Present Status and Challenge for Applications on Abiotic Stress Tolerance Research on Plants

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Present Status and Challenge for Applications on Abiotic Stress Tolerance Research on Plants

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LIST OF ABBREVIATIONS

ABA	: Abscisic acid
APX	: Ascorbate peroxidase
AFLP	: Amplified fragment length polymorphism
APHIS	: Animal and Plant Health Inspection Service
ATP	: Adenosine triphosphate
ARC	: Agriculture Research Council
Bt	: *Bacillus thuringiensis*
bZIP	: Basic-domain leucine-zipper
BCH	: Biosafety Clearing House
BSES	: Bureau of Sugar Experiment Stations
cDNA	: Complementary DNA
COD	: Choline oxidase
CPB	: Cartagena Protocol on Biosafety
CBD	: The Convention on Biological Diversity
CDH	: Choline dehydrogenase
CMO	: Choline monooxygenase
CBF	: C-repeat binding factor
CCM	: Carbon concentrating mechanism
CGIAR	: Consultative Group on International Agricultural Research
CIAT	: International Center for Tropical Agriculture
CNGCs	: Cyclicnucleotide-gated channels
CaMV	: Cauliflower mosaic virus
CSIRO	: The Commonwealth Scientific and Industrial Research Organisation
CFIA	: Canadian Food Inspection Service
DREB	: Dehydration-responsive element-binding
dw	: dry weight
DRE	: Dehydration-responsive element
DIR	: Dealings involving international release
ESTs	: Expressed sequence tags

ERA	: Environmental Risk Assessment
E. coli	: *Escherichia coli*
ERF	: Ethylene-responsive element-binding factor
ET	: Ethylene
FAO	: Food and Agriculture Organisation
fw	: fresh weight
GB	: Glycine betaine
GSMT	: Glycine sarcosine methyltransferase
GLRs	: Glutamate-activated channels
H_2O_2	: Hydrogen peroxide
HKT	: High-affinity potassium transporter
Ht	: Herbicide tolerance
HPLC	: High performance liquid chromatography
JA	: Jasmonic acid
KORC	: Outward rectifying K^+ channels
LEA	: Late embryogenesis abundant
LMOs	: Living modified organisms
Mha	: Million hectares
MDA	: Malondialdehyde
mM	: Millimolar
NaCl	: Sodium chloride
NCBI	: National Center for Biotechnology Information
NADPH	: Nicotinamide adenine dinucleotide phosphate
NAC	: Nitrogen assimilation control
NSCC	: Non-selective cation channels
NUE	: Nitrogen use efficiency
OECD	: Organisation for Economic Co-operation and Development
OGTR	: Office of the Gene Technology Regulator
POD	: Peroxidase
PSII	: Photosystem II
QTL	: Quantitative trait loci

ROS	: Reactive oxygen species
Rubisco	: Ribulose-1, 5-bisphosphate carboxylase/oxygenase
RARMP	: Risk Assessment and Risk Management Plan
SOD	: Superoxide dismutase
SNPs	: Single nucleotide polymorphism
SSRs	: Simple sequence repeats
SAGs	: Stress-associated genes
SDMT	: Sarcosine dimethylglycine methyltransferase
SIP	: Stress-inducible promoter
SIAS	: Stress-induced alternative splicing
SOS	: Salt overly sensitive
SA	: Salicylic acid
SNIF	: Summary Notification Information Format
T-DNA	: Transfer-DNA
TILLING	: Targeting Induced Local Lesions In Genomes
TIGR	: The Institute for Genome Research
UV	: Ultraviolet
USEPA	: United States Environmental Protection Agency
USDA	: United States Department of Agriculture
WUE	: Water use efficiency
WHO	: World Health Organisation

Present Status and Challenge for Applications on Abiotic Stress Tolerance Research on Plants

（植物における非生物的ストレス耐性研究の現状と応用への試み）

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Abstract

Abiotic stresses such as salt and drought are serious threat to agriculture, and account for more than 50 percent of average yield losses for most of the major crop plants worldwide. Abiotic stresses affect plants physiological and developmental processes, mainly by imposing osmotic, oxidative and ionic stresses. Abiotic stress response in plants is a complex process that involves expression of a large number of genes. In recent years, transgenic plants with improved salt and drought stress have been developed with a large number of genes encoding stress-related proteins, enzymes and metabolites. Among these, the most extensively used genes are the glycine betaine biosynthetic *codA* gene, the DREB transcription factors, and vacuolar membrane Na^+/H^+ antiporters. The use of *codA*, DREBs, and Na^+/H^+ antiporters for genetic engineering of plants has conferred significant stress tolerance. However, many of these findings were based on studies conducted under controlled conditions, and until now there are some reports where the transgenic plants have exhibited increased yield under field conditions. Despite initial achievements under controlled conditions, there are several important issues that need to be addressed. Some of the issues include 1) further increasing stress tolerance of transgenic plants with these genes; 2) enhancing the effectiveness of these genes in terms of yield increase under natural stressed environment in the fields; 3) and addressing concerns over environmental risk assessment of these genes. As abiotic stress tolerance is a quantitative trait, therefore, a multigenic approach, targeting multiple stress response mechanisms, should be adopted to further increase stress tolerance with the above mentioned genes. Superior alleles of these selected genes should be combined with other alternative strategies to increase stress tolerance, improve water use efficiency (WUE), CO_2 assimilation and overall photosynthesis leading to reduction in yield losses under realistic field conditions. Moreover, the most important challenge to the deployment of abiotic stress tolerant transgenic plants is the environmental risk assessment issues. Environmental release of transgenic plants, with abiotic stress tolerance genes depends on their safety

to the environment. The current risk assessment procedures, based on the Cartagena Protocol on Biosafety, have been used for insect resistance and herbicide tolerance traits. The nature of abiotic stress tolerance genes is different from that of insect resistance Bt genes. Therefore, the questions arise, 1) whether abiotic stress tolerance genes such as the salt tolerance-inducing *codA* needs additional considerations and new measurements in risk assessment and, 2) whether these genes will have effects on weediness and invasiveness potential of transgenic plants. In the present work, we discussed various alternative strategies to increase stress tolerance and yield in transgenic plants under stress conditions. To address environmental concerns, we examined and compared the salt tolerance-inducing *codA* gene with insect resistance Bt gene for the risk assessment elements. Based on this comparison and the recent environmental risk assessment studies conducted on a number of transgenic plants with abiotic stress tolerance genes including the *codA*-transgenic eucalyptus, we report that the *codA* gene does not need additional considerations or new and changed measurements in environmental risk assessment.

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