

Plant Gene Register

Arabidopsis DNA Encoding Two Desiccation-Responsive *rd29* Genes¹

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During drought or water-deficit conditions, plants undergo a number of physiological and developmental responses. Recently, many genes have been shown to be responsive to water deficiency at the transcriptional level. Most of the genes that have been studied to date are also induced by the plant hormone ABA (Skriver and Mundy, 1990; Bray, 1991).

To analyze signal transduction pathways between drought stress and gene expression, we have cloned and characterized nine independent cDNAs (named RD) whose corresponding genes are responsive to desiccation stress in *Arabidopsis thaliana* (Yamaguchi-Shinozaki et al., 1992). One of the RD clones, RD29, is induced by drought stress very quickly and strongly, and this induction is a two-phase process (Yamaguchi-Shinozaki et al., 1992; Yamaguchi-Shinozaki and Shinozaki, 1992). The first, quick induction, occurred within 20 min and the second, slow induction, was observed within 3 h. Exogenous ABA induced RD29 mRNA, but the quick induction of the RD29 gene, found during the desiccation treatment, was not observed after ABA treatment (Yamaguchi-Shinozaki and Shinozaki, 1992). These observations suggest that the RD29 gene is induced by ABA, but its quick induction within 20 min by desiccation is not mediated by ABA. There seem to be ABA-independent as well as ABA-mediated signal transduction pathways between water stress and the induction of the RD29 gene.

Genomic Southern analysis revealed that there are several genes for the RD29 cDNA on the *Arabidopsis* genome (Yamaguchi-Shinozaki and Shinozaki, 1992). We isolated two genes corresponding to the RD29 clone, and these two genes are tandemly located in an 8-kb region of the *Arabidopsis* genome. We designated these two genes *rd29A* and *rd29B*. The characteristics of the two genes and their flanking regions are summarized in Table I. The coding region of *rd29A* was determined on the basis of the sequence of RD29 cDNA. The coding region of *rd29B* was determined by comparing the nucleotide sequence of *rd29B* with that of *rd29A*. Both *rd29A* and *rd29B* genes contain three introns at the same positions.

Table I. Characteristics of two desiccation-responsive genes, *rd29B* and *rd29A*, from *A. thaliana*

Organism:	<i>Arabidopsis thaliana</i> , Columbia ecotype.
Location:	Multigene family of unknown location.
Function:	Unknown, drought-inducible hydrophilic protein.
Techniques:	Isolation of RD29 cDNA clone was described by Yamaguchi-Shinozaki et al. (1992). Genomic DNA library from Clontech (Palo Alto, CA) was screened with RD29 cDNA clone (Yamaguchi-Shinozaki and Shinozaki, 1992).
Expression Characteristics:	The <i>rd29A</i> gene was induced within 20 min after desiccation began, but <i>rd29B</i> mRNA did not accumulate to a detectable level until 3 h after desiccation (Yamaguchi-Shinozaki et al., 1992; Yamaguchi-Shinozaki and Shinozaki, 1992). Both genes were induced by exogenous ABA 3 h after ABA was applied to plants (Yamaguchi-Shinozaki and Shinozaki, 1992).
Features of Genes:	The nucleotide sequence of 8048 bp includes the two coding regions for <i>rd29B</i> (from nucleotide 1786 to nucleotide 3870) and <i>rd29A</i> (from nucleotide 5512 to nucleotide 7909) in this order, 1785-bp 5' flanking region of <i>rd29B</i> , 1641-bp spacer region between <i>rd29B</i> and <i>rd29A</i> , and 139-bp 3' flanking region of <i>rd29A</i> . The <i>rd29A</i> gene has three introns of 85, 96, and 84 bp. The <i>rd29B</i> gene contains three introns of 81, 113, and 76 bp at the same positions as those of the <i>rd29A</i> introns.

The border sequences of these introns are consistent with consensus intron-exon boundary sequences.

The 5' end of the *rd29A* transcript was determined by the primer extension method. Nucleotide sequences around the ATG initiation codons and the putative TATA box sequences are conserved between *rd29A* and *rd29B*. We compared 5' upstream sequences between *rd29A* and *rd29B* to find a 40-bp conserved DNA sequence about 200 bp upstream from the transcriptional initiation site.

Both *rd29A* and *rd29B* encode hydrophilic proteins of 78 and 65 kD. RD29 cDNA has a high degree of sequence homology with a cDNA of a single-copy gene that is induced by low temperature (*lti140*) and encodes a 140-kD polypeptide in *Arabidopsis* (Nordin et al., 1991). The function of RD29 proteins remains to be elucidated.

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