A Novel Growth and Development of *Mesembryanthemum crystallinum* (Aizoaceae) in Thailand

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***Abstract*—We investigated the cultivation, growth and development of *Mesembryantheum crystallinum* L. (the common ice plant, Aizoaceae, Caryophyllales) in Thailand. *M. crystallinum* plant were grown indoor under light emitting diodes (LED)-lighting (16-h photoperiod) 25°C and 85±5% RH with adequate water supply. The life cycle of *M. crystallinum* were study in this research. Moreover, we also cultivated in field located in Phisanulok, Kanchanuri, Ratchaburi, Chonburi and Saraburi Province, during May to September 2018. The results shown that, the optimum area to grown the ice plant in Thailand was Phisanulok Province (16°49'29.32"N, 100°15'30.89"E) using plastic film to protect them from rain and fog. Moreover, the calcium concentration from ice plant cultivated in Thailand was three times higher than the one of China whilst the sodium concentration was forty-three times lower. There were no significant differences on the vitamin A and sugar content in the samples from both areas. Therefore, ice plant may have the potential to grow in Thailand and should be promoted as edible high-value crop**

***Index Terms*—Ice Plant, *Mesembryantheum crystallinum*, Growth, Antioxidants, Functional food**

I. INTRODUCTION

Ice Plant (*Mesembryanthemum crystallinum* L.) is a salt-accumulating halophyte originated in Namib Desert on the western coast of southern Africa and became leafy vegetable [1]. Large bladder cells covering the leaf and stem of *M. crystallinum* are enlarged epidermal cells that functions to reserve water and to store accumulated salt [2]. The ice plant Crassulacean Acid Metabolism (CAM) plant, but perform C_3 photosynthesis during the juvenile period [3]. The edible leaves of the *M. crystallinum* plants contain high nutritional values and were successfully grown inside greenhouses and plant factory with artificial lighting (PFAL) in China Japan and Taiwan under cool until low temperature. The growth of these plants were mostly studied in different treatments of soil [4]. To enhance local vegetable production, recently we have successfully grown them in land scarce Singapore using an indoor aeroponic farming system with adequate water supply under light emitting diodes (LEDs) lighting. However, there is no cultivate in Thailand. In this study, we focus on cultivation and development of *M. crystallinum* plant in Thailand.

II. MATERIALS AND METHODS

A. Plant materials under environment control

A series of experiments were conducted in the temperature control room of Panyapiwat Institute of Management in Nonthaburi Province (13° 51' 38.70"N, 100° 30' 53.17" E)

Ice plant seeds that obtained from the farmer in Shanghai, China were used in this research. Before sowing, the seed of ice plant were surface sterilized with 2.5% (v/v) sodium hypochlorite for 3 minutes and rinsed with distilled water for 20 minutes. The seed of ice plant were sown in plastic cell trays (50 long × 50 wide × 70 mm deep with an 8-mm-diameter hole at the bottom) filled with the growing medium (peat moss; Klasmann Potground H, Germany). The cell tray were place in plastic tray (450 long × 300 wide × 60 mm deep) filled with tap water at a depth of 10 mm for 3 weeks. After growing for 3 weeks, the ice plant seedlings were transferred to potted contained with mixed culture soil. After that, all potted ice plant were held under light emitting diodes (LED)-lighting (16-h photoperiod) 25°C and 85±5% RH with adequate water. After harvest (65 days after transplant), all plant were send to analyze the nutrition compare with *M. crystallinum* cultivated in China. Once flowering has begun, the plant are no longer watered.

B. Cultivation on field

The 3 weeks ice plant seedlings were transferred to local area in Thailand including Phisanulok, Kanchanuri, Ratchaburi, Chonburi and Saraburi Province. All plants were held under 200 micron plastic film to protect them from rain and fog with adequate water two times each day and natural lighting. Growth rate and development of the plant were observe.

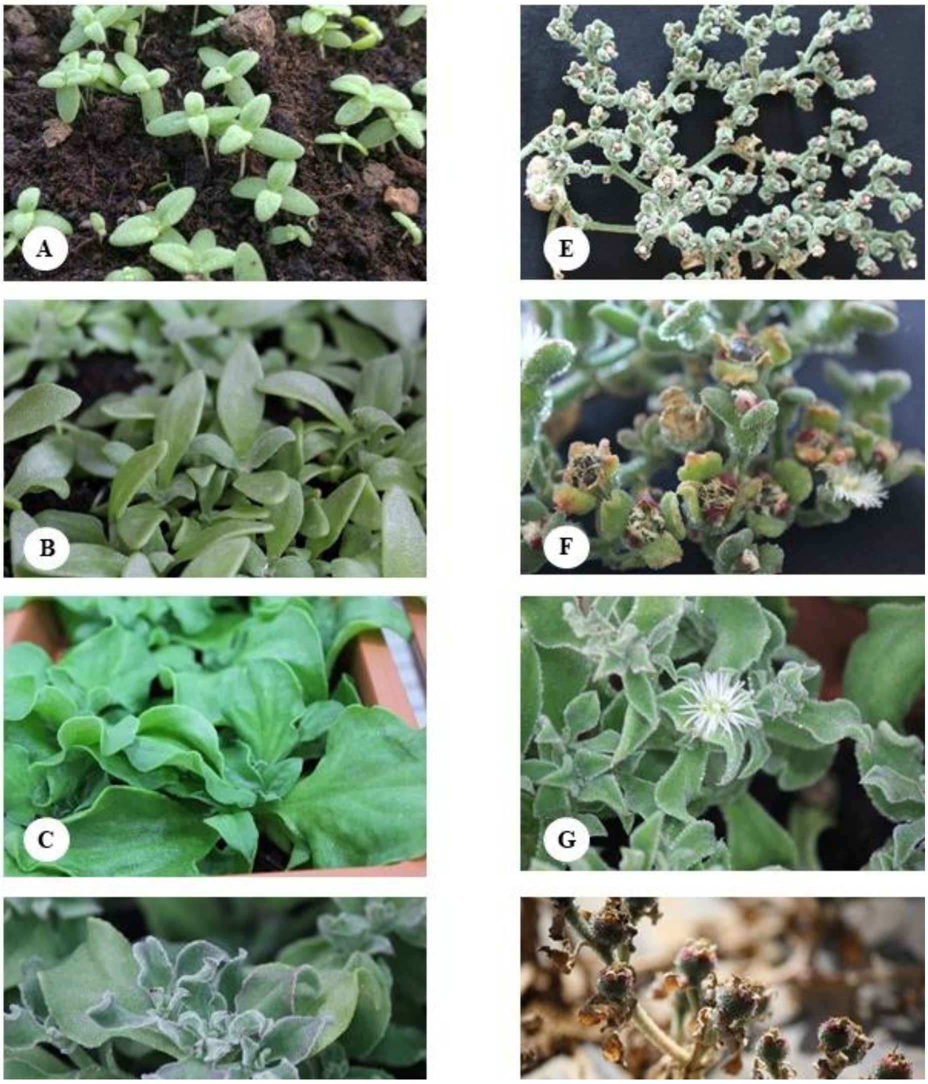

Fig. 1. Growth development of M. crystallinum. (A) Seedling with one primary leaf pair. (B) Juvenile plant (3-weeks old). (C) The stage transformation from juvenile to adult stage (6-weeks old). (D) Adult plant (12-weeks old). (E) Adult plant after stress (F) Size of plant and bladder cell depend on nutrition in medium and stress (14-weeks old). (G) Flowering at 12-weeks old. (H) Seed capsules, epidermal bladder cell are pigmented by betalaines.

III. Results and Discussion

The developmental stage are show in Fig. 1, and the pattern of growth and development are described following as below.

A. Growth and Development

1) Stage 1: Germination of seedlings

The seed germination were start within 3 days after sowing. The cotyledons are indistinct and 4-5 mm long (Fig. 1A). The germination rate depend on the quality of seed and suitable growth factors.

2) Stage 2: Juvenile leaves

After transplanted, the juvenile plants grow leaf pair (primary leaves) (Fig. 1B, 1C). One leaf pair a week occur in normal condition.

3) Stage 3: Adult stems and leaves

The mature stem and leaves start to appear on 8-weeks old plant. The bladder cell, unicellular trichomes functioning as peripheral salinity and water reservoirs covered on stem and leaves appeared in this stage [5].

4) State 4: Flowering

The onset of flowering is accelerated by any environmental stress including salt stress, lack of water and nutrition. In unstress plant; during mature growth they will produce the larger with a few flowers (Fig. 1G). While stress condition induced to end of juvenile growth smaller plant and many flowers (Fig. 1E, 1F).

5) Stage 5: Seed formation

The seed capsules were developed at 6-weeks old under stress condition, an is followed by senescence of roots, leaves and shoots whereas the seed capsules remain photosynthetically viable (Fig. 1F). This period in the last several weeks for plant [6]. The onset of seed formation is characterized by the appearance of intensely large epidermal bladder cell (Fig. 2)

III. Nutrition Facts

Once *M. crystallinum* plant growth to adult, all plants were harvested in early morning. Then all harvested plants were pack in the plastic box and transferred to laboratory at Kasetsart University Bangkhen within 1 hour. The nutrition fact in the plant were analyses compare with the plant growth in China following as TABLE I. All most of the nutrition, there were no significant differences among the both cultivation area. Accept sodium (Na) concentration in the plant cultivated in China was forty-three times higher than that cultivated in Thailand. Whereas, the calcium (Ca) concentration from ice plant cultivated in Thailand was three

Fig. II. Epidermal bladder cell (EBC) extremely appear when seed formation period. (A) EBC of the surface stem and leaves. (B) EBC on the surface of stem during seed formulation. (C) EBC on the surface of seed capsules. (D) The inside of seed capsule.

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times higher than the one of China. Previous study reported that, the ice plant is contain abundant level of polyol and various minerals, as well as inositol, which is particular interest because it can in the treatment of diabetes mellitus [7]. At different stage and part, M. crystallinum shown different amount of sodium accumulation. The highest sodium accumulation was found in bladder cell at 1009 μmol g-1 f.wt. [2].

TABLE I
THE NUTRITION'S FACT IN 100 G PLANT IN BOTH AREA.

Nutrition	**Cultivation area**	
	China	**Thailand**
Energy	12.86 Kcal	11.68 Kcal
Fat	0.18 g	0.00 g
Protein	1.13 g	0.37 g
Carbohydrate	1.68 g	2.55 g
Fiber	1.07 g	0.00 g
Sugar	0.24 g	0.10 g
Na	708.62 mg	16.5 mg
Vitamin A	146.12 µg	117.61 µg
Ca	55.77 mg	174.22 mg
Mg	46.56 mg	26.91 mg
Ash	2.11 g	1.63 g
Moisture	94.90 g	95.45 g

Kcal = kilo calorie, g = gram, mg = milligram, µg = microgram

IV. SUITABLE AREA IN THAILAND

Growth of *M. crystallinum* can be influenced by temperature, light quantity and quality, and nutrient supply [8]. The plant cultivated in Kanchanuri, Ratchaburi, Chonburi and Saraburi Province have the abnormal physiology were shown in Fig.3. From these results, Phisanulok Province (16°49'29.32"N, 100°15'30.89"E) is consider as suitable area to produce *M. crystallinum* because suitability of factors and environment. However, in unsuitable are should more analysis by considering several limiting and supporting factor, such as accessibility infrastructure including water, soil and weather management.

Fig. 3. The physiology of M. crystallinum cultivated in (A) Kanchanaburi Province. (B) Chonburi Province. (C) Phisanulok Province

V. CONCLUDSION

In conclusion, the results suggest that the common ice plant or *M. crystallinum* are considered as proper crops with high commercial potential for the production in Thailand, especially at Phisanulok Province area. Because the relation of considering high quality, high production yield and operation costs in plant cultivation.

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