The Effect of Smoke Treatment on the Germination of Four Species of Mesembryanthemum: Some Preliminary Observations

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Abstract

In reaction to excessive salt and drought, the common ice plant, Mesembryanthemum crystallinum L. (Aizoaceae, Caryophyllales), shifts from C3 photosynthesis to Crassulacean acid metabolism (CAM). "Given the controversy over whether genetics or the environment play a greater role in M. crystallinum growth, it makes sense to give a high-level overview of the life cycle under laboratory settings. In order to characterize the first five stages of development using morphological, physiological, and molecular biological parameters, we aim to create a framework. The first two steps are germination and the development of the juvenile form, and they take place in a predictable order. Stages 3-5, when the plants would expand, bloom, and produce seeds absent the salt, are prevented from maturing into their full shape by early stresses. The third developmental stage is ambiguous under typical circumstances, but when CAM is expressed constitutively, environmental disturbances hasten maturation and flowering. Plants have already started to bloom, but they will soon wither and die from the ground up, leaving only their seed capsules and the salt they have stored in their enormous epidermal bladder cells in order to assure the survival of the human species (stage 5). This paper discusses salinity reactions that result in the compartmentalization of ions and compatible solutes, the maintenance of turgor, and CAM. This article concludes with a discussion of the genes and proteins encoded by those genes in the ice plant genome. Finally, we consider how each growth stage may be viewed as an ecological reaction to increasing stress. The enormous mass of plant material produced by the first, rigid juvenile phase is essential for the success of the indeterminate, mature phase. The degree to which this occurs depends on how severe the stress was, after which the fully mature form is driven toward flowering and seed set.

Keywords: Growth, development, Mesembryanthemum, salt stress. LED lights

1. Introduction

A succulent with a low, spreading growth habit prefers hot, dry regions. Perennial Mesembryanthemum, also known as stargazer lilies, are summer annuals with star-shaped flowers in a rainbow of colors that adorn their glistening stems and leaves. This genus, native to semiarid parts of South Africa, contains over 218 species of erect or prostrate perennial succulents. These plants are typically dwarfed in stature and favor well-drained soil; yet, they make a stunning summer bedder in arid regions. (Barkla, 2018)

The flowering plants in the genus Mesembryanthemum belong to the Aizoaceae family, and their persistent flower heads are characteristic of this group of plants. Mesembryanthemum flowers close at night to protect their gametes from the risk of dews or frosts, but they open wide for the day. When the reproductive organs are exposed to the elements (sun, dew, frost, wind, or predators), it can be good for the flowers to close so that they don't get eaten. Its native range is in southern Africa. (El-Amier, 2021)

2. Background

Mesembryanthemum, a member of the Aizoaceae family, is easily identifiable by its ability to withstand dry conditions, its short stature, and the continuous summer bloom of daisy-like blooms in a wide range of pastel tones." The frosted appearance of the plant's stems and leaves when exposed to sunshine lends credence to the ice plant's moniker. Several similar plant species share the common name "Livingstone daisy," which is traditionally attributed to the intrepid explorer David Livingstone. (Zhang J. W., 2018)

The seeds, stems, and leaves of the Mesembryanthemum plant are all edible. Knowing which of the numerous varieties of plants you have before you select and utilize it is crucial because they all go by the label "ice plant." Mesembryanthemum plant leaves and stems have a salty, biting flavor. They can be prepared by steaming in the same way as spinach. bouquets of flowers that remain in place to protect themselves from the elements at night, flowers close their petals. In the UK but not elsewhere, pollinators enjoy flowers with orange centers and pink, yellow,

doi.org/10.31838/hiv22.02.749 Received: 10.07.21, Revised: 22.08.21, Accepted: 09.09.21

white, or orange petals. To wit: (Visscher, 2018)

For seeds to start to grow, water must be given to them. Only if there is enough water will this be possible. When temperatures rise, it can be hard for seedlings to grow in dry soil. During seed germination, temperature affects how much water is there, how well hormones work, and how enzymes work. Heat speeds up chemical reactions in seeds and makes new cells grow faster. (2020 Burana)

Several abiotic and biochemical factors have a big effect on how quickly seeds sprout. "Prescribed burning." is a common way for both developed and developing countries to get rid of agricultural waste. "This method may be useful and cheap, but it also has some risks, like adding to air pollution and killing off good bacteria in the soil. Scientists have found that smoke from a fire can be used to help seeds grow in places that are prone to fires. Controlled burning is the key to this method. So, smoke from plants and aqueous extracts of smoke can be used in agriculture and to protect rare and/or endangered species in several ways. Research (Gajewska, 2018) shows that the speed at which seeds sprout depends on several internal and external factors, such as light, temperature, and moisture. Gibberellin and abscisic acid control seed germination and the start of dormancy by making it easier for -amylase to be made and made. (He J. K., 2021)

During the germination of Arabidopsis seeds, the active ingredient in smoke water also cut down on ABA and controlled GA. Surprisingly, only a small number of studies have shown that light affects how long seeds stay dormant and how they respond to smoke by sprouting. Researchers Ren et al. found that smoke water made it easier for lettuce seeds to grow when they were put in the dark. Nelson et al. found that the seeds of the plant Arabidopsis would only sprout in very bright light. For a good ecological understanding of how seeds respond to smoke-water, research must be done both in constant light and in cycles of light and dark. A look at what's been written (Otsuka, 2021).

Because many Mesembryanthemum species have shiny, globular bladder cells on their stems, fruits, and leaves, they are often called ice plants. Because ice plant leaves have hairs that look like bladders on the surface, light reflects and bends in a way that makes it look like the plant is covered in small ice crystals.

Some people think that Mesembryanthemum should be in the genus Cleretum, while others think it should be in the genus Carpobrotus or Sceletium.

Kingdom:	Plantae
Clade:	**Tracheophytes**
Clade	Angiosperms
clade	Eudicots
order	Caryophyllales
family	Aizoaceae
Subfamily	Mesembryanthemoideae
Genus	Mesembryanthemum

Clade: Eudicots
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Species of Mesembryanthemum

Common ice plant
Baby sun Roz
Mesembryanthemum actions
Mesembryanthemum Barkly

Baby sun rose

The succulent species known as the baby sun rose or Mesembryanthemum cordifolium is native to South Africa. In urban and suburban settings, baby sun rose is most often employed for ornamental purposes. This fast-growing plant is frequently seen in flower boxes and other public plantings since it is utilized to cover the ground." It's simple to propagate from cuttings and can easily outgrow weeds in the same environment. (He J. N., 2022)

Problem statement

Mesembryanthemum effect when exposed to dry heat or smoke, either it responds to germinate or hinders the germination and the movement of water during ultra-heat exposure and to observe the changes in plant

Aims of the study

To prove growth by exposure to dry heat/smoke and photochemical effect.

To prove that water is necessary for germination.

Questions of the study

Do they need light for germination?

How do seeds grow when exposed to ultra-dry heat?

Significance of the study:

Planting Mesembryanthemum as an annual in temperate climates is common to practice due to the plant's limited cold tolerance. This plant requires little care after it has been planted in late spring, except for the first few weeks. Allow the compost in the container to dry out entirely before watering again. (Manzoor, 2018)

Uses of Mesembryanthemum

Mesembryanthemum crystallinum's leaves and fruits can be eaten. The leaves can be crushed to make a substitute for soap, and they have a few medical applications as well. The leaves can take the place of spinach in a dish after being boiled, albeit they have a different flavor profile due to being more acidic and salty than spinach.

Ascites (abdominal fluid accumulation), diarrhea, liver and kidney issues, and pneumonia are just some of the conditions that an ice plant can alleviate." When put on the skin topically, it reduces itching, pain, swelling, and redness. (You, 2021)

literature review

When studying the effects of environmental factors on gene expression in higher plants, Mesembryanthemum crystallinum is a useful model organism.

There is a need for greater study because the available information indicates that numerous plants exhibit striking regional variability in morphological, genetic, and chemical properties. "Basic biological knowledge is required to direct the rapidly developing commercialization process in areas such as the selection of superior clones, cultivar improvement, and raw material standardization. (Kataoka, 2021)

3. Methodology

The method of preparing an ice plant extract is distinguished by the following steps:

Pick clean ice leaf grass, store it in an insulating foam case where the temperature stays below 25 degrees Celsius, and have it at the processing plant within 24 hours;

Everything is cleaned, sterilized, and dried that can be cleaned.

Process for beating: cross colloid mill beating after ice leaf grass is weighed, then 1.05.0%K350 is added and stirred;

Treatment through centrifugation: spin off the filter cake, and then wait 24 to 72 hours to collect the usable material.

The material body generated in step S4 is filtered using 100-500 order filter plants, the filtrate is collected, and the coarse filtration liquid is irradiated using light irradiation equipment for 2472 hours, causing it to fade from yellow to light green as the chlorophyll decomposes.

Secondary filtration: after 28 hours at 210 degrees Celsius, the filtrate generated in step S5 is collected after being filtered through plants of the 400-1000 order filter.

Filtrate three times: the filtrate obtained in step S6 is filtered through medium-speed filter paper, and the collected filtrate is then pressure filtered with a frame plate filter to remove micron order impurities and partial electrolyte; filter four times: the filtrate obtained in step S7 is filtered through a 0.150.355-micron micro porous filter membrane, and the collected filtrate is then pressure filtered with a frame plate filter to remove micron order impurities and partial electro

Weigh: after obtaining the filtrate in step 8, weigh it so that the yield can be calculated, then seal and store it.

To see if Aizoaceae species could withstand dry heat treatment, we retested previously reported procedures." The purpose of this was to replicate the conditions in which each species' seeds typically germinated. "For the sake of brevity, know that the identical four Aizoaceae species' seed lots stored in RBG Kew's Millennium Seed Bank (-20 °C and 15% RH) were acclimated to dry room conditions (-18 °C and 15% RH) at RBG Kew. Then, germination tests were conducted by sowing dried seeds on 1% water agar at 20 degrees Celsius, both those that had been exposed to heat (103 degrees Fahrenheit in open plates for 17 hours) and those that had not. (SATO, 2022)

When the 19 days were up, we t-tested the data in Excel 2013 based on the percentage of seeds that had germinated in each group. (Two-tailed, equal variance, two-sample) Seventy-four dried seeds were soaked in water at 20 degrees Celsius for 24 hours before being planted in 1% agar for three days. After that, 1% buffered 2,3,5-triphenyl tetrazolium chloride (International Seed Testing Association) was applied to the scarified seeds and left on them for two days at 30 °C in the dark (ISTA, 2003). (ISTA, 2003). After washing and slicing the seeds lengthwise, their vitality was assessed. In 2022 (Zhang X. T.)

Seeds that grew or developed fully stained, brilliant crimson embryos were considered viable. A seed was deemed not viable if its embryo did not stain, or just partially stain. The seeds often were hollow or had fungal development. Seeds of M. crystallinum were weighed before and after being exposed to three different conditions: control, scarified, and heat (103 °C for 17 hours in open dishes) in micro centrifuge tubes filled with water. After the seeds were removed from the water, before they were weighed, they were surface-dried. (Nosek, 2019)

Under a dissecting microscope, the seed coats were first manually scarified by slicing them with a knife. A total of 75 seeds were divided into three divisions (control, scarified, and heat-exposed). One-way analysis of variance (ANOVA), followed by post hoc t-tests (two-tailed distribution, two-sample equal variance), and lastly Bonferroni multiple testing correction were used to analyze the gathered seed weight data statistically. Mahmood (2019)

We do not know if M. crystallinum seed germination is affected by heat and/or ultra-drying. A series of longer germination tests, each lasting 10 weeks, were carried out after a shorter germination test showed that M. crystallinum had seeds whose germination is aided by dry heat. The first experiment included a control group, a heat-exposed group (103 °C after 17 hours on either open or sealed plates), and a scarified group, all with four replicates of around 30 seeds each.

Hermetically sealed aluminium crucibles and lids were utilized in sealed dishes for Differential Scanning Calorimetry, and the process was made possible through sealing presses (MettlerToledo). The International Seed Testing Association recommends drying seeds at 103 degrees Celsius for 17 hours, during which time the seeds in open dishes become ultra-dried while the seeds in covered dishes have a change in moisture content of less than 0.1%. (ISTA, 2017). The seeds for this preliminary test were scarified before being placed in airtight dishes. Mohammad (2021)

There was one ultra-dried group and one control group with the same number of replicates and seed lots in the second trial. After ultra-drying on silica beads at 20 °C for 2.5 weeks, the MC of the treated seeds averaged 3.93% (0.82 s.e), as measured by the International Seed Testing Association (ISTA) (ISTA, 2017). The International Seed Testing Association found that the average MC of control seeds stored at 20 °C and 15% RH was 6.35% (0.04 sec) during this period (ISTA, 2017). (Guan, 2020)

Then, the seeds, both ultra-dried and controlled, were sown on agar and placed in a growth room with 20 degrees Celsius temperatures and a 12-hour photoperiod. In the third experiment, the number of repetitions and seeds used for each replication were the same for both the treatment (ultra-dried) and control groups. The seeds in the treatment group were ultra-dried to an average MC of 2.51% using an IGAsorp (Hidden Analytical) at 18 degrees Celsius for 136 days. (0.01 s.e.) ISOTA is an acronym for the International Seed Testing Association (ISTA, 2017)

This was done while keeping the control seedlings at 18 degrees Celsius and 15% relative humidity. After that, both the ultra-dried seeds and the control seeds were planted on agar and placed in a chamber with 20 °C temperatures and a 12-hour photoperiod. Total germination percentages (the number of seeds that germinated relative to the total number of seeds sowed) were calculated weekly for each of the three studies. One-way analysis of variance (ANOVA), followed by post hoc t-tests (two-tailed distribution, two-sample equal variance), and Bonferroni correction for multiple testing were used to analyze the preliminary germination data." T-tests were used to compare the outcomes of the second and third germination trials (two-tailed distribution, two-sample equal variance). (Rodríguez-Hernández, 2021)

4. Findings

M. crystallinum seed germination after exposure to heat and/or ultra-drying Several lengthier germination tests lasting 10 weeks each were conducted after an initial short-duration germination test that identified M. crystallinum as having seeds for which dry heat favors germination. The initial test consisted of a control group, a heat-exposed group (103 °C for 17 hours in either open or sealed plates) or a scarified group, each with four replicates and roughly 30 seeds per duplicate. Aluminum crucibles and lids that are typically used for Differential Scanning Calorimetry were utilized to create sealed dishes, and they were then sealed shut with a sealing press. Since seeds are often exposed to dry heat at 103 °C for 17 hours as part of a normal seed moisture content test, the moisture content of seeds in covered dishes changed after heat exposure by less than 0.1% while seeds in open dishes were ultra-dried (International Seed Testing Association) (ISTA, 2017). According to Daws et al. (2007), this initial test was conducted with the inclusion of sealed dishes and a scarification process for which the seeds were scarified. The second test included the same number of replicates per group and seeds per replication, but it had one treatment group (ultra-dried) and one control group. The basics treatment group's seeds were ultra-dried on silica beads in a sealed glass jar at 20 °C for 2.5 weeks, resulting in an average MC of 3.93% (0.82 s.e.) (International Seed Testing Association (ISTA, 2017). Control seeds were kept at 20 °C and 15% RH during this time, with an average MC of 6.35% (0.04s.e.) according to the International Seed Testing Association (ISTA, 2017). The seeds were then planted on agar and placed in a chamber set at 20 °C with a 12-hour photoperiod, using both ultra-dried and control seeds. The third test included the same number of replicates per group and seeds per replication, but it had one treatment group (ultra-dried) and one control group. Using the IGAsorp (Hidden Analytical) drying setting at 18 °C for 136 days, seeds in the treatment group were ultra-dried to an average MC of 2.51% (0.01s.e.) (International Seed Testing Association (ISTA, 2017). Control seeds were kept at 18 °C and 15% RH during this time. The seeds were then planted on agar and placed in a chamber set at 20 °C with a 12-hour photoperiod, using both ultra-dried and control seeds. The total germination percentage (number of seeds that germinated compared to the total number of seeds sowed) for each of the three experiments was calculated weekly throughout the experiment. The statistical analysis of the germination data from the initial test included one-way ANOVA, post hoc t-tests (two-tailed distribution, two-sample equal variance), and Bonferroni multiple testing correction. T-tests were used to assess the germination data from the second and third testing (two-tailed distribution, two-sample equal variance).Both treated and untreated (control) M. crystallinum seeds were examined under a scanning electron microscope in order to look for any potential structural alterations brought on by dry heat exposure (103 °C for 17 hours in open dishes) (SEM). Using double-sided conductive adhesive tabs (Carbon Tabs, Agar Scientific), seeds were attached on aluminium SEM stubs and then coated with platinum using a Quorum Q150 T sputter coater. Using a HITACHI S-4700 cold-field emission SEM with an accelerating voltage of 2.0 kV and a working distance of 12.0 mm, specimens were analyzed and captured on camera. Adobe Photoshop was used to process the digital SEM pictures. The SEM was used to look at a total of 10 replicates for each group (heat exposed or control).

M. crystallinum seed permeability after dry heat exposure

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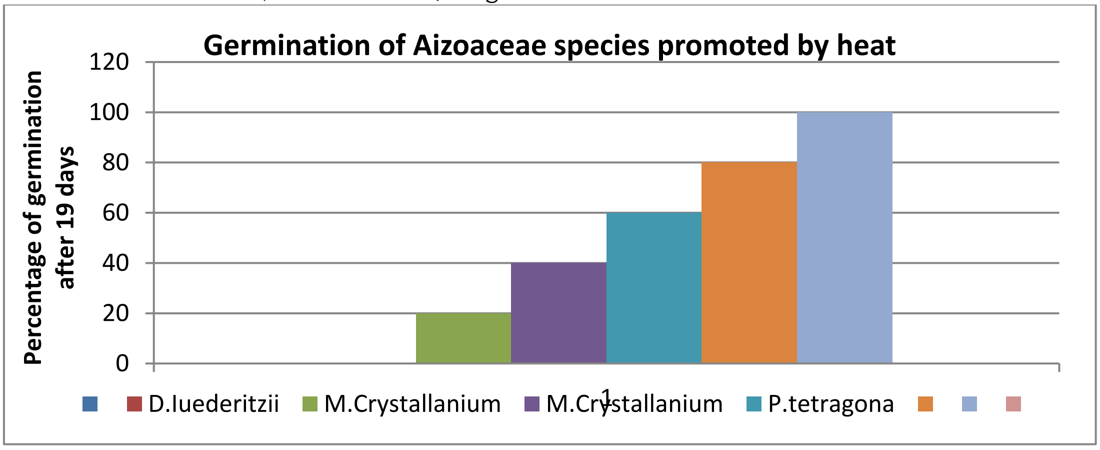


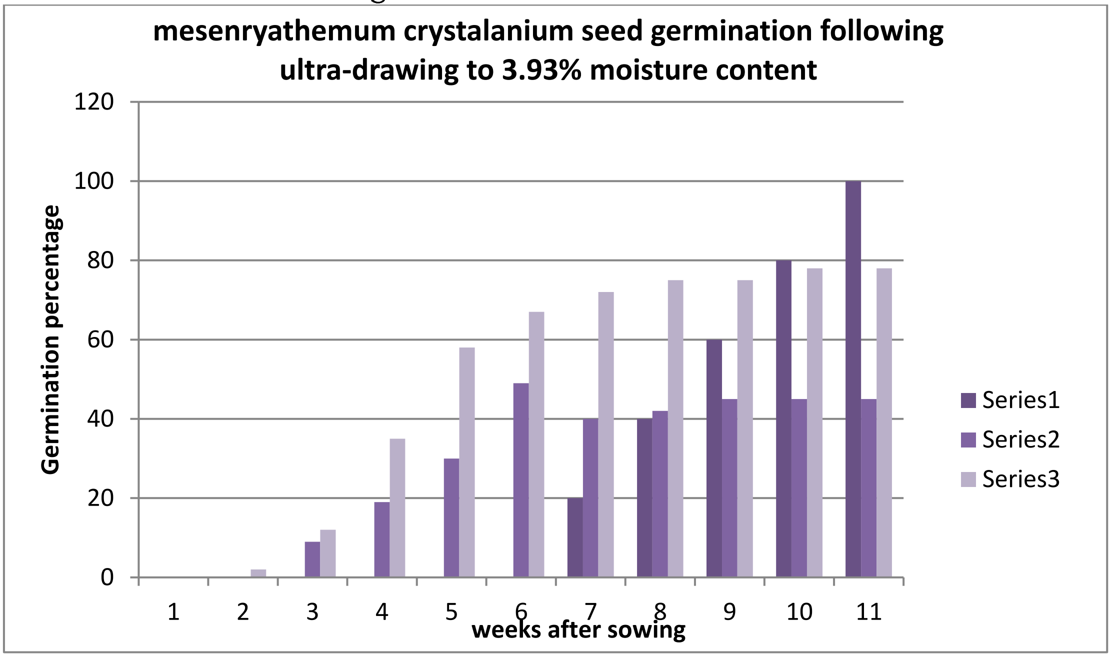
M. crystallinum seed permeability after dry heat exposure

Methylene blue stain was injected into the permeability of untreated (control) and heat-exposed (103 °C for 17 hours in open dishes) M. crystallinum seeds. For 2, 9, 17, and 30 days, seeds were immersed in methylene blue solution in micro centrifuge tubes. A minimum of three seeds per group (heat exposed or control) were cut into sections at each time point using a cryomicrotome at -20 °C.
After being exposed to dry heat, M. crystallinum seeds' hydrogen peroxide levels changed
The potential effects of dry heat exposure on hydrogen peroxide (H2O2) levels in M. crystallinum seeds were evaluated using a modified version of the spectrophotometric DMAB-MBTH method that was previously published. In a nutshell, 100 mg of seeds per replicate were either left untreated (control) or exposed to heat (103 °C for 17 hours in open dishes). Three times, the same M. crystallinum seeds were utilized in the experiment because of their small size. Instead of using 4 M KOH, the supernatant was neutralized to pH 7.5 using 1 M KOH. DMAB was also first dissolved in 600 L of ethanol rather than 200 L of ethanol. A WPA Light Wave s2000 UV/Vis spectrophotometer was used to determine H2O2 using spectrophotometry. The outcomes were statistically examined with t-tests in Excel 2013 (two-tailed distribution, two-sample equal variance), and the results were reported as mole H2O2 g1 DW.
There are three Aizoaceae plants for which dry heat encourages germination.

M. crystallinum seeds exposed to dry heat assimilate more water

A water imbibition test was conducted to determine whether the improved germination of M. crystallinum seeds after dry heat treatment was caused by an increase in water uptake. Untreated M. crystallinum seeds did drink water during the duration of 63 days, supporting earlier findings that they are not in a dormant state physically. When compared to untreated seeds, exposure to dry heat greatly boosted the uptake of water during the first two weeks of imbibition (at time points 48 h, 7 days and 14 days). After two weeks, the increase in water uptake in heat-exposed seeds was hardly noticeable, but it persisted in untreated seeds.
The difference between the control and heat-treated seeds was insignificant after 28 days of imbibition. For both control and heat-exposed seeds, the maximum amount of imbibed water relative to the initial dry seed weight (15% RH) was around 30% after 49–63 days, whereas scarified seeds attained 36% water uptake after 48 h. We looked into whether these outcomes could be related to high seed oil content

because the seeds ingested relatively little water overall. However, time-domain NMR research revealed that the average seed oil content is only 7.5% (w/w), which does not adequately account for the imbibition outcomes.



5. Discussion

According to the results of analyzing the growth characteristics of ice plants grown under different combinations of red and blue LEDs. "The results show that increasing the quantity of red light is a fundamental cause that promotes the amount of biomass in the ice plant. It has been observed that red light aids in the growth of leafy plants such as lettuce and perilla.
To acquire nutrients from soil fungi, seeds need water, but this compromises the strength of the seed coat. As the embryo inside these seeds needs to come into contact with soil fungus to thrive, they have a very short shelf life. Uyeda K. (2019).
In this work, we demonstrate that the highly dormant, darkly pigmented seeds of M. crystallinum can undergo a complete reversal of their physiologically imposed dormancy upon exposure to dry heat treatment. Seeds that have gone into a physical dormancy state cannot absorb water, but the seed coats of M. crystallinum are porous. Our data, however, demonstrates that after being heated to 103 °C for 17 hours, water absorption speeds up significantly during the first two weeks. This discovery demonstrates that the water-permeability of M. crystallinum seed coats can be increased through dry heat treatment. (Atzori 2021)
In addition to restricting water absorption, seed coverings can restrict the exchange of gases, prevent inhibitors from leaving the embryo, and mechanically regulate embryonic progress. The seeds of M. crystallinum are distinguished by a semitransparent, rigid perisperm that encloses a peripheral embryo. Rows of epidermal cells with elongated outer wall outlines, highly convex outer periclinal cell walls and deeply depressed anticlinal borders characterize the coating morphology of M. crystallinum seeds. In addition, the anticlinal surface is covered in coarse wax crystals, while the outer cell walls are covered in a dense covering of minute wax platelets. (Zhang X. T., 2021)
According to SEM analysis of treated M. crystallinum seeds revealed no evidence of damage to the epidermal cells, in contrast to SEM analysis of treated Emmenanthe penduliflora seeds, which revealed a variety of changes in the coat morphology, including the formation of fissures. While undetectable structural changes may account for the reported increase in water intake after dry heat exposure, we found no evidence that dry heat exposure relaxed the mechanical limitations on the outer testa. While we did find evidence that prolonged exposure to dry heat boosted water intake, this was not the case. (Tran, 2019)

6. Conclusion

In conclusion, red and blue LEDs applied in a closed-type plant production system were found to be the most successful way when considering the phytochemical contents per biomass of the eaten ice plant. Some members of the Aizoaceae family have seeds that can survive temperatures of up to 100 degrees Celsius. However, no species-specific germination data was found in this study. To further investigate the effects of dry heat on germination, we re-examined the results from over 20 distinct Aizoaceae species (103 degrees Celsius for 17 hours in open dishes). The purpose of this study was to identify heat-tolerant Aizoaceae plants by determining whether or not heat treatment improved germination relative to controls. Three out of almost two dozen species had significantly higher overall germination rates in 19 days following the dry heat treatment compared to the controls. This category included species like Prenia tetragona, M. crystallinum (two separate batches of seeds), and Drosanthemum luederitzii.

7. Recommendations

Growing Mesembryanthemum is easiest when done so in a gravel or rock garden, between paving stones, or in the crevices between bricks on a wall, all of which receive full sun and excellent drainage." They can be grown in both the ground and in containers. Keeping the plant at the proper size requires regular maintenance, including the removal of spent flowers and, if required, pruning in the fall. (Qalby, 2020)

References

Atzori, G. (2021). The Potential of Edible Halophytes as New Crops in Saline Agriculture: The Ice Plant (Mesembryanthemum crystallinum L.).
Barkla, B. J.-H. (2018). Single cell-type analysis of cellular lipid remodelling in response to salinity in the epidermal bladder cells of the model halophyte Mesembryanthemum crystallinum.
Burana, C. C. (2020). A Novel Growth and Development of Mesembryanthemum crystallinum (Aizoaceae.
El-Amier, Y. A.-h.-Z. (2021). Phytochemical analysis and biological activities of three wild Mesembryanthemum species growing in heterogeneous habitats.
Gajewska, E. S. (2018). Nitrogen metabolism-related enzymes in Mesembryanthemum crystallinum after Botrytis cinerea infection.
Guan, Q. T. (2020). Physiological changes in Mesembryanthemum crystallinum during the C3 to CAM transition induced by salt stress.
He, J. K. (2021). LED spectral quality and NaCl salinity interact to affect the growth, photosynthesis and phytochemical production of Mesembryanthemum crystallinum.
He, J. N. (2022). Salinity and Salt-Priming Impact on Growth, Photosynthetic Performance, and Nutritional Quality of Edible Mesembryanthemum crystallinum L. Plants.
Kataoka, R. A. (2021). Metabolomics analyses reveal metabolites affected by plant growth-promoting endophytic bacteria in the roots of the halophyte Mesembryanthemum crystallinum.
Kim, Y. J. (2021). Growth and phytochemicals of ice plant (Mesembryanthemum crystallinum L.) as affected by various combined ratios of red and blue LEDs in a closed-type plant production system.
Mahmood, A. A. (2019). High salt tolerant plant growth promoting rhizobacteria from the common ice-plant Mesembryanthemum crystallinum L.
Manzoor, M. G. (2018). Screening of indigenous ornamental species from different plant families for Pb accumulation potential exposed to the metal gradient in spiked soils. Soil and Sediment Contamination.
Mohamed, E. A. (2021). alinity alleviates the toxicity level of ozone in a halophyte Mesembryanthemum crystallinum.
Nosek, M. K. (2019). The response of a model C3/CAM intermediate semi-halophyte Mesembryanthemum crystallinum L. to elevated cadmium concentrations.
Otsuka, M. K. (2021). Root system architecture analysis in Mesembryanthemum crystallinum (ice plant) seedlings.
Qalby, N. S. (2020). Colchicine induced polyploidy in Common Ice plant Mesembryanthemum crystallinum L. In IOP Conference Series: Earth and Environmental Science .
Rodríguez-Hernández, M. D. (2021). Implementation of ice plant (Mesembryanthemum crystallinum L.) production under semi-controlled conditions.
SATO, R. T. (2022). NaCl–promoted Respiration and Cell Division in Halophilism of a Halophyte, the Common Ice Plant Mesembryanthemum crystallinum L.
Tran, N. H. (2019). Development and evaluation of novel salt-tolerant Eucalyptus trees by molecular breeding using an RNA-Binding-Protein gene derived from common ice plant (Mesembryanthemum crystallinum L.).
Uyeda K. A. (2019). Effects of Salt and Drought Stress on Germination of Non-native Plants in the Salt Marsh to Upland Transition Zone, 2019).
Visscher, A. M. (2018). Dry heat exposure increases hydrogen peroxide levels and breaks physiological seed coat-imposed dormancy in Mesembryanthemum crystallinum (Aizoaceae) seeds. Environmental and Experimental Botany, .
Xia, J. &. (2022). Response of Common Ice Plant (Mesembryanthemum crystallinum L.) to Photoperiod/Daily Light Integral in Vertical Hydroponic Production. Horticulturae,.
You, X. Y. (2021). Biochar and fertilizer improved the growth and quality of the ice plant (Mesembryanthemum crystallinum L.) shoots in a coastal soil of Yellow River Delta, China. Science of the Total Environment.
Zhang, J. W. (2018). Identification of interior salt-tolerant bacteria from ice plant Mesembryanthemum crystallinum and evaluation of their promoting effects.
Zhang, X. T. (2021). Proteomics of Homeobox7 Enhanced Salt Tolerance in Mesembryanthemum crystallinum.
Zhang, X. T. (2022). Overexpression of McHB7 Transcription Factor from Mesembryanthemum crystallinum Improves Plant Salt Tolerance. International journal of molecular sciences.