Reception: **April 24, 2023** | Acceptance: **July 23, 2023** | Publication: **October 1, 2023**

Study of the effect of drought-induced by polyethylene glycol in *Capsicum frutescens* in a hydroponic system

—

Blanca Olivia Trejo-Paniagua[1] • d06270242@tuxtla.tecnm.mx
ORCID: 0009-0008-3617-149X

María Goretty Caamal-Chan[2] • goretty_caamal@hotmail.com
ORCID: 0000-0002-9351-4734

Rosa Isela Cruz-Rodríguez[1] • rosa.cr@tuxtla.tecnm.mx
ORCID: 0000-0002-4743-9112

Anayancy Lam-Gutiérrez • alam@cintalapa.tecnm.mx
ORCID: 0000-0001-9124-5721

Nancy Ruiz-Lau[4] • nancy.rl@tuxtla.tecnm.mx*
ORCID: 0000-0002-5624-8561

1 Tecnológico Nacional de México, Campus Tuxtla. Tuxtla Gutiérrez, Chiapas, México
2 CONAHCyT/Centro de Investigaciones Biológicas del Noroeste S.C. La Paz, Baja California Sur, México
3 Tecnológico Nacional de México Campus Cintalapa. Cintalapa, Chiapas, México

---

* Agradecimientos: Al Consejo Nacional de Humanidades, Ciencias y Tecnologías (CONAHCyT-México) por el apoyo otorgado a través de la beca 919744 para los estudios de doctorado de Trejo-Paniagua, B. O.

To quote this article:

Trejo Paniagua, B. O., Caamal Chan, M. G., Cruz Rodríguez, R. I., Lam Gutiérrez, A., & Ruiz Lau, N. Estudio del efecto de la sequía inducida por polietilenglicol en Capsicum frutescens en un sistema hidropónico. *Espacio I+D, Innovación más Desarrollo, 12*(34). https://doi.org/10.31644/IMASD.34.2023.a03

— Abstract—

Drought is the most common factor limiting crop development and productivity, severely affecting agriculture. In Mexico, one of the crops of economic and gastronomically important sensitive to water stress is the *Capsicum* genus. In the present study, the application of proline on *Capsicum frutescens* plants exposed to drought induced by polyethylene glycol (PEG) in a hydroponic system was evaluated. Using a 2^2-factorial design, a total of 60 seedlings were evaluated for 120 hours divided into four treatments: PEG (0 and 10 %) and Pro (0 and 10 mM) as study variables. The results showed that exposure to 10 mM of Pro induced a significant increase in the chlorophyll concentration and endogenous proline (leaf and root) in seedlings in the absence of stress. In addition, 80 % survived of seedlings, and an increase in proline content was observed in those exposed to 10 mM Pro + 10 % PEG. Similarly, there was an increase in chlorophyll content (13 $\mu g \cdot mL^{-1}$), relative water content (RWC) in the root (77.6 %), and percentage of electrolytes in the leaf and root (~44 and ~52 % respectively) compared to the treatment of 0 mM Pro + 10 % PEG. These results suggest that the pre-application of proline has a positive effect on seedlings' survival under PEG-induced drought conditions.

Keywords:

Drought; Capsicum frutescens; tolerance; survival.

Drought is considered the main stress that affects the growth and productivity of agricultural crops, and economic losses are estimated to exceed those caused by other types of abiotic stress. Unfortunately, due to climate change, more extreme conditions are expected in the coming years (dos Santos *et al*., 2022). One of the crops affected of great importance due to the wide variety of culinary and economic uses is chili. The genus *Capsicum* belongs to the family Solanaceae and is native to tropical and subtropical America. As of 2019, 40 species have been identified, of which five are of great economic relevance (*C. annum, C. chinense, C. baccatum, C. frutescens, and C. pubescens*) and have been domesticated or semi-domesticated depending on the region in which they are grown. However, it experiences a significant impact on its production due to water stress during the different phenological stages of the crop, which limits its development and productivity (Tripodi & Kumar, 2019; Toppino *et al*., 2021). The effects of water deficit on plants depend on their stage of development, the time of exposure, the species, and the degree of severity, which leads to metabolic alterations such as the reduction in the synthesis of photosynthetic pigments, loss of turgidity, increase in reactive oxygen species, among others (Jalil & Ansari, 2020; Taiwo *et al*., 2020). Currently, Mexico is the fourth largest producer of fresh chili in the world and the five main species of economic importance are cultivated (Food and Agriculture Organization [FAOSTAT], 2023). In addition, around 25 wild or semi-domesticated species are present in the territory, one of which is *C. frutescens*, distributed in the southeast of the country (La Cruz-Lázaro *et al*., 2017), the gene pool of semi-domesticated species offers the opportunity to use it as unique study models for crop breeding. In recent years, various investigations have been carried out to mitigate the effects of water stress and improve plant tolerance. The exogenous application of biostimulants to increase performance and minimize the effects of environmental stress is one of the most promising strategies (Sahoo *et al*., 2019). The amino acid proline (Pro) is considered one of the most important signaling molecules, in addition to participating as an osmoprotectant by presenting a positive correlation between proline accumulation and stress tolerance (Elewa *et al*., 2017; Suekawa *et al*., 2019). However, the application of exogenous proline in various agricultural crops under drought conditions reduced the effects and increased their tolerance (Elewa *et al*., 2017; Farooq *et al*., 2017; Alkahtani *et al*., 2021). However, plant response varies based on genotypes, severity, and extent of drought. Therefore, the effect of proline application and polyethylene glycol (peg) -induced drought on semi-domesticated chili (C. frutescens) seedlings in a hydroponic system was evaluated in this study.

2. MATERIALS AND METHODS

2.1 Plant material

The chili seeds were germinated in polystyrene seedbeds with a mixture of peat (Peat moss®) and agrolite (Termolita® Hortiperl) in a ratio of 3:1 v/v. After 30 days of germination, the seedlings were transplanted to a hydroponic system with Hoagland solution (Hoagland & Arnon, 1950) for 3 days under constant aeration for adaptation (de Freitas *et al*., 2019), with a photoperiod of 16/8 h light/dark, at an average temperature of 25 ± 2°C. Hoagland's solution contains 50 *µM* de $CaCl_2$ (Sigma Aldrich®), 12.5 *µM* de H_3BO_3 (Sigma Aldrich®), 1 *Mm* $MnSO_4$ (Sigma Aldrich®), 1 *µM* de $ZnSO_4$ (Sigma Aldrich®), 0.5 *µM* de $CuSO_4$ (Sigma Aldrich®), 0.1 µM $(NH_4)_6Mo_3O_{24}$ (Sigma Aldrich®), 0.1 *µM* de NiCl (Sigma Aldrich®), 10 *µM* Fe-EDTA (Sigma Aldrich®), 1.2 *mM* de KNO_3 (Sigma Aldrich®), 0.8 *mM* de $Ca(NO_3)_2$ (Sigma Aldrich®), 0.2 *mM* de KH_2PO_4 (Sigma Aldrich®), and 0.2 *mM* de $MgSO_4$ (Sigma Aldrich®).

2.2 Water stress induced by polyethylene glycol

The experiment was performed using a 2^2-factorial design to analyze the effect of proline and polyethylene glycol (PEG-8000 Sigma Aldrich®) -induced drought on chili seedlings. A total of 60 seedlings distributed in four treatments were evaluated. After acclimatization of the chili plants, they were treated with proline for 48 h, which was done by supplementing Hoagland's solution in the hydroponic culture, using concentrations of 0 and 10 mM proline (Sigma Aldrich®).

Subsequently, the seedlings were exposed to 0 and 10 peg for 120 h.

At the end of the exposure to drought stress, the percentage of survival, relative water content (RWC), electrolyte quantification, chlorophyll content, and endogenous proline were evaluated for each of the treatments.

2.3. Survival rate

The survival rate of chili seedlings was determined by calculating the percentage of live plants at the end of the experimental phase concerning the number of live plants at the beginning, using equation (2), proposed by Linares (as cited in Peñalba, 2022).

$$Survival\ \% = \frac{P_V}{P_v + P_m} * 100 \tag{2}$$

Where:
P_v = live plants
P_m = dead plants

2.4. Relative Water Content (RWC)

To evaluate the CRA of leaves and roots, the fresh weight (P_F) of the seedlings was determined after collection. Subsequently, they were dried at 65 °C in a Hamilton Beach® hot air desiccator for 48 h to obtain the constant dry weight (P_S). Equation (1) described by Jothimani & Arulbalachandran, (2020) was used.

$$\% \, CRA = \frac{P_F - P_S}{P_F} * 100 \tag{1}$$

Where:
% CRA = Relative water content
P_F = Fresh weight of plant tissue
P_s = Dry weight of plant tissue

2.5. Electrolyte Quantification

To evaluate the percentage of electrolyte leakage, the methodology described by Restrepo *et al*. (2013) was followed with some modifications. Discs of the fresh plant material were placed in test tubes with tri-distilled water. Initial conductivity (CE_1) was measured, using a CON-BTA (Vernier®) conductivity probe, after 2 hours of incubation at room temperature (30±2 °C). Subsequently, the samples were incubated at 120°C for 20 min, and the final conductivity (CE_2) was measured. The percentage of electrolytes released was calculated using equation (3).

$$\text{Electrolytes } \% = \frac{CE_1}{CE_2} * 100 \tag{3}$$

2.6. Chlorophyll content

The total chlorophyll content was determined, using the method of Inskeep & Bloom (1985) with modifications. 50 mg of fresh leaf was macerated with 80 % acetone (MEYER®) and incubated at 4°C for 60 min, then centrifuged at 10,000 rpm for 5 min. The quantification of total chlorophyll was performed by the UV-visible spectrophotometry technique, using a HACH® brand spectrophotometer, DR model 5000, at wavelengths (λ) of 664 and 647 nm, using equation (4).

$$\text{Total chlorophyll}\ (\mu g \cdot mL^{-1}) = 17.95A_{647} + 7.90A_{664} \tag{4}$$

2.7. Determination of endogenous proline content in leaf and root

The Escalante-Magaña protocol (2020) was used to extract and quantify endogenous proline in leaf and root samples. The reaction was carried out with acid ninhydrin (Sigma Aldrich®) and glacial acetic acid (MEYER®), and the samples were incubated at 96°C for 60 min. Subsequently, the organic phase was extracted with toluene (MEYER®) and the amount of proline was quantified by spectrophotometry at λ of 520 nm, using equation (5).

$$\mu\text{mol proline} * g^{-1} = \left(\frac{\frac{(\mu g\ \text{proline} * mL^{-1})(mL\ \text{toluene})}{115.5\ \mu g * \mu mol^{-1}}}{\frac{g\ \text{sample}}{5}} \right) \tag{5}$$

2.8. Statistical Analysis

The data obtained were evaluated using one-way analysis of variance (ANOVA) and the comparison of means was performed by LSD test ($P \leq 0.05$), through Statgraphics Centurion XIX® software (Statgraphics Technologies, Inc., Madrid, Spain).

3. RESULTS

To determine the effect of proline application on chili seedlings (*C. frutescens*) 35 days after germination were subjected to water stress induced by -8000 PEG 10% for 120 h. The results indicate that exposure to 10 mM Pro significantly improved survivability reaching a value of 80% in seedlings pre-treated with proline (Table 1), compared to 40% in untreated seedlings.

3.1. Chlorophyll content

The chili seedlings previously treated with proline had a higher chlorophyll content, compared to the control treatment in the absence of stress (Table 2). On the other hand, when exposing seedlings to PEG-induced drought stress, it was observed that treatment with 10 mM Pro + 10% PEG had a higher total chlorophyll content than treatment with 0 mM Pro + 10% PEG, which showed a significant decrease due to the effects of drought.

3.2. Relative Water Content (RWC)

It was observed that the RWC, both in the aerial part and the root system of the chili seedlings significantly decreased under drought conditions (Table 3), compared to the control (no PEG). However, seedlings previously treated with proline and exposed to PEG had a significantly higher RWC in the root system, compared to seedlings without prior proline treatment. These results suggest that the application of proline could have helped maintain hydration in the roots during drought.

3.3. Electrolyte leakage percentage

PEG-induced drought exposure significantly increased electrolyte leakage into leaf and root tissues in chili (*C. frutescens*) seedlings (Table 4), relative to control. However, pre-treatment with proline reduced electrolyte loss in both tissues, compared to 0 mM Pro + 10% PEG treatment.

3.4. Endogenous proline content

The values obtained indicate that the endogenous proline content in the leaves and roots of *C. frutescens* increased significantly in response to treatment with 10% PEG, compared to treatments in the absence of stress (Table 5). This suggests that plants exposed to PEG-induced drought increased proline synthesis as a defense response to water stress. In addition, a significant difference in endogenous proline concentration was observed in the leaves and roots of *C. frutescens* treated with exogenous proline. It is important to note that the seedlings previously treated with exogenous proline and subsequently exposed to stress, had the highest content of endogenous proline.

4. DISCUSSION

Drought stress reduced the survival rate of chili seedlings, the relative water content in leaf and root tissues, and total chlorophyll, as well as an increase in the percentage of electrolyte leakage and endogenous proline content in both tissues. This is because plant water potential and turgidity are significantly reduced, which can interfere with plant metabolic functions (Pandey *et al*., 2019; Abobatta, 2020).

Jothimani and Arulbalachandran (2020) reported that the water deficit induced by 20% PEG in tomato cultivation critically affects photosynthesis, due to the increase in reactive oxygen species (ROS), altering the total chlorophyll content, and damage to cell membranes. While Restrepo *et al.* (2013) demonstrated that electrolyte loss can indicate the integrity of cell membranes and that the impairments are mainly due to lipid peroxidation under stress conditions, due to ROS acting on the free radicals of the lipids that make up cell membranes in corn plants exposed to abiotic stress.

Even though the effects of drought-induced by 10% PEG in *C. frutescens* were negative, in the seedlings that were pre-treated with proline at the concentration of 10 mM, a decrease in the negative impact of stress was observed. This led to a significant increase in the survival rate, the RWC of the root system, and a decrease in the percentage of electrolyte leakage, suggesting that the integrity of the cell membrane was maintained, and the efficiency of photosynthesis by presenting an increase in the total chlorophyll content, compared to untreated plants.

Proline is considered a multifunctional amino acid under stressful conditions. Its accumulation in high concentrations is related to the ability to provide protection and participate in various cellular processes, such as osmotic regulation, energy, nutrient availability, and changes in redox balance. The accumulation of this amino acid under dehydration conditions, such as in seedlings exposed to PEG, is because the anabolism of Pro, mainly in the leaves, is activated and catabolism is repressed (Abobatta, 2020; Alvarez *et al.*, 2022; Hosseinifard *et al.*, 2022).

Previous application of exogenous proline to drought-exposed chili seedlings may likely have activated physiological and biochemical mechanisms that enhanced their ability to tolerate PEG-induced stress, which enabled an increase in chlorophyll content, reduced electrolyte leakage, and increased survival rate. Semida *et al.* (2020) report an increase in chlorophyll in onion plants treated with proline (1 – 2 mM) in a foliar manner, indicating that one of the mechanisms that may be related to the increase is due to the protection of the structure and function of photosystems. In addition, proline can also act as an antioxidant, protecting cells from reactive oxygen species by reducing chloroplast cell membrane damage and chlorophyll degradation (Ashraf *et al.*, 2018; Merwad *et al.*, 2018; Cha-um *et al.*, 2019).

Regarding the decrease in the percentage of electrolyte leakage and the increase in the concentration of endogenous proline, Farooq *et al.* (2017) reported that the foliar application of osmoprotectants (proline, gamma-aminobutyric acid) in wheat reduced lipid peroxidation of cell membranes, allowing greater stability in the integrity of cell membranes; and that proline, applied exogenously, improved the endogenous proline content, under conditions of drought stress could be related to an increase in the content of proline precursors (ornithine, glutamic acid, and arginine).

CONCLUSION

Previous application of exogenous proline at a concentration of 10 *mM* has a positive effect on percent survival, electrolytes, relative water content, chlorophyll, and proline in chili plants *C. frutescens* exposed to 10% PEG under *in vitro* conditions. These findings could lay the groundwork for investigating different concentrations of proline and establishing the optimal concentration to improve percent survival in hydroponic cultivation under drought-stress conditions.

REFERENCES

Abobatta, W. F. (2020). *Plant Responses and Tolerance to Combined Salt and Drought Stress*. 17–52. https://doi.org/10.1007/978-3-030-40277-8_2

Alkahtani, M. D. F., Hafez, Y. M., Attia, K., Rashwan, E., Husnain, L. Al, Algwaiz, H. I. M., & Abdelaal, K. A. A. (2021). Evaluation of Silicon and Proline Application on the Oxidative Machinery in Drought-Stressed Sugar Beet. *Antioxidants 2021, Vol. 10*, Page 398, 10(3), 398. https://doi.org/10.3390/ANTIOX10030398

Alvarez, M. E., Savouré, A., & Szabados, L. (2022). Proline metabolism as regulatory hub. *Trends in Plant Science, 27*(1), 39–55. https://doi.org/10.1016/J.TPLANTS.2021.07.009

Ashraf, M. A., Iqbal, M., Rasheed, R., Hussain, I., Perveen, S., & Mahmood, S. (2018). Dynamic Proline Metabolism: Importance and Regulation in Water-Limited Environments. *Plant Metabolites and Regulation under Environmental Stress*, 323–336. https://doi.org/10.1016/B978-0-12-812689-9.00016-9

Cha-um, S., Rai, V., & Takabe, T. (2019). Proline, Glycinebetaine, and Trehalose Uptake and Inter-Organ Transport in Plants Under Stress. *Osmoprotectant-Mediated Abiotic Stress Tolerance in Plants*, 201–223. https://doi.org/10.1007/978-3-030-27423-8_9

de Freitas, P. A. F., de Carvalho, H. H., Costa, J. H., Miranda, R. de S., Saraiva, K. D. da C., de Oliveira, F. D. B., Coelho, D. G., Prisco, J. T., & Gomes-Filho, E. (2019). Salt acclimation in sorghum plants by exogenous proline: physiological and biochemical changes and regulation of proline metabolism. *Plant Cell Reports, 38*(3), 403–416. https://doi.org/10.1007/s00299-019-02382-5

dos Santos, T. B., Ribas, A. F., de Souza, S. G. H., Budzinski, I. G. F., & Domingues, D. S. (2022). Physiological Responses to Drought, Salinity, and Heat Stress in Plants: A Review. *Stresses, 2*(1), 113–135. https://doi.org/10.3390/stresses2010009

Elewa, T. A., Sadak, M. S., & Saad, A. M. (2017). Proline treatment improves physiological responses in quinoa plants under drought stress. *Bioscience Research, 14*(1), 21–33.

Escalante-Magaña, C. A. (2020). *Efecto del estrés salino (NaCl) sobre el metabolismo de la prolina (Pro) y el papel de este aa suplementado de manera exógena en plantas de chile habanero (Capsicum chinense Jacq.)* [Tesis que presenta Camilo Andrés Escalante Magaña, en opción al título de Doctorado en Ciencias (Ciencias Biológicas: Opción Bioquímica y Biología Molecular)] Centro de Investigación Científica de Yucatán, A. C.

Food and Agriculture Organization, FAOSTAT. (Retrieved April 24, 2023). https://www.fao.org/faostat/en/#data/QCL/visualize

Farooq, M., Nawaz, A., Chaudhry, M. A. M., Indrasti, R., & Rehman, A. (2017). Improving resistance against terminal drought in bread wheat by exogenous application of proline and gamma-aminobutyric acid. *Journal of Agronomy and Crop Science, 203*(6), 464–472. https://doi.org/10.1111/JAC.12222

Hoagland, D. R., & Arnon, D. I. (1950). Preparing the nutrient solution. *The Water-Culture Method for Growing Plants without Soil*, 347, 29–31.

Hosseinifard, M., Stefaniak, S., Javid, M. G., Soltani, E., Wojtyla, Ł., & Garnczarska, M. (2022). Contribution of Exogenous Proline to Abiotic Stresses Tolerance in Plants: A Review. *International Journal of Molecular Sciences 2022, Vol. 23, Page 5186, 23*(9), 5186. https://doi.org/10.3390/IJMS23095186

Inskeep, W. P., & Bloom, P. R. (1985). Extinction Coefficients of Chlorophyll a and b in N, N-Dimethylformamide and 80% Acetone. *Plant Physiology, 77*(2), 483–485. https://doi.org/10.1104/pp.77.2.483

Jalil, S. U., & Ansari, M. I. (2020). Stress implications and crop productivity. *Plant Ecophysiology and Adaptation under Climate Change: Mechanisms and Perspectives I: General Consequences and Plant Responses*, 73–86. https://link.springer.com/chapter/10.1007/978-981-15-2156-0_3

Jothimani, K., & Arulbalachandran, D. (2020). Physiological and biochemical studies of black gram (Vigna mungo (L.) Hepper) under polyethylene glycol induced drought stress. *Biocatalysis and Agricultural Biotechnology, 29*(June), 101777. https://doi.org/10.1016/j.bcab.2020.101777

la Cruz-Lázaro, D., Efraín de la Cruz-Lázaro, M., Márquez-Quiroz, C., Osorio-Osorio, R., Preciado-Rangel, P., y Márquez-Hernández, C. (2017). Caracterización morfológica in situ de chile silvestre pico de paloma (*Capsicum frutescens*) en Tabasco, México. *Acta Universitaria, 27*(2), 10–16. https://doi.org/10.15174/au.2017.1083

Merwad, A. R. M. A., Desoky, E. S. M., & Rady, M. M. (2018). Response of water deficit-stressed Vigna unguiculata performances to silicon, proline or methionine foliar application. *Scientia Horticulturae*, 228, 132–144. https://doi.org/10.1016/J.SCIENTA.2017.10.008

Pandey, A. K., Ghosh, A., Rai, K., Fatima, A., Agrawal, M., & Agrawal, S. B. (2019). Abiotic Stress in Plants. *Approaches for Enhancing Abiotic Stress Tolerance in Plants,* 1–46. https://doi.org/10.1201/9781351104722

Peñalba, D. (2022). *Recursos Naturales y Ambiente 41*(22), 78–84. https://orcid.org/0000-0002-0407-3712/

Restrepo, H., Gómez, M. I., Garzón, A., Alzate, F. y López, J. (2013). Respuesta bioquímica de plántulas de maíz (Zea mays L.) a diferentes condiciones de temperaturas nocturnas. *Revista Colombiana de Ciencias Hortícolas, 7*(2), 252–262.

Sahoo, S., Borgohain, P., Saha, B., Moulick, D., Tanti, B., & Panda, S. K. (2019). Seed Priming and Seedling Pre-treatment Induced Tolerance to Drought and Salt Stress: Recent Advances. *Priming and Pretreatment of Seeds and Seedlings*, 253–263. https://doi.org/10.1007/978-981-13-8625-1_12

Semida, W. M., Abdelkhalik, A., Rady, M. O. A., Marey, R. A., & Abd El-Mageed, T. A. (2020). Exogenously applied proline enhances growth and productivity of drought stressed onion by improving photosynthetic efficiency, water use efficiency and up-regulating osmoprotectants. *Scientia Horticulturae, 272*, 109580. https://doi.org/10.1016/j.scienta.2020.109580

Suekawa, M., Fujikawa, Y., & Esaka, M. (2019). Exogenous proline has favorable effects on growth and browning suppression in rice but not in tobacco. *Plant Physiology and Biochemistry, 142*, 1–7. https://doi.org/10.1016/J.PLAPHY.2019.06.032

Taiwo, A. F., Daramola, O., Sow, M., & Semwal, V. K. (2020). Ecophysiology and responses of plants under drought. *Plant Ecophysiology and Adaptation under Climate Change: Mechanisms and Perspectives I: General Consequences and Plant Responses*, 231–268. https://doi.org/10.1007/978-981-15-2156-0_8

Toppino, L., Prohens, J., Rotino, G. L., Plazas, M., Parisi, M., Carrizo García, C., & Tripodi, P. (2021). *Pepper and Eggplant Genetic Resources*. 119–154. https://doi.org/10.1007/978-3-030-30343-3_6

Tripodi, P., & Kumar, S. (2019). *The Capsicum Crop: An Introduction*. 1–8. https://doi.org/10.1007/978-3-319-97217-6_1

Table 1

Effect of proline application on Capsicum frutescens under PEG drought

Treatments		Survival %
% PEG	[mM Pro]	
0	0	100^{Aa}
	10	100^{Aa}
10	0	40^{Bc}
	10	80^{Ab}

Note. Different capital letters indicate a statistically significant within-treatment difference (% PEG); whereas, different lowercase letters indicate a statistically significant difference between LSD treatments ($P \leq 0.05$).

Table 2

Total chlorophyll content in drought-exposed Capsicum frutescens

Treatments		Chlorophyll (µg/mL)
% PEG	[mM Pro]	
0	0	$19.03^{Bb}\pm1.4$
	10	$28.96^{Aa}\pm2.1$
10	0	$6.05^{Bd}\pm1.7$
	10	$13.14^{Ac}\pm2.9$

Note. Different capital letters indicate a statistically significant within-treatment difference (% PEG); whereas different lowercase letters indicate a statistically significant difference between LSD treatments ($P \leq 0.05$).

Table 3

Relative water content (RWC) in Capsicum frutescens seedlings under drought

Treatments		Aerial part %	Root system %
% PEG	[mM Pro]		
0	0	$86.80^{Aa}\pm1.3$	$85.32^{Aa}\pm1.2$
	10	$85.95^{Aa}\pm0.9$	$85.34^{Aa}\pm1.6$
10	0	$80.46^{Ab}\pm5.2$	$55.90^{Bc}\pm2.6$
	10	$82.44^{Ab}\pm1.4$	$77.63^{Ab}\pm2.6$

Note. Different capital letters indicate a statistically significant within-treatment difference (% PEG); whereas different lowercase letters indicate a statistically significant difference between LSD treatments ($P \leq 0.05$).

Table 4

Percentage of electrolyte leakage in drought-exposed Capsicum frutescens seedlings

Treatments		**Aerial part %**	**Root system %**
% PEG	[mM Pro]		
0	0	$14.87^{Ac}\pm2.6$	$31.16^{Ac}\pm2.4$
	10	$12.31^{Ac}\pm1.1$	$30.88^{Ac}\pm1.1$
10	0	$58.47^{Aa}\pm0.9$	$72.96^{Aa}\pm3.9$
	10	$43.91^{Bb}\pm3.0$	$51.81^{Bb}\pm3.6$

Note. Different capital letters indicate a statistically significant within-treatment difference (% PEG); whereas different lowercase letters indicate a statistically significant difference between LSD treatments (P ≤ 0.05).

Table 5

Endogenous proline content in drought-exposed Capsicum frutescens seedlings

Treatments		**Leaf (μmoles Pro·gPF/mL)**	**Root (μmoles Pro·gPF/mL)**
% PEG	[mM Pro]		
0	0	$33.52^{Bd}\pm1.4$	$29.77^{Bd}\pm4.9$
	10	$57.06^{Ac}\pm3.2$	$37.16^{Ac}\pm2.6$
10	0	$168.87^{Bb}\pm2.3$	$99.17^{Bb}\pm3.1$
	10	$212.38^{Aa}\pm11.8$	$129.03^{Aa}\pm4.5$

Note. Different capital letters indicate a statistically significant within-treatment difference (% PEG); whereas different lowercase letters indicate a statistically significant difference between LSD treatments (P ≤ 0.05).