

# Calcium Chloride Pre-treatment Enhances Waterlogging Tolerance of Chrysanthemum under High Temperatures

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## Abstract

Field-grown chrysanthemum [*Dendranthema xgrandiflorum* (Ramat.) Kitam.] would not grow well or even die in heavy summer rain conditions in subtropical and tropical areas, while exogenous calcium might enhance waterlogging tolerance and alleviate plant damages. The effects of various  $\text{CaCl}_2$  concentrations pretreatment were studied on growth and malondialdehyde concentration in waterlogging-intolerant 'Kaa Dei-Na'. Vegetative young plants with 14-16 leaves were placed in a phytotron at 30/25 °C under natural daylengths (13-13.5 h). Apart from normal irrigation (control), plants were pretreated with 0, 60, 90, or 120 mM  $\text{CaCl}_2$ , respectively, to the medium on 1 and 3 days before subjected to 3-d waterlogging followed by 9-d recovery. Plants without waterlogging grew well. Plants of 'Kaa Dei-Na' exhibited increased plant height, leaf number, and root dry weight as  $\text{CaCl}_2$  concentration increased from 0 to 120 mM. Application of 120 mM  $\text{CaCl}_2$  pretreatment enhanced growth of waterlogging-intolerant 'Kaa Dei-Na' through higher root dry weight and lower malondialdehyde concentration.

## Introduction

Chrysanthemum is majorly cultivated in field in many areas. Heavy summer rain causes poor growth or death of chrysanthemums. Elevated calcium levels in leaf can enhance waterlogging tolerance and reduce oxidative stress. Malondialdehyde (MDA) concentration in leaves has been considered a reliable indicator of oxidative damage. Thus, we studied the effects of  $\text{CaCl}_2$  pretreatment on growth and oxidative stress in 'Kaa Dei-Na' subjected to short-term waterlogging and high temperature conditions followed by the recovery.



## Materials and Methods



Control treatment

- Well drained and normal irrigation
- 12 days

$\text{CaCl}_2$  pretreatment

- 3-d waterlogging
- 9-d recovery

Day/Night 30/25 °C, RH 40%-70%, Natural day light of 13-13.5 h

3, 1 days before waterlogging with 0 (WL), 60, 90, 120 mM  $\text{CaCl}_2$  30 mL per plot

- Plant height
- Leaf number
- Shoot and root dry weight
- Malondialdehyde

## Results

- Plants without waterlogging grew well during the experiment (Fig. 1).
- Waterlogged plants exhibited leaf wilting and much reduction of root growth (Fig.1).
- However, shoot and root growth increased as the  $\text{CaCl}_2$  concentration increased from 0 to 120 mM (Fig. 1).

- Plant height, leaf number and root dry weight of 'Kaa Dei-Na' significantly decreased due to waterlogging, while these growth parameters increased as the  $\text{CaCl}_2$  concentration increased (Table 1).
- Shoot to root ratio of dry weight of 'Kaa Dei-Na' declined as the  $\text{CaCl}_2$  concentration increased (Table 1).

Table 1. Effects of calcium chloride pretreatment concentration on plant height, leaf number, root dry weight, shoot to root ratio, and reduced root dry weight of 'Kaa Dei-Na' subjected to 3-day waterlogging followed by 9-day recovery at 30/25 °C<sup>z</sup>.

$\text{CaCl}_2$ (mM)	Waterlogging (d)	Plant height (cm)	Leaf number	Root dry weight (mg)	Shoot to root ratio of dry weight	Reduced root dry weight (%)
'Kaa Dei-Na'						
0 (CK)	0	21.0	25.1	482	4.2	
0	3	14.6	20.3	92	11.8	80.9
60	3	15.6	22.0	161	8.0	66.6
90	3	19.5	25.0	219	8.0	54.6
120	3	18.4	24.5	277	5.7	42.6
CK versus waterlogging without $\text{CaCl}_2$ (t-test)		***	***	***	***	
$\text{CaCl}_2$ concn.		L***Q***	L***Q***	L***Q***	L***Q**	

<sup>z</sup> Plants were pretreated with 0, 60, 90, 120 mM  $\text{CaCl}_2$  respectively to growing medium 1 and 3 days before 3-d waterlogging followed by 9-d recovery. Control (CK) plants were neither waterlogged nor pretreated with  $\text{CaCl}_2$ .

NS, \*\*, \*\*\* Nonsignificant or significant at  $P < 0.05, 0.01$  or  $0.001$ , respectively. L = linear; Q = quadratic.

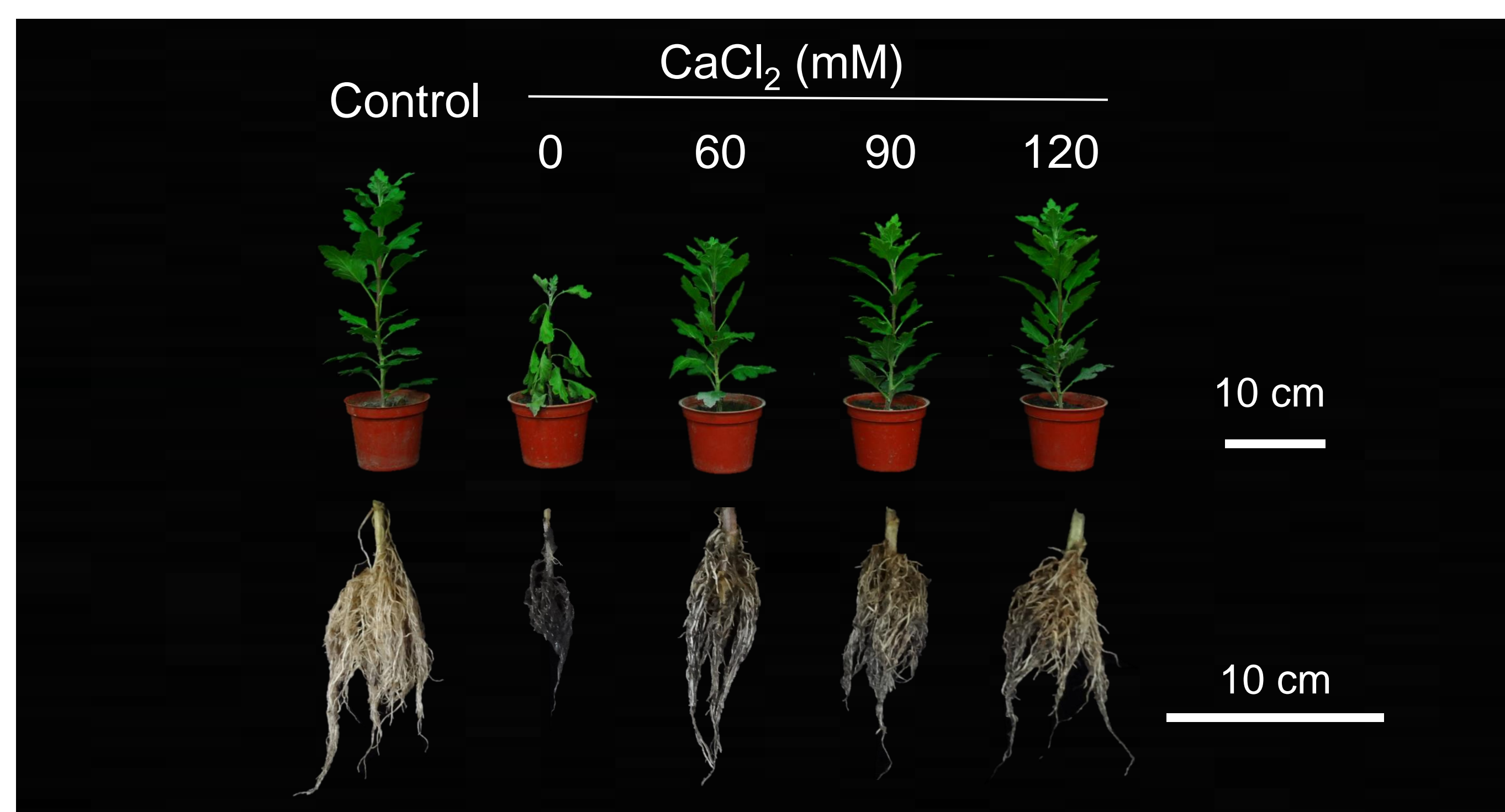
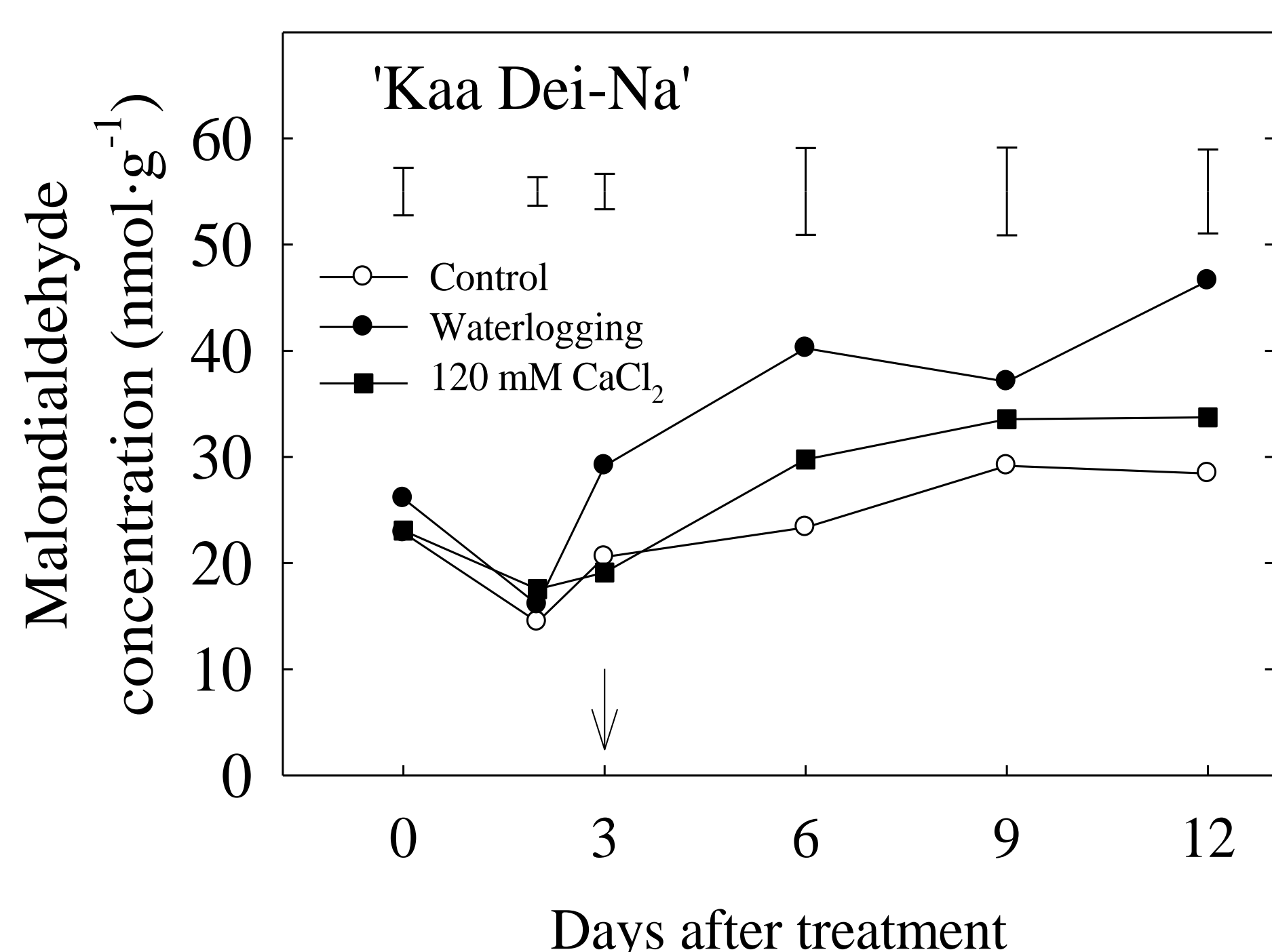


Fig. 1. Effect of pretreatment with various concentrations of calcium chloride on shoot and root growth of 'Kaa Dei-Na' subjected to 3-day waterlogging followed by 9-day recovery at 30/25 °C.



- Leaf MDA concentration in 'Kaa Dei-Na' increased after 3-d waterlogging (Fig. 2).
- Application of 120 mM  $\text{CaCl}_2$  pretreatment reduced leaf MDA concentration at the end of waterlogging and the recovery (Fig. 2).

Fig. 2. Effect of pretreatment with 120 mM calcium chloride on leaf malondialdehyde concentration of 'Kaa Dei-Na' subjected to 3-day waterlogging followed by 9-day recovery at 30/25 °C. Arrows indicate the beginning of the recovery from waterlogging.

## Conclusions

- The growth of 'Kaa Dei-Na' reduced when subjected to 3-d waterlogging followed by the recovery.
- Application of 120 mM  $\text{CaCl}_2$  pretreatment alleviated waterlogging-injury of 'Kaa Dei-Na' through maintaining higher root dry weight (80.9% vs. 42.2%) and efficiently reduced leaf MDA concentration.