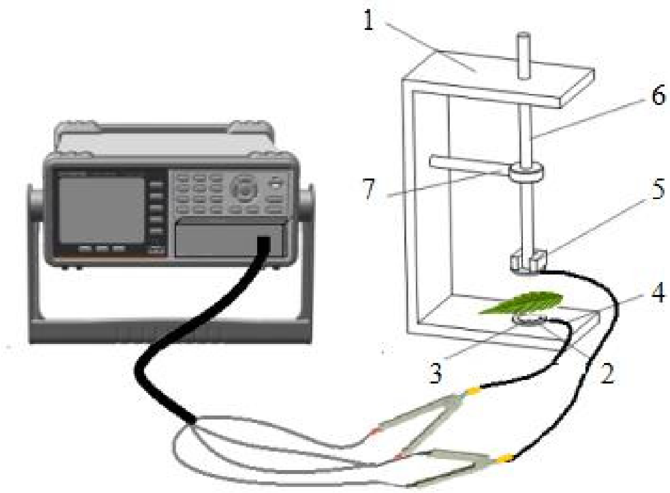

Figure S1 The experimental setup used in the study and a schematic diagram of the parallel-plate capacitor. (1) holder; (2) cystosepiment; (3) plate electrode; (4) electrical conductor; (5) iron block; (6) plastic rod; (7) bench holdfast.

Formula S1: The deduction process of clamping force and electrophysiological parameter model

The leaf capacitive reactance (Xc) and inductive reactance (Xl) were calculated according to Formulas (1) and (2):

$$\mathrm{Xc} = \frac{1}{2\pi f C} \quad (1)$$

$$\frac{1}{-\mathrm{Xl}} = \frac{1}{\mathrm{Z}} - \frac{1}{\mathrm{R}} - \frac{1}{\mathrm{Xc}} \quad (2)$$

where π= 3.1416, f= frequency, C= physiological capacitance, Xc: capacitive reactance, Xl: inductive reactance, Z: impedance, and R: resistance.

According to bioenergetics, the Nernst equation can be used to quantitatively describe the potential of ions, ion groups and electric dipoles inside and outside of the cell membrane. Thus, the concentration differences in electrolytes that respond to Z inside and outside of the cell membrane obey the Nernst equation and can be expressed as follows:

$$\mathrm{E} - \mathrm{E}^0 = \frac{\mathrm{R_0 T}}{\mathrm{n_Z F_0}} \ln \frac{\mathrm{Q_i}}{\mathrm{Q_o}} \quad (3)$$

where E= the electromotive force (V), E^0= the standard electromotive force (V), R_0= the gas constant (8.314570 $J{\cdot}K^{-1}{\cdot}mol^{-1}$), T= the thermodynamic temperature (K), Q_i= the concentration of electrolytes that respond to Z inside the cell membrane ($mol{\cdot}L^{-1}$), Q_o= the concentration of electrolytes that respond to Z outside the cell membrane ($mol{\cdot}L^{-1}$), F_0= Faraday constant (96485 $C{\cdot}mol^{-1}$), and n_Z= the number of transferred electrolytes (mol).

The internal energy of the electromotive force can be converted into pressure work, and they have a direct relationship, PV= aE, that is:

$$\mathrm{PV} = \mathrm{aE} = \mathrm{a\,E^0} + \frac{\mathrm{a\,R_0 T}}{\mathrm{n_Z F_0}} \ln \frac{\mathrm{Q_i}}{\mathrm{Q_o}} \quad (4)$$

where P= the pressure intensity on the leaf cells (Pa), a= the energy conversion coefficient of the electromotive force, and V= the cell volume (m^3). $\mathrm{P} = \frac{\mathrm{F}}{\mathrm{S}}$, where F= the clamping force (N) and S= the effective area of the electrode plate (m^2). F can be calculated by the gravity formula:

$$\mathrm{F} = (\mathrm{M} + \mathrm{m})\mathrm{g} \quad (5)$$

where M= the iron block mass (kg), m= the mass of the plastic rod and the plate electrode (kg), and g= 9.8 N/kg.

For mesophyll cells, the sum of Q_o and Q_i is certain. Q_i is directly proportional to the conductivity of electrolytes that respond to Z, and the conductivity is the reciprocal of Z. Hence, $\frac{\mathrm{Q_i}}{\mathrm{Q_o}}$ can be expressed as $\frac{\mathrm{Q_i}}{\mathrm{Q_o}} = \frac{\frac{J_0}{Z}}{Q - \frac{J_0}{Z}} = \frac{J_0}{QZ - J_0}$, where J_0= the ratio coefficient of the conversion between Q_i and Z and Q= Q_o + Q_i. Therefore, formula (4) was transformed into formula (6):

$$\frac{V}{S}F = a\,E^0 - \frac{a\,R_0T}{n_ZF_0}\ln\frac{QZ-J_0}{J_0} \qquad (6)$$

Formula (6) was rewritten:

$$\frac{a\,R_0T}{n_ZF_0}\ln\frac{QZ\text{-}J_0}{J_0} = a\,E^0\text{-}\frac{V}{S}F \qquad (7)$$

and

$$\ln\frac{QZ\text{-}J_0}{J_0} = \frac{n_ZF_0E^0}{RT}\text{-}\frac{Vn_ZF_0}{S\,a\,RT}F \qquad (8)$$

Formula (8) takes the exponents of both sides:

$$\frac{QZ\text{-}J_0}{J_0} = e^{\frac{n_ZF_0E^0}{R_0T}}\,e^{(-\frac{Vn_ZF_0}{Sa\,R_0T}F)} \qquad (9)$$

Further:

$$Z = \frac{J_0}{Q} + \frac{J_0}{Q}e^{\frac{n_ZF_0E^0}{R_0T}}\,e^{(-\frac{Vn_ZF_0}{Sa\,R_0T}F)} \qquad (10)$$

Because $d=\frac{V}{S}$, formula (10) was transformed into:

$$Z = \frac{J_0}{Q} + \frac{J_0}{Q}e^{\frac{n_ZF_0E^0}{R_0T}}\,e^{(-\frac{d\,n_ZF_0}{a\,R_0T}F)} \qquad (11)$$

For the same leaf tested in the same environment, d, a, E^0, R_0, T, n_Z, F_0, Q, and J_0 of formula (11) are constant. Let $y_0=\frac{J_0}{Q}$, $k_1=\frac{J_0}{Q}e^{\frac{n_ZF_0E^0}{R_0T}}$, and $b_1=\frac{d\,n_ZF_0}{a\,R_0T}$, and the intrinsic mechanism relationships of leaf impedance (Z) and F were:

$$Z=y_0+k_1\,e^{-b_1F} \qquad (12)$$

where y_0, k_1 and b_1 are model parameters.

When F=0, the intrinsic impedance (IZ) of the plant leaves could be obtained:

$$IZ=y_0+k_1 \qquad (13)$$

With the same Z, the intrinsic mechanism relationships of leaf capacitive reactance (Xc) and F were revealed:

$$Xc=p_0+k_2\,e^{-b_2F} \qquad (14)$$

where p_0, k_2 and b_2 are model parameters.

When F=0, the intrinsic capacitive reactance (IXc) of plant leaves could be calculated as:

$$IXc=p_0+k_2 \qquad (15)$$

The intrinsic capacitance (IC) of plant leaves could also be obtained:

$$IC = \frac{1}{2\pi f\,IXc} \qquad (16)$$

where π= 3.1416, f= the frequency, and IXc is the intrinsic capacitive reactance.

Similar to Z, the intrinsic mechanism relationship of leaf resistance (R) and F was:

$$R=g_0+k_3\,e^{-b_3F} \qquad (17)$$

where g_0, k_3 and b_3 are fitting equation parameters. When F=0, the intrinsic R (IR) of the plant leaves could be calculated as:

$$IR=g_0+k_3 \qquad (18)$$

Similar to Z, the intrinsic mechanism relationship of leaf inductive reactance (Xl) and

F was:

$Xl=q_0+k_4 e^{-b_4F}$ (19)

where q_0, k_4 and b_4 are fitting equation parameters. When F=0, the intrinsic Xl (IXl) of plant leaves could be calculated as:

$IXl=q_0+k_4$ (20)

According to the first law of thermodynamics, the work done by the clamping force obeys the Gibbs free energy equation:

$\Delta G = \Delta H + PV$ (21)

where ΔG= Gibbs free energy (J), ΔH= the internal energy of the leaf cell system (J), P= the pressure intensity of the leaf cells (Pa), and V= the cell volume (m^3). P can be calculated by the pressure intensity formula:

$P = \frac{F}{S}$ (22)

where F= the clamping force (N) and S= the effective area of the electrode plate (m^2).
Mesophyll cells can be regarded as concentric sphere capacitors, and the capacitor energy is:

$W = \frac{1}{2}U^2C$ (23)

where W= the capacitor energy (J), U= the test voltage (V), and C= the physiological capacitance (pF). Because the membrane potential of a cell at rest is approximately 50 mV, which is very low relative to the test voltage, the cell membrane potential of all test leaves was negligible.
According to energy conservation theory, the capacitor energy is equal to the work converted by Gibbs free energy, i.e., $W=\Delta G$. The leaf C and clamping force (F) relationship model was obtained:

$C = \frac{2\Delta H}{U^2} + \frac{2V}{SU^2}F$ (24)

It is assumed that d represents the specific effective thickness of the plant leaves; therefore, $d=\frac{V}{S}$. Formula (24) was transformed into formula (25):

$C = \frac{2\Delta H}{U^2} + \frac{2d}{U^2}F$ (25)

Let $x_0 = \frac{2\Delta H}{U^2}$ and $h = \frac{2d}{U^2}$, and formula (25) was transformed into formula (26):

$C = x_0 + hF$ (26)

Formula (26) is a linear model, where x_0 and h are the model parameters.

Because $h = \frac{2d}{U^2}$, the specific effective thickness (d) of the plant leaves could be calculated as:

$d=\frac{U^2h}{2}$ (27)

The cell is a spherical structure, and its growth is closely related to the increased volume. The C of plant leaf cells can be calculated by a formula for concentric spherical capacitors:

$$Cc = \frac{4\pi\varepsilon R_1 R_2}{R_2 - R_1} \qquad (28)$$

where π= 3.1416, Cc= the capacitance of the concentric spherical capacitor (pF), ε= the dielectric constant of electrolytes, R_1= the outer sphere radius (m), and R_2= the inner sphere radius (m). For a plant cell, $R_2 - R_1$ is the thickness of the cell membrane. $R_1 \approx R_2$, as well as ε, and the thickness of the cell membrane is constant. Therefore, the cell volume (Vc) has the following relationship with cell C:

$$Vc=\alpha\sqrt{C^3} \qquad (29)$$

The cell volume is positively correlated with the volume of vacuoles, and the main component of the vacuole and cytoplasm is water. In other words, the water-holding capacity of cells is directly proportional to $\sqrt{C^3}$. Therefore, $\sqrt{C^3}$ can represent the water-holding capacity of plant leaves. The intracellular water-holding capacity (IWHC) of plant leaves was obtained according to formula (30):

$$IWHC= \sqrt{(IC)^3} \qquad (30)$$

The specific effective thickness (d) of plant leaves represents cell growth, and the water-holding capacity supports plant cell growth. Therefore, the intracellular water use efficiency (IWUE) of leaves was represented by formula (31):

$$IWUE= \frac{d}{IWHC} \qquad (31)$$

According to Ohm's law, I_Z=U/Z, where I_Z= the physiological current (A), U= the test voltage (V), and Z= the physiological impedance (Ω). At the same time, the current is equal to the product of the capacitance and the differential of voltage over time as in formula (32):

$$I_Z= IC \times \int dU \qquad (32)$$

After the integral transformation, the current time is the product of the capacitance and impedance. Therefore, the intracellular water-holding time (IWHT) of plant leaves was represented by formula (33):

$$IWHT = IC \times IZ \qquad (33)$$

Furthermore, the dynamic water transfer rate (WTR) of plant leaves was calculated by formula (34):

$$WTR = \frac{IWHC}{IWHT} \qquad (34)$$