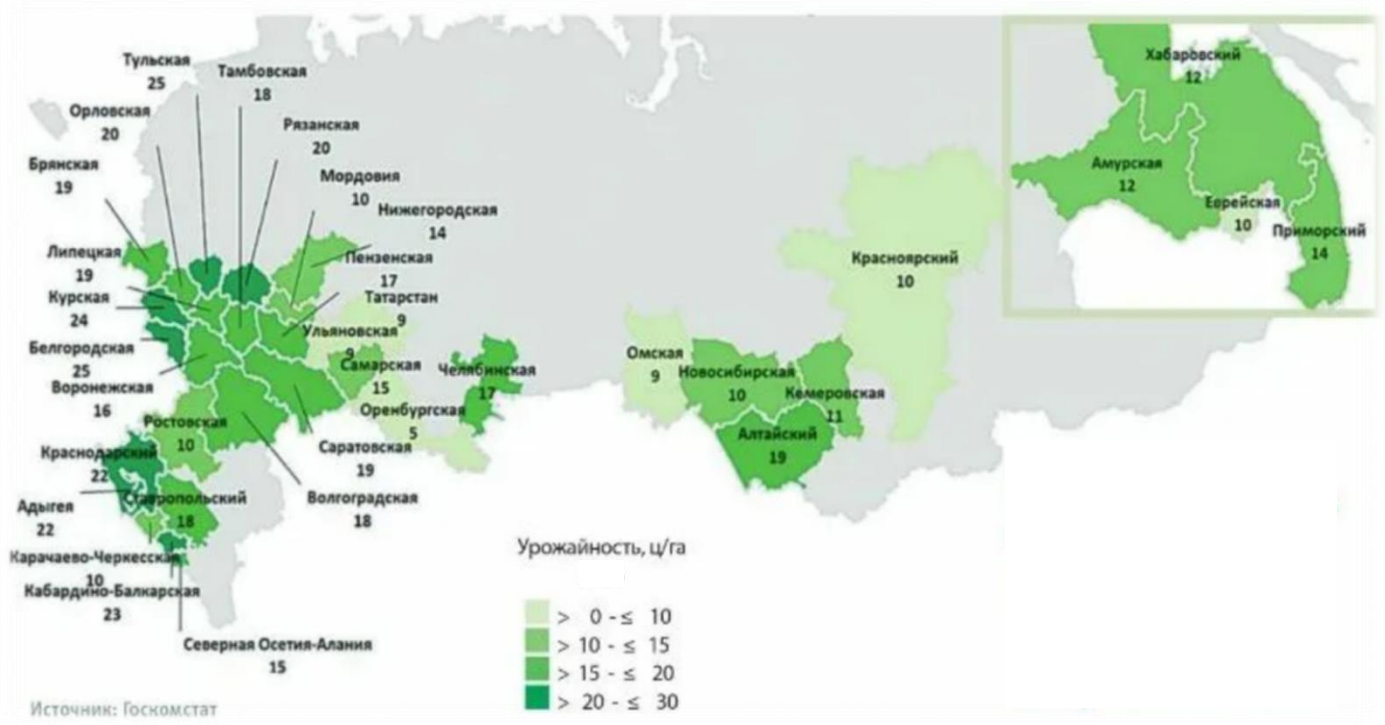
**Soybean (Glycine max) is a photoperiod-sensitive crop, with flowering time directly impacting yield and adaptation to latitudinal zones.**
**Photoperiod sensitivity is a critical adaptive trait in soybean, yet efficient marker-assisted selection (MAS) tools for breeding programs remain underdeveloped.**
**Here, we present approach to identify and validate genetic loci associated with photoperiodic response in domestic soybean cultivars**




Soybean yield by region

Krasnodar 2025 г.

**Objective:**

To develop molecular marker system for identifying photoperiod-responsive genes in soybean.

**Tasks:**

1.Select molecular markers associated with photoperiod sensitivity in soybean.

2.Test the selected markers on diverse soybean cultivars.

3.Evaluate marker polymorphism and establish a diagnostic system for photoperiod sensitivity in soybean varieties.

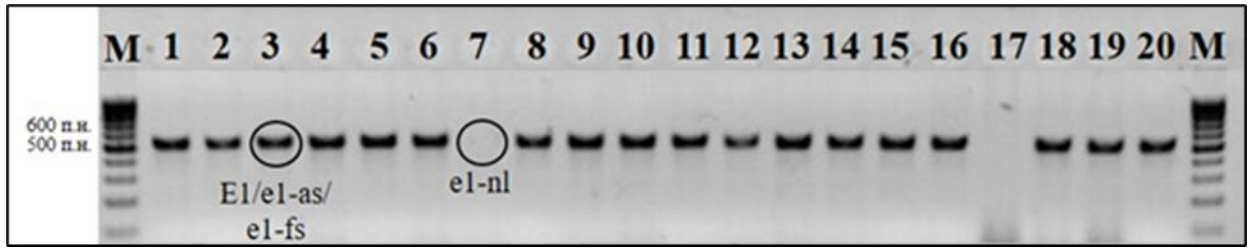
While major genes (E1-E4, FT) are well-studied, their allelic diversity and interactions in locally adapted cultivars require scalable molecular tools for precise selection.

E1

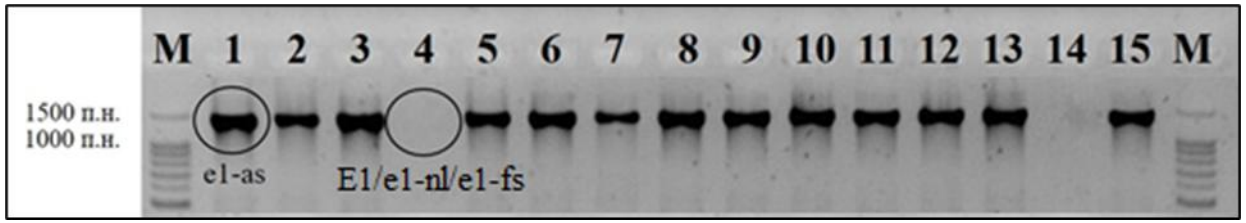
(E1/e1-fs/e1-nl) F: CACTCAAATTAAGCCCTTTCA; R: TCCGATCTCATCACCTTTCC

e1-as F: GGGAGCAGTGTCAAAAGAAGAC; R: GTGCTATCCCTTAGTTAATTAAATT

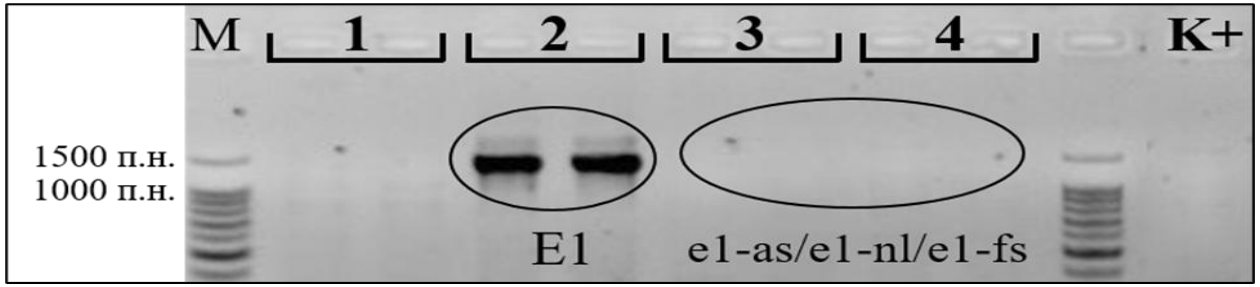
E1 F: GGGAGCAGTGTCAAAAGAAGAG; R: GTGCTATCCCTTAGTTAATTAAATA




Agarose gel electrophoresis patterns of PCR fragments generated by E1nlfsFR primers targeting the recessive e1-nl allele of the E1 gene.

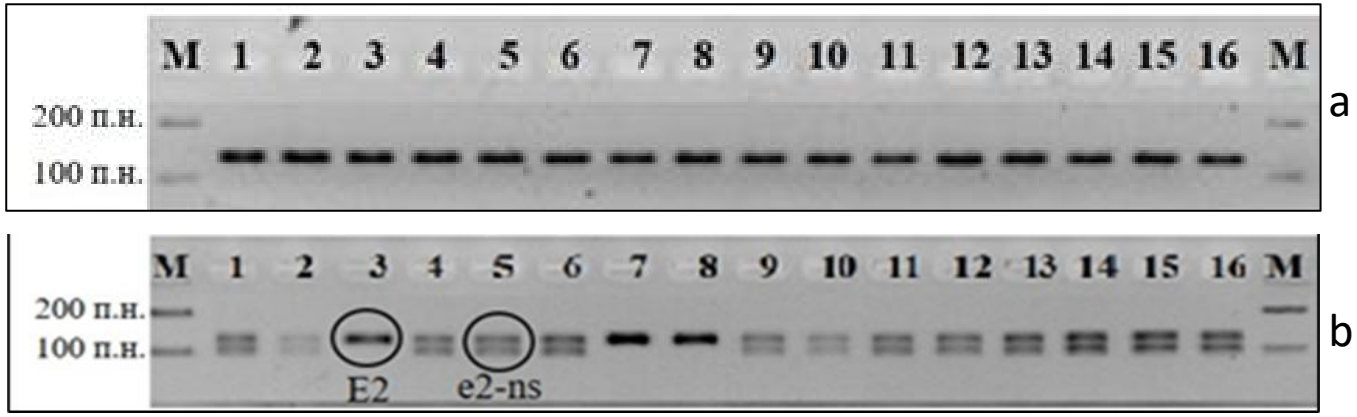



Agarose gel electrophoresis patterns of PCR fragments generated by e1-asFR primers targeting the recessive e1-nl allele of the E1 – e1-as. gene.




Electrophoretic patterns of PCR products amplified with E1FR primers for the dominant E1 gene allele

**E2** (E2/e2) F: GAAGCCCATCAGAGGCATGTCTTATT; R: AAGCCTATGCCAGCTAGGTATTT

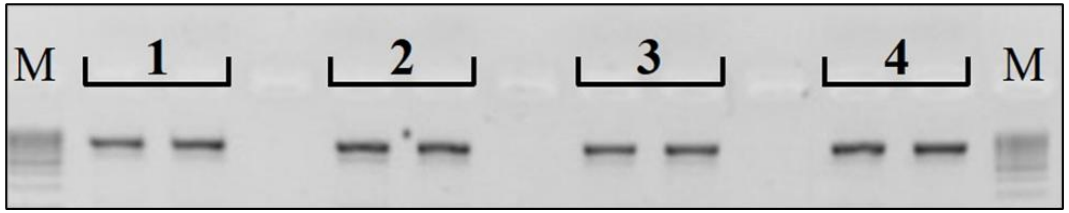



Electrophoretic patterns of PCR products amplified with E2FR primers before (a) and after digestion with DraI restriction endonuclease (b) for determining E2 gene allelic state.

**E3** (E3-Mi/E3-Ha/e3-tr) F: TGGAGGGTATTGGATGATGC
R1: CTAAGTCCGCCTCTGGTTTCAG
R2: CGGTCAAGAGCCAACATGAG
R3: GTCCTATACAATTCTTTACGACG

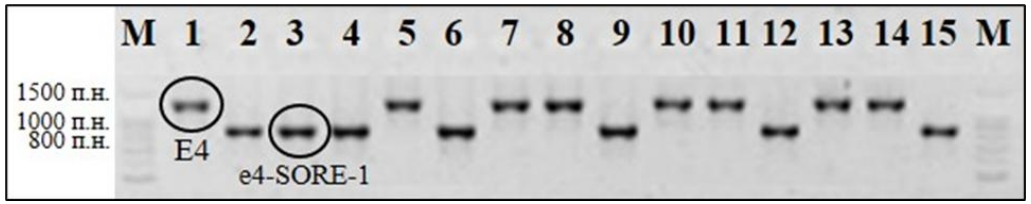
e3-fs F: GGGATAGTTCTGATGCTGTTCAA;

R:CCTTGTATCGATAGCATATGTGCT

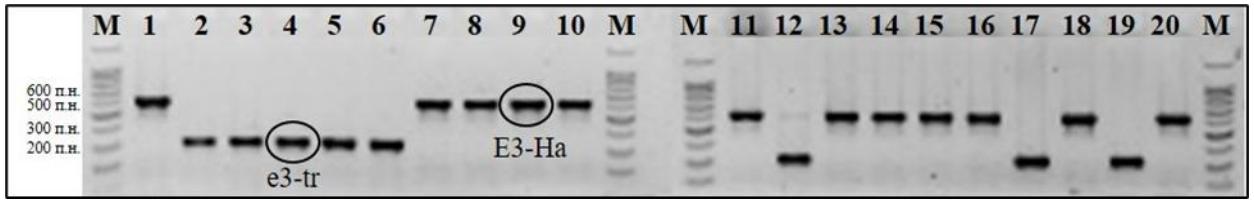



Electrophoretic patterns of PCR products amplified with e3-fsFR primers for the recessive e3-fs allele of the E3 gene.

**E4** (E4/e4-SORE-1) F: AGACGTAGTGCTAGGGCTAT
R1: GCATCTCGCATCACCAGATCA
R2: GCTCATCCCTTCGAATTCAG




Electrophoretic patterns of PCR products amplified with E4FR1-2 primers for genotyping the E4 gene allelic variants.




Electrophoretic patterns of PCR products amplified with E3FR1-3 primers for genotyping allelic variants of the E3 gene

# Soybean Varieties: Maturity Groups and E1-E4 Genotypes

| Variety | Maturity Group | E1-E4 Genotype Formula | Variety | Maturity Group | E1-E4 Genotype Formula |
|---|---|---|---|---|---|
| **SK Elana** | Very early | e1/e2/e3/e4 | **Puma** | Very early | e1/e2/E3/E4 |
| **SK Doka** | Very early | | **Soer 3** | Early | e1/E2/E3/e4 |
| **SK Unika** | Very early | | **Kasatka** | Early | e1/E2/e3/E4 |
| **Zabava** | Very early | | **Lidiya** | Early | |
| **Barguzin** | Very early | | **Delta** | Early | |
| **Lira** | Very early | | **Triada** | Early | |
| **Svetlaya** | Early | | **Duar** | Early | |
| **Belor** | Early | | **SK Optimal** | Early | |
| **Altom** | Early | | **Irbis** | Early | |
| | | | **Rys** | Mid-early | |
| | | | **Iney** | Mid-early | |
| | | | **Marinata** | Mid-early | |
| **Sibiriada** | Very early | e1/e2/E3/e4<br>e1/e2/e3/E4 | **Okskaya** | Early | e1/E2/E3/E4<br>E1/e2/E3/E4 |
| **Vita** | Very early | | **Georgiya** | Early | |
| **Yaselda** | Early | | **Mageva** | Early | |
| **Svapa** | Early | | **Luchezarnaya** | Early | |
| **Lancetnaya** | Early | | **Venera** | Mid-early | |
| **Dauria** | Early | | **Mamont** | Mid-season | |
| **Slavia** | Early | | | | |
| **Parus** | Early | | | | |
| **Selena** | Early | | | | |
| **SibNIIK 315** | Early | | | | |
| **Anton Tolpyshev** | Mid-early | | | | |

Using molecular markers for photoperiod sensitivity genes E1-E4, we identified alleles contributing most significantly to reduced day-length sensitivity in the studied soybean cultivars. The analysis demonstrated the effectiveness of this molecular marker panel for streamlining selection for this trait.