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Research Paper

Reproductive growth characteristics of *Mesembryanthemum crystallinum* L. in High-Salinity stress conditions

Hoang Thi Kim Hong [a,b,*], Pham Thi Hong Trang [a,b], Thanh-Tam Ho [a,b], Jian Dang [c], Ryoma Sato [c], Kazuki Yoshida [c], Penpatchara Silaguntsuti [c], Sakae Agarie [c,*]

[a] Biotechnology Department, College of Medicine and Pharmacy, Duy Tan University, Danang, 550000, Vietnam
[b] Institute for Global Health Innovations, Duy Tan University, Da Nang 550000, Viet Nam
[c] Laboratory of Plant production physiology, Department of Bio resource Sciences, Faculty of Agriculture, Kyushu University, Fukuoka 819-0395, Japan

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ABSTRACT

This study presents the reproductive growth characteristics of a halophyte *Mesembryanthemum crystallinum* L. when grown in high-salinity soil stress conditions. The experiments were arranged and carried out continuously from 2020 to 2023, the first two years at Kyushu University in Japan and the last year at Duy Tan University in Vietnam. During the time in Japan, the effects of salinity stress on the reproductive growth stages and the morphological characteristics of *M. crystallinum* cultured in the soil treated with saline solutions containing 0 mM, 100 mM, and 400 mM NaCl were determined. Then, the seeds harvested from these plants were reproduced to develop them as the high salt-tolerance plants in Vietnam. The results show that 400 mM NaCl-treated plants maintained their growth and developed well during the vegetative growth stage. These plants had shorter flower blooming times than the 100 mM NaCl-treated and control ones (0 mM NaCl). The seeds harvested from NaCl-treated and control plants in Japan had regenerated *in vitro* plants well in the Vietnamese culture rooms. Interestingly, the 400 mM NaCl-treated *M. crystallinum* grew healthily in the soil, and their leaves, flowers, and seedpods tended to accumulate more betacyanin and epidermal bladder cells (EBCs) than other plants. These characteristics may be desirable for rehabilitating saline soil and developing high-salinity tolerance *M. crystallinum* for cultivation and growth in Vietnam.

1. Introduction

The study of the salinity tolerance in plants and their adaptability to adverse environmental changes due to global climate change is currently of significant research inquiry. It is of particular concern given the anticipated ecological changes in climate. The salinity-stressed environment damages the development and reproduction of most plants due to the possible accumulation of toxic sodium and chloride ions in reproductive tissues, significantly decreasing photosynthetic efficiency and plant growth.

Amongst the model plants, *M. crystallinum* belongs to the annual herb of the Aizoaceae family. *M. crystallinum* is an excellent model for integrative CAM (Crassulacean acid metabolism) and salinity-stressed research. The salt-responsive expression of *M. crystallinum* has been studied and reported previously (Schaeffer et al., 1995; Thomas and Bohnert, 1993; Tran et al., 2020). Many published papers showed that *M. crystallinum* could grow under various treatment conditions, especially drought and high-salinity stress (Kore-eda et al., 2004; Sunagawa et al., 2007; Hong et al., 2019). Under saline conditions, *M. crystallinum* exhibited all the physiological features of a CAM plant (Winter and Lüttge, 1976). *M. crystallinum* is also considered a halophyte plant species that can survive salinity stress, and this species has been used as a model in many types of research worldwide. When compared with other CAM species, *M. crystallinum* has many attributes that make it an attractive candidate for development under high-salinity stress conditions (Cushman, 2001). This fast-growing annual plant completes its life cycle rapidly through five distinct growth phases within 4–5 months (Bohnert et al., 2007) depending on prevailing environmental conditions (Adams et al., 1998). The plant produces large seeds under standard growth chambers or glasshouse conditions (Cushman, 2001; Cushman et al., 2008). Therefore, it quickly attracted the interest of most CAM experts, especially the studies on the transformation mechanism from CAM to C3 photosynthesis (Taybi and Cushman, 2002).

M. crystallinum is well-known for its pigment and epidermal bladder

* Corresponding authors.
E-mail address: hoangtkimhong@duytan.edu.vn (H.T.K. Hong).

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