

RESEARCH  
PAPERS

# Heterologous Expression of a Halophilic Archaeon Manganese Superoxide Dismutase Enhances Salt Tolerance in Transgenic Rice<sup>1</sup>

Z. Chen<sup>a, c</sup>, Y. H. Pan<sup>b</sup>, L. Y. An<sup>a</sup>, W. J. Yang<sup>a</sup>, L. G. Xu<sup>a</sup>, and C. Zhu<sup>b, a</sup>

<sup>a</sup> College of Life Sciences, Zhejiang University, Hangzhou 310058, P.R. China;  
e-mail: pzhch@cjlu.edu.cn

<sup>b</sup> College of Life Sciences, China Jiliang University, Hangzhou 310018, P.R. China

<sup>c</sup> School of Life Sciences, Taizhou University, Taizhou 317000, P.R. China

## Abstract

*Oryza sativa* *Natrinema altunense* *NaMnSOD*  
*Agrobacterium* *NaMnSOD*

(<sup>•-</sup>)

*NaMnSOD*

Keywords: *Natrinema altunense* *Oryza sativa*

DOI:

2

(<sup>•-</sup>)  
(H<sub>2</sub>O<sub>2</sub>). H<sub>2</sub>O<sub>2</sub> O<sub>2</sub> H<sub>2</sub>O

2

2

2

•

N

2

2

2

Abbreviations

F

F

F

O

N SOD

A • -

β

•-

**Reverse transcription–polymerase chain reaction (RT PCR).**

*N M SOD*

**Construction of vector and rice transformation.**

*Natrinema altun-*

*ense*

2

Script™

*NaSOD*

*N M SOD*  
2

2 L  
A

**Determination of ion leakage and lipid peroxidation.**

2

*NaMnSOD*

*SOD*

*NaMn-*

25 C

*C*<sub>1</sub>

*C*<sub>2</sub>

p1301 *35S::N M SOD*

25 C

*C*<sub>1</sub>/*C*<sub>2</sub>

*Agrobacterium tumefaciens*

*Oryza sativa*

2

*A. tumefaciens*

*35S::NaMnSOD*  
2

**Assays of superoxide anion radical and hydrogen peroxide.**

•-

**Screening of transgenic plants.**

*T*<sub>0</sub>

2 H<sub>2</sub>O<sub>2</sub>

2

*T*<sub>1</sub>

2  
0.28/( M cm)

**Enzyme assays.**

2

50 g

2

4 C

H<sub>2</sub>O<sub>2</sub>

4 C

•

2

**Growth condition and stress treatment.**

37 C

1.3 M

67 M

2

(200 mol/(m<sup>2</sup> s)),

30 C

150 mol/(m<sup>2</sup> s)

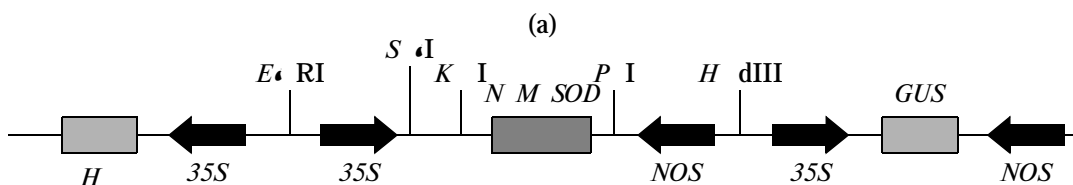
26/22 C

H<sub>2</sub>O<sub>2</sub>

**Measurements of photosynthetic gas exchange and chlorophyll fluorescence.**

H<sub>2</sub>O<sub>2</sub>





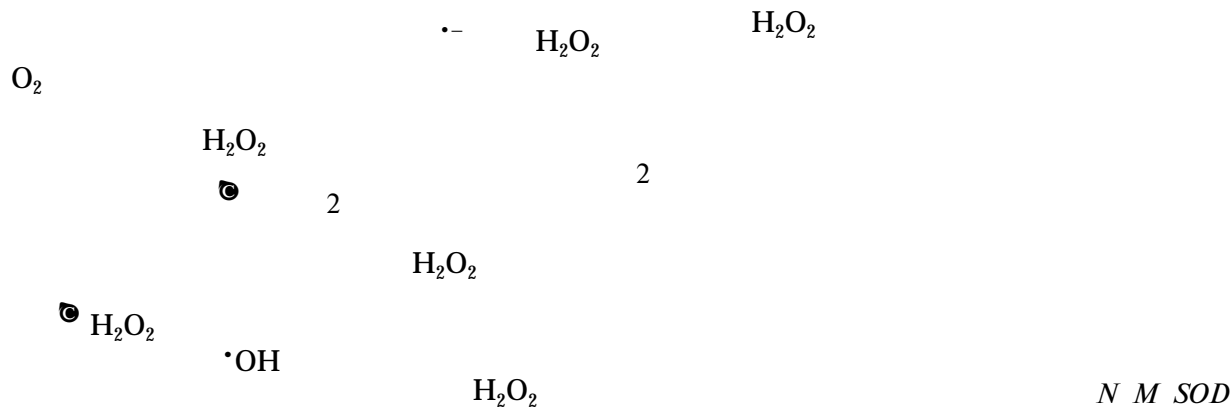
(b)

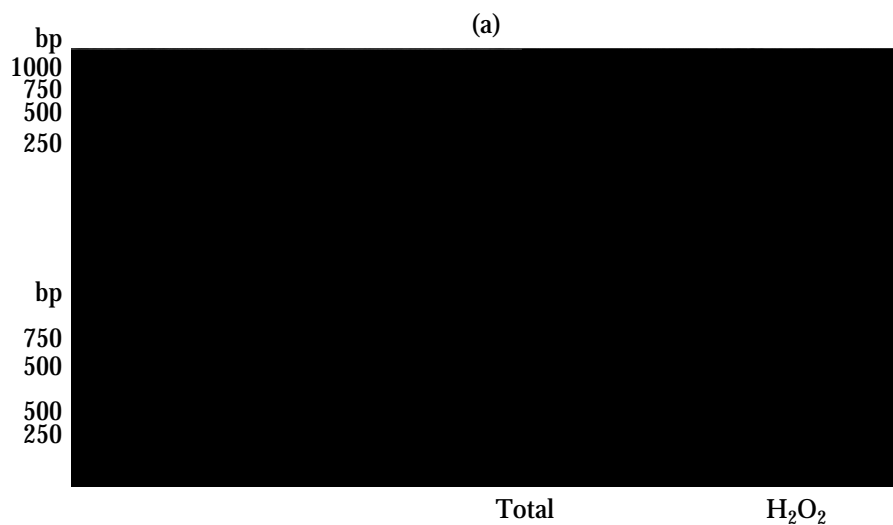
```

nt1  ATG ACT GAT CAC GAA CTT CCA CCA CTC CCG TAC GAT TAC GAC GCG CTC GAA CCG GCA CTG
aa1  M  T  D  H  E  L  P  P  L  P  Y  D  Y  D  A  L  E  P  A  L
nt61  TOC GAA CAG GTA CTG ACC TGG CAT CAC GAT ACG CAC CAC CAG GGC TAC GTC AAC GGC CTC
aa21  S  E  Q  V  L  T  W  H  H  D  T  H  H  Q  G  Y  V  N  G  L
nt121 AAC GGC GGC GAG GAG ACC CTC GCG GAG AAC CGC GAG GAG GGC GAC TTC GGC TOG ACG CCC
aa41  N  A  A  E  E  T  L  A  E  N  R  E  E  G  D  F  G  S  T  P
nt181 GGT GGC CTC AAA AAC GTT ACT CAC AAC GGC TGT GGT CAC TAT CTC CAC ACG CTG TTC TGG
aa61  G  A  L  K  N  V  T  H  N  G  C  G  H  Y  L  H  T  L  F  W
nt241 GAG AAC ATG TCC CCC AAC GGC GGC GGC GAG CCG GAC GGC GAC CTC GGC GAC CGC ATG GAG
aa81  E  N  M  S  P  N  G  G  G  E  P  D  G  D  L  A  D  R  I  E
nt301 GAG GAC TTC GGA TOC TAC GAG GGC TGG AAA GGC GAG TTC GAG GOC GCT GOC GGT GOC GOC
aa101 E  D  F  G  S  Y  E  G  W  K  G  E  F  E  A  A  A  G  A  A
nt361 GGT GGC TGG GCA CTG CTG GTG TAC GAT CCG GTT GCG AAG CAA CTT CGC AAC GTC GCG GTC
aa121 G  G  W  A  L  L  V  Y  D  P  V  A  K  Q  L  R  N  V  A  V
nt421 GAC AAG CAC GAC CAG GGC GCG CTC TGG GGC GCA CAT OCA GTG CTC GCG CTG GAC GTC TGG
aa141 D  K  H  D  Q  G  A  L  W  G  A  H  P  V  L  A  L  D  V  W
nt481 GAG CAC TCC TAC TAC TAC GAC TAC GGT CCG GAC CGC GGA GAC TTC ATC GAC GOC TTC TTC
aa161 E  H  S  Y  Y  Y  D  Y  G  P  D  R  G  D  F  I  D  A  F  F
nt571 GAC GTC GTC AAC TGG GAG AAG GOC GAA GAG GAG TAC CAG ACC TGC CTC GAG CAC TTC GAG
aa181 D  V  V  N  W  E  K  A  E  E  E  Y  Q  T  C  L  D  H  F  E
nt601 TAA CTCGCCGCGAAGCGAOCGAGOCAGITGATOGGTCITTTTTATTGCCAOCGCCACGGCGACTGTGCGTTGCACCTC
aa201 .
  
```

**Fig 1.**  $H$   $N M SOD$  p1301 35S::N M SOD 35S NOS GUS  $\beta$

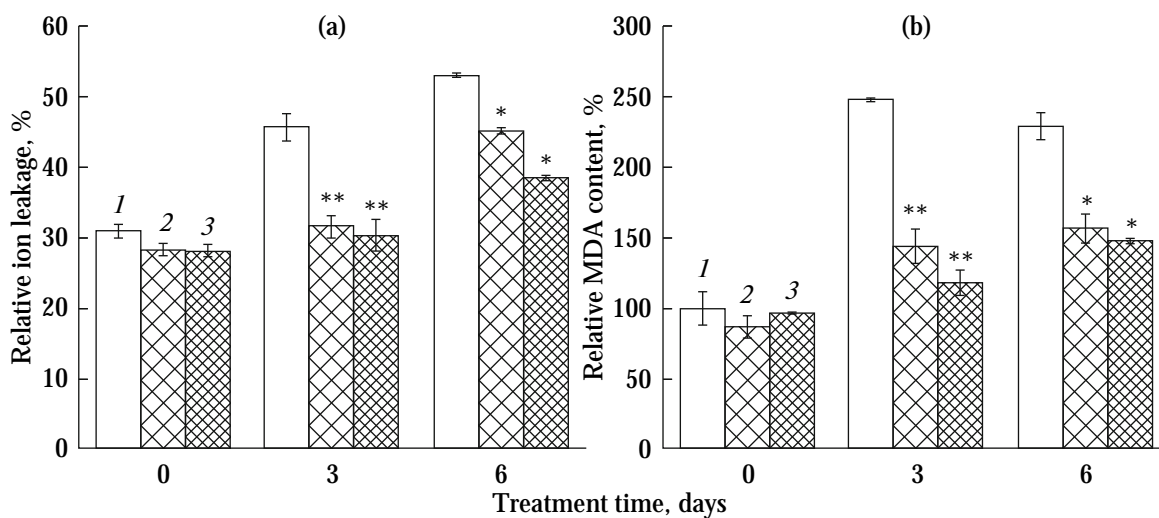
*Effect of Salt Stress on Activities of SOD and CAT*





**Fig. 2.**

*NaMnSOD*  
*NM SOD*  
*Actin*  
 T<sub>0</sub> 1\_14



**Fig. 3.**

\*  $P \leq 0.05$ ; \*\*  $P \leq 0.01$

1 2 3

*Effects of Salt Stress on Net Photosynthetic and Fluorescence Parameters*

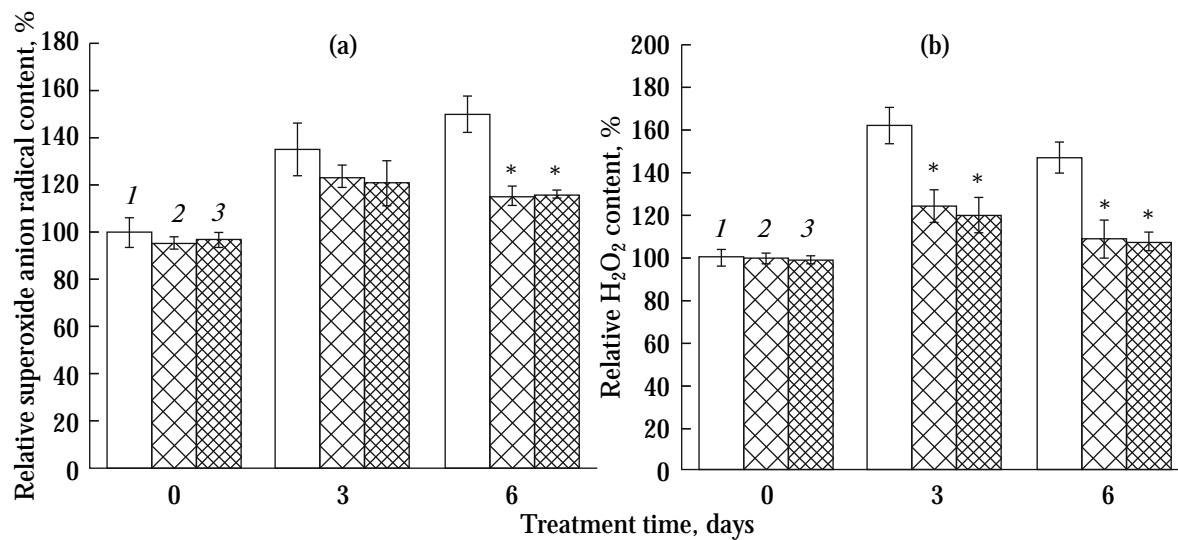


Fig. 4.

( $\cdot^-$ )

$H_2O_2$

1 2 3

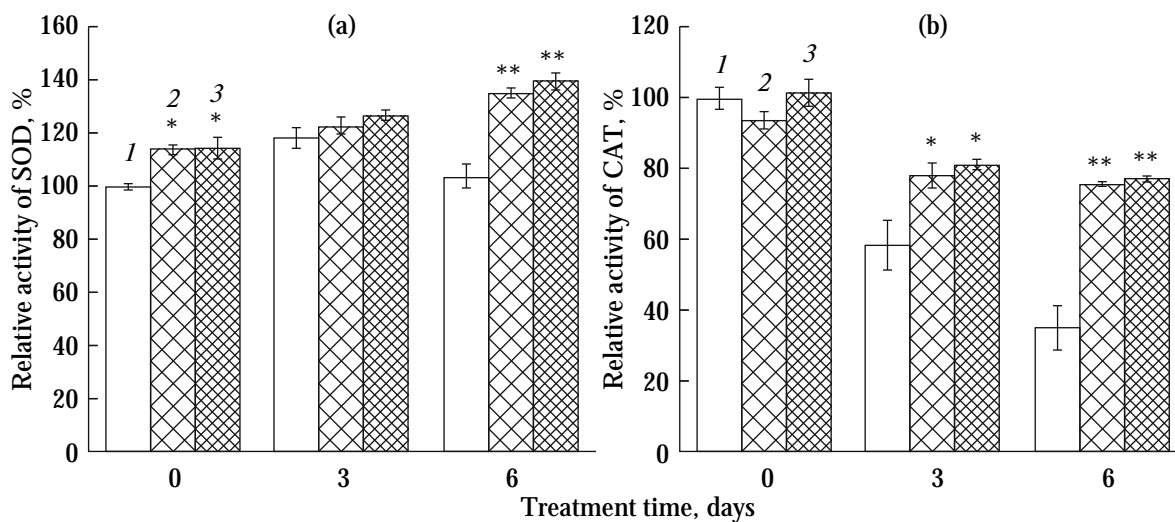


Fig. 5.

1 2 3

$P_n$

$F_v/F_m$

$P_n$

$F_v/F_m$

$(F'/F')$ ,

$\cdot^-$ ,

$H_2O_2$



*Oryza sativa* Mol. Breed. *Physiol.* *Plant*  
*Cicer arietinum* Russ. J. Plant Physiol. *Anal. Biochem.*  
*Curr. Opin. Biotechnol.,* *Gene Dev.*  
*Russ. J. Plant Physiol.* *iol. Plant.* *Phys-*  
*Plant Physiol. Biochem.* *Photosynthetica*  
*Nicotiana tabacum* *J. Plant Physiol.,*  
*Plant Sci.* *Aquat. Bot.*  
*Electron. J. Biotech.,* *Plant Sci.,*  
*Tamarix androssowii, Mol.* *Bruguiera parviflora*  
*Biol. Rep.* *Natrinema altunense* *J. Plant Physiol.*  
*PRC Inv. Appl. Publ.,* *Photosynthetica*  
*Agrobacterium* *Oryza sativa* *Plant J.*  
*Plant Mol. Biol. Rep.* *cyrtoloba* *Physiol. Plant.,* *Glycine*