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Phenotypic and Transcriptomic Characterization of RHT-B1b$_{E529K}$, a Novel EMS-induced Dwarfing Allele Conferring Intermediate Plant Height in Wheat

Youngjun Mo[1,3]*, Stephen Pearce[2], Jorge Dubcovsky[1,4]

[1]Department of Plant Sciences, University of California, Davis, CA 95616, USA
[2]Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523, USA
[3]National Institute of Crop Science, Rural Development Administration, Wanju 55365, South Korea
[4]Howard Hughes Medical Institute, Chevy Chase, MD 20815, USA

[Introduction]

During the Green Revolution in the 1960s, introduction of the gibberellin (GA) insensitive semi-dwarfing RHT-B1b and RHT-D1b alleles contributed to unprecedented yield gains in wheat. Despite the beneficial effects in high-input environments, the dwarfing effects of these alleles are often excessive in adverse conditions such as dry/hot environments resulting in yield penalty. Also, reduced coleoptile length associated with these alleles leads to poor seedling emergence in deep sowing cultivation. This has motivated wheat breeders to search for alternative height genes/alleles conferring mild dwarfing effect.

[Materials and Methods]

A tall mutant line 'T4-934' was identified from a previously developed tetraploid wheat (var. Kronos carrying RHT-B1b) EMS mutant population. Candidate sequencing of RHT-B1 showed that T4-934 carries a nonsynonymous mutation (G1585A) changing glutamate (E) to lysine (K) in the RHT-B1b protein (hereafter RHT-B1bE529K). F2 (Kronos/T4-934) and BC1F2 (Kronos*2/T4-934) populations were developed to validate the effect of RHT-B1bE529K on plant height and to evaluate its influence on other agronomic traits. An additional BC1F2 (Kronos*2/Gredho) population segregating for RHT-B1b and RHT-B1a was used as control to estimate the relative dwarfing effect of RHT-B1bE529K. RNA-seq was conducted to study the effects of RHT-B1bE529K on the transcriptome in coleoptile, first leaf, early- and mid-stage elongating peduncle tissues.

[Results and Discussion]

The height-increasing effect of RHT-B1b$_{E529K}$ relative to RHT-B1b was 21% (19 cm), while that of RHT-B1a relative to RHT-B1b was 34% (33 cm). Plants carrying RHT-B1b$_{E529K}$ also showed significantly increased length in coleoptile, seedling shoot, and stem internodes compared to those carrying RHT-B1b. The level of GA sensitivity of RHT-B1b$_{E529K}$ lines was slightly higher than that of RHT-B1b lines, but lower than that of RHT-B1a lines and RHT-B1 null lines. RHT-B1b$_{E529K}$ did not affect other investigated traits including germination rate, seedling root length, tiller number, internode number, flag leaf size, spike length, and yield components. RNA-seq between RHT-B1b and RHT-B1b$_{E529K}$ lines indicated that the DELLA protein encoded by RHT-B1 regulates the transcriptome in a highly tissue-specific manner. The list of differentially expressed genes in each tissue provided useful information on potential DELLA downstream targets involved in cell wall and carbohydrate metabolism, cell cycle/division, and hormone pathways. Our study suggests that RHT-B1b$_{E529K}$may provide a useful alternative dwarfing source to confer intermediate plant height. Seeds of the RHT-B1b$_{E529K}$mutant (PI 687144) are publicly available through the USDA-ARS National Plant Germplasm System (https://npgsweb.ars-grin.gov/gringlobal/accession detail.aspx?id=1961292).

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*Corresponding author: Tel. +82-63-238-5232, E-mail. moyj82@korea.kr