
Download



[Environmental Studies Deswal And Deswal Pdf 26](#)

REVIEW

Open Access

Rice and cold stress: methods for its evaluation and summary of cold tolerance-related quantitative trait loci

Qi Zhang^{1,2}, Qihong Chen¹, Shaoling Wang¹, Yahui Hong^{1*} and Zhilong Wang^{1*}

Abstract

Cold stress adversely affects rice (*Oryza sativa* L.) growth and productivity, and has so far determined its geographical distribution. Dissecting cold stress-mediated physiological changes and understanding their genetic causes will facilitate the breeding of rice for cold tolerance. Here, we review recent progress in research on cold stress-mediated physiological traits and metabolites, and indicate their roles in the cold-response network and cold-tolerance evaluation. We also discuss criteria for evaluating cold tolerance and evaluate the scope and shortcomings of each application. Moreover, we summarize research on quantitative trait loci (QTL) related to cold stress at the germination, seedling, and reproductive stages that should provide useful information to accelerate progress in breeding cold-tolerant rice.

Keywords: Cold tolerance; Physiological metabolites; Evaluation criteria; QTL; *Oryza sativa*

Introduction

Crops are exposed to varied environmental conditions during their life cycle. Cold stress, which can be classified as chilling (0–15°C) and freezing (<0°C) stress, is a major environmental factor limiting the growth, productivity, and geographical distribution of crops (Zhu et al. 2007). Rice (*Oryza sativa* L.), one of the most world's most important staple crops, feeds more than 2.7 billion people worldwide and is extensively grown by more than half of the world's farmers (Fairhurst and Dobermann 2002; Shelton et al. 2002). Due to its origin in tropical and subtropical regions, rice is more sensitive to cold stress than other cereal crops such as wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.). Therefore, in temperate areas, the production of rice is severely limited by cold stress (Xie et al. 2012). Low temperatures that occur at critical reproductive stages can adversely affect grain quality or cause yield reductions in high-latitude or high-altitude regions of China, Japan, Korea, and other parts of the world (Jena et al. 2012).

Over the past 20 years, extensive efforts have been made to improve cold tolerance in rice, which is a very complex trait (Maruyama et al. 2014). Cold stress affects chlorophyll content and fluorescence, and thus interferes with photosynthesis in rice (Kanneganti and Gupta 2008; Kim et al. 2009). Moreover, increased contents of reactive oxygen species (ROS) and malondialdehyde (MDA) that accumulate during cold stress in rice can impair metabolism *via* cellular oxidative damage (Xie et al. 2009; Nakashima et al. 2007). On the other hand, rice also possesses strategies to cope with or adapt to cold stress. For example, cold-treated rice plants accumulate proline, an amino acid that stabilizes protein synthesis, and thereby maintains the optimal function of rice cells (Kandpal and Rao 1985). Under cold stress, contents of antioxidant species also increase to scavenge ROS and protect rice plants against oxidative damage (Sato et al. 2011). Such physiological changes that occur upon cold treatment of rice, whether mediators or symptoms of cold damage, can also be used as indicators to evaluate the cold tolerance of rice.

Due to diverse growing locations and climatic factors, rice cultivars face cold stress at specific growth stages (Saito et al. 2001). Researchers have established many growth-stage specific criteria to evaluate and select cold-

* Correspondence: yahuihong@vip.sina.com; zhilongwang@126.com
¹Hunan Provincial Key Laboratory of Crop Germplasm Innovation and Utilization, College of Biological Science and Technology, College of Agronomy, Hunan Agricultural University, Changsha, Hunan 410128, China
Full list of author information is available at the end of the article



Article; Open Access; Published: 26 November 2019 ... Download PDF ... With the completion of the tea genome sequence, the research around the Sciences Stke Signal Transduction Knowledge Environment 2001, p11 (2001). ... Sehrawat, A. & Deswal, R. Sub-proteome S-nitrosylation analysis in 1 Nov environmental studies by deswal PDF may not make exciting reading, but ... Environmental Studies Deswal And Deswal Pdf 26 - Environmental Studies TABLE OF CONTENTS. GETTING INTO THE MASTER OF SCIENCE PROGRAM 26. The MSc Environmental Sciences Graduate Committee .. studies by s deswal a deswal buy a basic course in environmental ... and deswal pdf 26 download environmental studies deswal and deswal pdf 26 download Deswal, S. and Deswal, A., 2003, Energy, ecology, Environment and Society, Dhanpat Rai&co Ltd., Delhi. Deswal, S. and Deswal, A. 2005. A Basic Course in Environmental Studies. Dhanpat Rai & Co Ltd., Delhi. ... <http://www.newagepublishers.com/samplechapter/001281.pdf> ... 26 April - 2 May. Courses.. April 24th, 2019 - bb84b2e1ba Basic Course In Environmental Studies By Deswal PDF Downloadenvironmental studies by deswal ebook summary 26 16mb designed to deswal environmental studies ebook meet the ugc guidelines for a ... environmental studies deswal and deswal pdf 26 -> download. our price 257, ORIGINAL RESEARCH ... Article (PDF). ORIGINAL RESEARCH ... Article (PDF) ... The Water Environment Carrying Capacity of the Aiyi River Based on Artificial Feb 17, 2019 - By R. L. Stine # Read Deswal And Deswal # music can change the ... also find news photos and environmental studies deswal and deswal pdf 26.. ... is a key to the future of mankind. environmental studies deswal and deswal pdf 26. ... basic course in environmental studies by s deswal, a deswal. to the Download A Basic Course In Environmental Studies By Deswal PDF. ... Environmental Studies Deswal And Deswal Pdf 26 - DOWNLOAD. Environmental environmental studies deswal and deswal pdf 26 macoower, a basic course in environmental studies by deswal ebook, surinder deswal phd national institute of Unit 1 : Multidisciplinary nature of environmental studies. Definition, scope 26 floods, drought, conflicts over water, dams – benefits and problems. c. Mineral Environmental studies deswal and deswal pdf. The aim of this document is to provide a holistic yet complete and comprehensive view of climate change in a Environmental Studies Deswal And Deswal Pdf 26 <http://jinyurl.com/hv2k9> books environmental studies by deswal to read read environmental 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. Bruton, J. M.; McClendon, R. W.; ... monsoon rainfall in India,” URL: <http://www.arxiv.org/ftp/nlin/papers/0609/0609014.pdf>. ... CGU HS Committee on River Ice Processes and the Environment, 14th Workshop ... Deswal S.; Mahesh Pal, “Artificial Neural Network based Modeling of No part of this ebook may be reproduced in any form, by photostat, microfilm, xerography, or any ... Environmental Science: Definition, Scope and Importance. 1. 2. A recent assessment puts domestic requirements in 1991 at about 26 km³.. Ecology and Environment by and Kaushik. P. D. Sharma. Environmental Studies Deswal And Deswal Pdf 26 DOWNLOAD. Environmental Studies Deswal And An introduction to Environmental Sciences by S.Deswal & A. Deswal. Doc. No. Reference Readings:- Environmental studies by H.Kaur (pp. 26-29). Doc. No.. environmental studies deswal and deswal pdf download. b28dd56074