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Short Communication

Selection of drought tolerant accessions in tomato based on ion efflux test

Selección de accesiones de tomate tolerantes al estrés hídrico basada en prueba de eflujo de iones

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ABSTRACT: Drought stress reduces the yield and production of tomato. The purpose of this study was to evaluate the tolerance to water stress in 22 genotypes of three tomato species and to identify tolerant accessions for use in breeding programmers. For this objective, the efflux of UV-absorbing substances was measured in leaf discs of 21-day-old tomato seedlings treated with PEG-6000 at 0 and 2 mPa. The results showed a differentiated response in the behavior of the accessions to water stress simulated with PEG-6000. *S. pimpinellifollium* and *S. lycopersicum* variety *cerasiforme* genotypes showed lower phenols efflux under drought stress conditions. These genotypes can be used to increase tomato drought stress tolerance, and include in plant breeding programmers.

Key words: *Solanum lycopersicum* L., drought, abiotic stress.

RESUMEN: El estrés por déficit hídrico reduce el rendimiento y la productividad en tomate. El propósito de este estudio fue evaluar la tolerancia al estrés hídrico en 22 genotipos de tres especies de tomate e identificar accesiones tolerantes para su empleo y uso en programas de mejoramiento genético. Para ello, se midió el eflujo de sustancias que absorben radiación UV, en discos de hojas de plántulas de tomate de 21 días tratadas con PEG-6000 a 0 y 2 mPa. La respuesta del comportamiento en los genotipos fue diferenciada frente al estrés hídrico simulado con PEG-6000. Los genotipos pertenecientes a *S. pimpinellifollium* y *S. lycopersicum* variedad *cerasiforme* presentaron menores eflujos de fenoles en condiciones de déficit hídrico. Se identificaron genotipos que pueden ser seleccionados y utilizados para incrementar la tolerancia al estrés hídrico en el cultivo y formar parte del programa de mejoramiento de esta especie.

Palabras clave: *Solanum lycopersicum* L., *S. pimpinellifollium* L., sequía, estrés abiótico.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the second most important species within the genus *Solanum* spp. because of its role in the dietary habits of a large part of the world's population (1, 2). However, crop yield is seriously affected by adverse environmental conditions, mainly water stress and extreme temperatures (3, 4).

Water stress affects the processes of transpiration, photosynthesis, stomata opening, leaf temperature and antioxidant metabolism; these metabolic changes alter plant development and compromise production and yield (5-7). Several studies point out that membranes are the site where most stress affects plants. Losses in membrane integrity due to water stress have been assessed mostly by measuring membrane stability, and to a lesser extent by the

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leakage of UV-absorbing substances, including amino acids, nucleosides, and nucleotides (4, 8-12). The loss of UV-absorbing substances has been used to assess the relative salt stress tolerance of plant tissues, but not in water stress assessments (4, 8).

In simulation studies of water stress under laboratory conditions, polyethylene glycol (PEG) is frequently used. PEG is a polymeric alcohol with high water solubility and low toxicity that acts as a non-penetrating osmotic agent by decreasing the water potential of the culture medium; it produces a water deficiency in plant cells and an imbalance of metabolism in general (13).

Based on the above, and due to the need to look for techniques that can be used as standardized tests for tolerance to water deficit, the present work was carried out with the objective of evaluating the tolerance to this stress in leaf tissue of 22 tomato accessions by means of the relative determination of the efflux of substances that absorb UV radiation, with the purpose of identifying tolerant accessions for selection and use in genetic improvement programs.

MATERIALS AND METHODS

To determine the efflux of ions absorbing in UV radiation, 15 random discs of approximately 90 mm in diameter were collected from the second true leaf of 21-day-old seedlings for 22 tomato accessions; four replicates per treatment were performed (Table 1). Plant tissue was placed in 10 mL vials, washed three times with distilled water to remove external ions that might be released after cutting. They were then immersed in 2 mL of distilled water (control treatment) and 2 mL of PEG 6000 solution at 2 mPa (stress treatment), and allowed to standing in total darkness at 25 °C overnight. Subsequently, the optical density was measured at 280 nM with a Genesys 10 spectrophotometer. The efflux of phenols was calculated with the following formula (8):

$$PE \quad (\%) = \frac{OD \quad stress \quad x \quad 100}{OD \quad control}$$

Where:

PE: phenol efflux

OD stress: optical density values of the stress treatments

OD control: optical density values of the control treatments

The experiment was performed in duplicate. Data were processed by simple rank ANOVA, fixed effects model and means were compared by Duncan's Multiple Range test for 5 % statistical significance. The analysis was performed using the SPSS statistical package version 22.0, for Windows.

RESULTS AND DISCUSSION

The ion efflux data of the 22 genotypes under study are shown in Table 2, highly significant differences were found for this character, with a range from 14.60 to 43.18 % efflux. The accessions Ciapan 31-5 and Mex-121-A of *S. pimpinellifollium* had the lowest ion efflux, with no significant differences with LA-2807 and P-531, accessions belonging to the wild form of the cultivated species. Mayle, Mercy and Yaily cultivars showed no differences with the Santa Clara genotype.

Table 1. Accessions used in the study and their origin

Accesion	Species	Origin
Amalia	*S. lycopersum* L.	Cuba
AN-104-1	*S. lycopersum* L.	Spain
Campbell-28	*S. lycopersum* L.	USA
CL-1131-00-7-2-0-9	*S. lycopersum* L.	Taiwan
Claudia	*S. lycopersum* L.	Cuba
CO-7040	*S. lycopersum* L.	Cuba
Lignom	*S. lycopersum* L.	Cuba
Mara	*S. lycopersum* L.	Cuba
Mariela	*S. lycopersum* L.	Cuba
Mayle	*S. lycopersum* L.	Cuba
Mecy	*S. lycopersum* L.	Cuba
Rilia	*S. lycopersum* L.	Cuba
Roma	*S. lycopersum* L.	Italy
Santa Clara	*S. lycopersum* L.	USA
Yaily	*S. lycopersum* L.	Cuba
Nagcarlang	*S. lycopersum* L. *var. cerasiforme*	Philippines
LA-2807	*S. lycopersum* L. *var. cerasiforme*	Bolivia
LA-2871	*S. lycopersum* L. *var. cerasiforme*	Bolivia
P-531	*S. lycopersum* L. *var. cerasiforme*	Cuba
Ciapan 31-5	*S. pimpinellifollium* L.	Mexico
Mex-121-A	*S. pimpinellifollium* L.	Mexico
Rojo Veracruz	*S. pimpinellifollium* L.	Mexico

Table 2. Ion efflux (%) in tomato genotypes

Accesion	Ion efflux (%)
Amalia	27.92 cd
AN-104-1	35.69 ef
Campbell-28	33.49 de
CL-1131-00-7-2-0-9	30.74 cde
Claudia	37.27 ef
CO-7040	36.18 ef
Lignom	33.05 de
Mara	29.96 cd
Mariela	32.33 cde
Mayle	43.18 gh
Mecy	40.25 gh
Rilia	30.67 cde
Roma	35.18 def
Santa Clara	39.13 efg
Yaily	42.87 gh
Nagcarlang	24.68 c
LA-2807	16.74 ab
LA-2871	21.47 bc
P-531	17.76 ab
Ciapan 31-5	15.01 a
Mex-121-A	14.60 a
Rojo Veracruz	20.35 b
x̄	29.92

For each genotype, different letters indicate significant differences (p< 0.05)

Notably, ion efflux, calculated on the basis of compounds absorbing at 280 nm, is a useful method for determining cell damage under simulated water stress conditions with PEG. This method is relatively simple, fast and there is no electrolyte leakage by measuring membrane stability (8). The differences found among the different genotypes suggest that this can be used as a quantitative test to determine the effect of water deficit in leaf tissue in tomato.

In this regard, most researches base selection for genotypes tolerant to abiotic stresses, including water deficit on crop yield and stability under stress conditions. However, this type of selection that is performed by testing at multiple locations or in different years has low heritability (3, 14, 15). Furthermore, screening for tolerance under field conditions requires considerable resources and precise environmental conditions that can be used to distinguish tolerant genotypes. Hence, rapid and less expensive tests are often used. Cell membrane stability (CMS) is one of the most commonly used tests to select tolerant genotypes (10-12).

CONCLUSIONS

- A differentiated response of genotypes to water stress was observed, which confirms the usefulness of this methodology in the selection of tolerant accessions in the early stages of breeding programs. The usefulness of PEG-6000 for the selection of genotypes tolerant to water stress is also evidenced.
- The accessions belonging to *S. pimpinellifollium* and *S. lycopersicum* cerasiforme variety, mainly Mex-121A, Ciapan 31-5, LA-2807 and P-531, showed lower efflux of these substances under water deficit conditions. These genotypes can be used to increase tolerance to water stress in the crop in future breeding programs.

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