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ORIGINAL ARTICLE

Comparative Analysis of *GS2* and *Fd-GOGAT* Genes in Cultivated Wheat and Their Progenitors Under N Stress

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Abstract

Polyploidization plays an important role in the genesis of cultivated wheat (hexaploid and tetraploid) from its diploid progenitors. Thus, evolution during polyploidization resulted in present-day hexaploid bread wheat. GS2 and Fd-GOGAT enzymes are core components involved in the assimilation of primary nitrogen (N) in plants. In the present study, we aimed to analyze these two important genes at their molecular level to find the extent of variation that occurred during evolution from the ancient diploid progenitors to the modern-day hexaploid bread wheat. Furthermore, we studied their gene expression pattern and assayed both the enzymes under N stress. We also investigated the degree of resilience among these species in terms of certain important morphophysiological and biochemical parameters under N stress. Comparison of the genomic sequences along with their promoter region revealed that both *GS2* and *Fd-GOGAT* genes were located on chromosome 2 and were comprised of 13 and 33 exons respectively. A limited sequence divergence at cDNA and amino acid levels was observed among the genome species, but the divergence was significantly higher in the promoter region. Both these genes were present in three copies in the bread wheat, two copies in the durum wheat, and a single copy in their diploid progenitors. Differential gene expression among the five genome species under N stress suggested major differences in gene regulation due to the difference in *cis*-elements. Enzyme activity did not correlate with the gene expression level probably due to post-transcriptional and post-translational modification of the enzymes. There was neither correlation between the GS2 and Fd-GOGAT activity in any species. All growth parameters, except root length, decreased or remain unchanged with different degrees of plasticity in the genotypes under N stress and correlated with reduced Fd-GOGAT activity, which supply the primary assimilate glutamate. GS2/Fd-GOGAT enzyme activity along with total N accumulation, protein, chlorophyll, and carotenoid content in shoot were found responsive to the N stress through combined PCA analysis. Our study confirmed the conserved nature of GS2 and Fd-GOGAT enzymes at the CDS and protein level; however, their expression and subsequent effects were different in cultivated wheat and their progenitors.

Keywords Cultivated wheat · Fd-GOGAT · GS2 · Nitrogen stress · Progenitors

Background

Nitrogen (N) is considered to be quantitatively one of the most essential and major limiting factors in plant growth and productivity. Hence, its use by crop plants in optimum quantity is a major concern and one of the major areas of research. Optimum use of N would primarily help in reducing the cost of production and lowering the negative impact of unutilized applied N fertilizer on the environment (Galloway et al. 2006; Hirel et al. 2007). Among all cereals, bread wheat is an extensively cultivated crop worldwide, followed by durum wheat (pasta wheat), which is the second most cultivated species of wheat. Moreover, wheat plays an important role in the food and nutritional security of the global human population (Foulkes et al. 2009). The allohexaploid bread wheat

Key message Comprehensive analysis of *GS2* and *Fd-GOGAT* genes revealed difference in copy number and gene expression profile among the polyploid cultivated species of wheat and their diploid progenitors, in spite of near conserved protein structure across the genome species.

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