September 2012 Vol. 19 No. 3 1-13
Journal of Northeast Agricultural University (English Edition)

Regulatory Network of Transcription Factors in Response to Drought in *Arabidopsis* and Crops

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Abstract: Drought is one of the most important environmental constraints limiting plant growth, development and crop yield. Many drought-inducible genes have been identified by molecular and genomic analyses in Arabidopsis, rice and other crops. To better understand reaction mechanism of plant to drought tolerance, we mainly focused on introducing the research of transcription factors (TFs) in signal transduction and regulatory network of gene expression conferring drought. A TF could bind multiple target genes to increase one or more kinds of stress tolerance. Sometimes, several TFs might act together with a target gene. So drought-tolerance genes or TFs might respond to high-salinity, cold or other stresses. The crosstalk of multiple stresses signal pathways is a crucial aspect of understanding stress signaling.

Key words: drought stress, stress tolerance, transcription factor, gene expression, signal pathway

CLC number: S332.4; Q943.2 **Document code:** A **Article ID:** 1006-8104(2012)-03-0001-13

Introduction

Transcription factors (TFs), which are known as trans-acting elements, can bind to cis-acting elements located in the promoter of stress-inducible genes, and regulate their expressions. Stress-inducible gene expressions are regulated by some signal pathways, such as AREB/ABF, DREB, NAC, MYB/ MYC, WRKY, NFYA, HD-ZIP etc (Table 1). AREB/ABF is ABA-dependent , DREB is ABA-independent, while NAC, MYB/MYC, WRKY, NFYA, and HD-ZIP families include several subfamilies, in which some are ABA-dependent, the other are ABA- independent, even different members in the same subfamily involve in different signal pathways. But they are not totally isolated. The crosstalk of multiple stress signal pathways puts these TFs together. These TFs show differential transcript regulations in response to different stresses (Table 2).

Plants have adapted to respond to various environment stresses, such as drought, high-salinity, extreme temperature etc., through a series of stress stimuli, signal perception, signal transduction, stress-responsive gene expression, appropriate morphological and physiological, molecular and cellular level changes occurred in plants, they protect themself from the damage of biotic and abiotic stresses. TFs play an important role in signal transduction. (Fig. 1).

Received 9 June 2011
Supported by Cultivation of New Varieties of Genetically Modified Major Projects (2011ZX08004-005); Soybean Industry Technology System (CARS-04-PS08)
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Table 1 Sorts of transcription factors in different families

Stress-responsive TFs	TFs families	Binding to cis-elements	Core sequence of cis-elements
DREB/CBF	AP2/EREBP	DRE/CRT	CCGAC
AREB/ABF	bZIP	ABRE	CACGTG (G box) CACGTC (C box) TACGTA (A box)
MYB/MYC	MYB/MYC	MYBRS/MYCRS	TAACTG
NAC	NAC	NACRS	CATGTG
WRKY	WRKY	WRKYRS	TTGAC (W-BOX)
NF-YA/NF-YB	NF-Y	NF-YRS	CCAAT
HD-ZIP	HB	HDERS	CAAT (A/T) AT TG (HDE1) CAAT (G/C) AT TG (HDE2)

Table 2 Abiotic stress tolerance of transgenic plant over-expressing transcription factors in different species

Family	Gene	Responsive to ABA	Increased tolerance to	Source species	Reference
bZIP	AREB1	Yes	Drought	*Arabidopsis*	Furihata *et al*., 2006
	AREB2	Yes	Drought	*Arabidopsis*	Furihata *et al*., 2006
	ABF3	Yes	Drought	*Arabidopsis*	Furihata *et al*., 2006
	ABP9	Yes	Drought, heat shock	*Arabidopsis*	Zhang *et al*., 2008
	OsbZIP23	Yes	Drought, high-salinity	Rice	Xiang *et al*., 2008
	OsbZIP72	Yes	Drought	Rice	Lu *et al*., 2009
	SlAREB	Yes	Drought, salt	Tomato	Hsieh *et al*., 2010
DREB/CBF	DREB1A	No	Cold	*Arabidopsis*	Liu *et al*., 1998
	DREB1B	No	Cold	*Arabidopsis*	Liu *et al*., 1998
	DREB1C	No	Cold	*Arabidopsis*	Liu *et al*., 1998
	DREB1D/CBF4	No	Drought (low)	*Arabidopsis*	Haake *et al*., 2002
	DREB2A	No	Drought, high-salinity	*Arabidopsis*	Nakashima *et al*., 2000
	DREB2B	No	Drought, high-salinity	*Arabidopsis*	Nakashima *et al*., 2000
NAC	ANAC019	Yes	Drought, high-salinity	*Arabidopsis*	Tran *et al*., 2004
	ANAC055	Yes	Drought, high-salinity	*Arabidopsis*	Tran *et al*., 2004
	ANAC72	Yes	Drought, high-salinity	*Arabidopsis*	Tran *et al*., 2004
	ANAC092	–	Salt	*Arabidopsis*	Balazadeh *et al*., 2010
	ANAC102	–	Low-oxygen	*Arabidopsis*	Christianson *et al*., 2009
	ATAF1	Yes	Drought	*Arabidopsis*	Lu *et al*., 2007
	SNAC1	Yes	Drought	Rice	Hu *et al*., 2006
	OsNAC52	Yes	Drought	Rice	Gao *et al*., 2010
	OsNAC6	Yes	Drought, high-salinity, cold	Rice	Nakashima *et al*., 2007
	ONAC045	Yes	Drought, high-salinity	Rice	Zheng *et al*., 2009
	OsNAC10	Yes	Drought	Rice	Jeong *et al*., 2010
MYB	AtMYB2	Yes	Drought	*Arabidopsis*	Abe *et al*., 2003
	MYB96	Yes	Drought	*Arabidopsis*	Seo *et al*., 2009
	OsMYB3R-2	–	Drought, high-salinity, cold	Rice	Dai *et al*., 2007
	StMYB1R-1	–	Drought	Potato	Shin *et al*., 2011