

Supplementary materials

Effects of the Rhizosphere Fungus *Cunninghamella bertholletiae* on the *Solanum lycopersicum* Response to Diverse Abiotic Stresses

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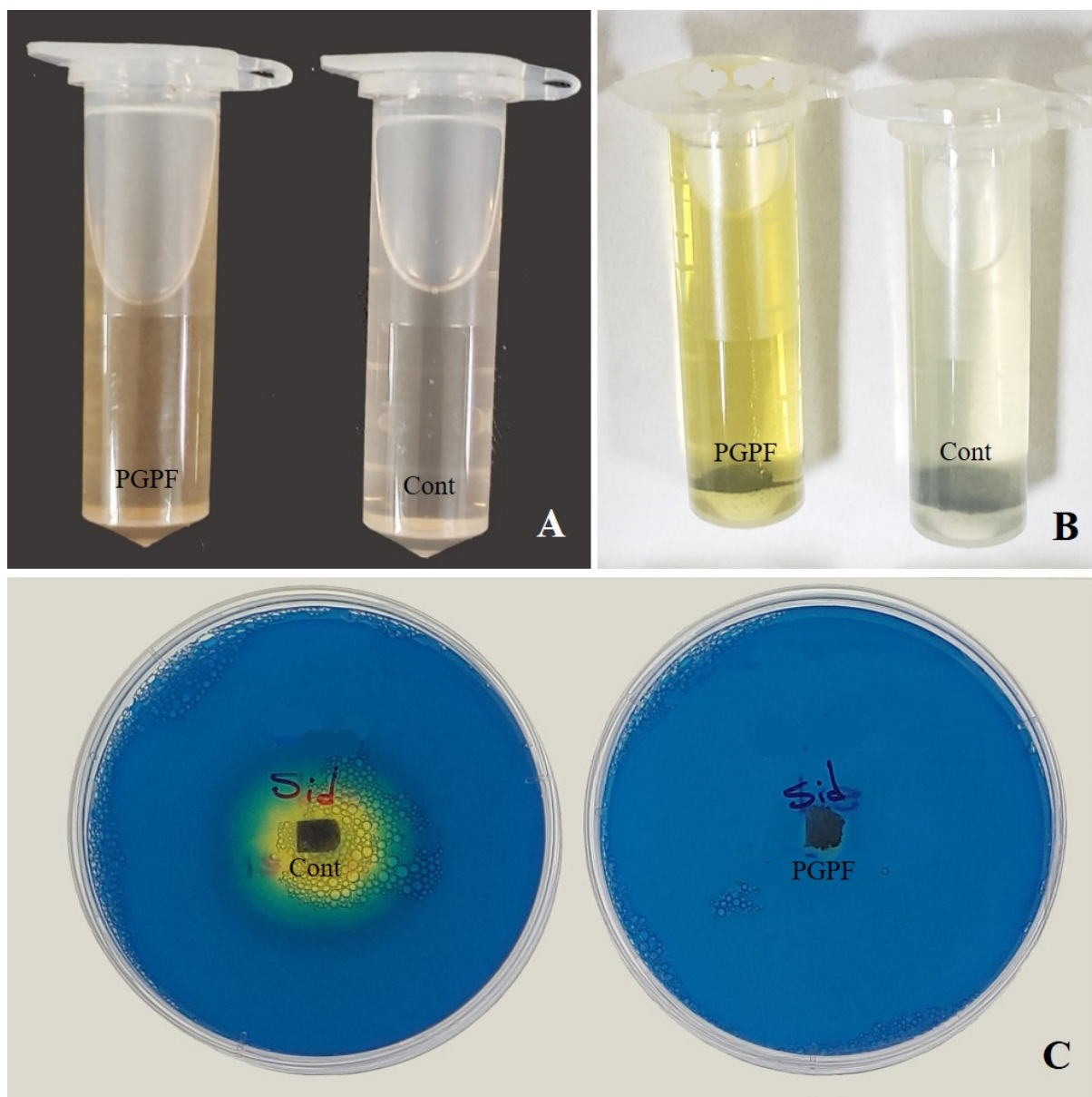


Figure S1. (A) IAA production, (B) Ammonia production, (C) Siderophore production of the selected fungal strain (*Cunninghamella bertholletiae*) associated with *Solanum lycopersicum* in this study.

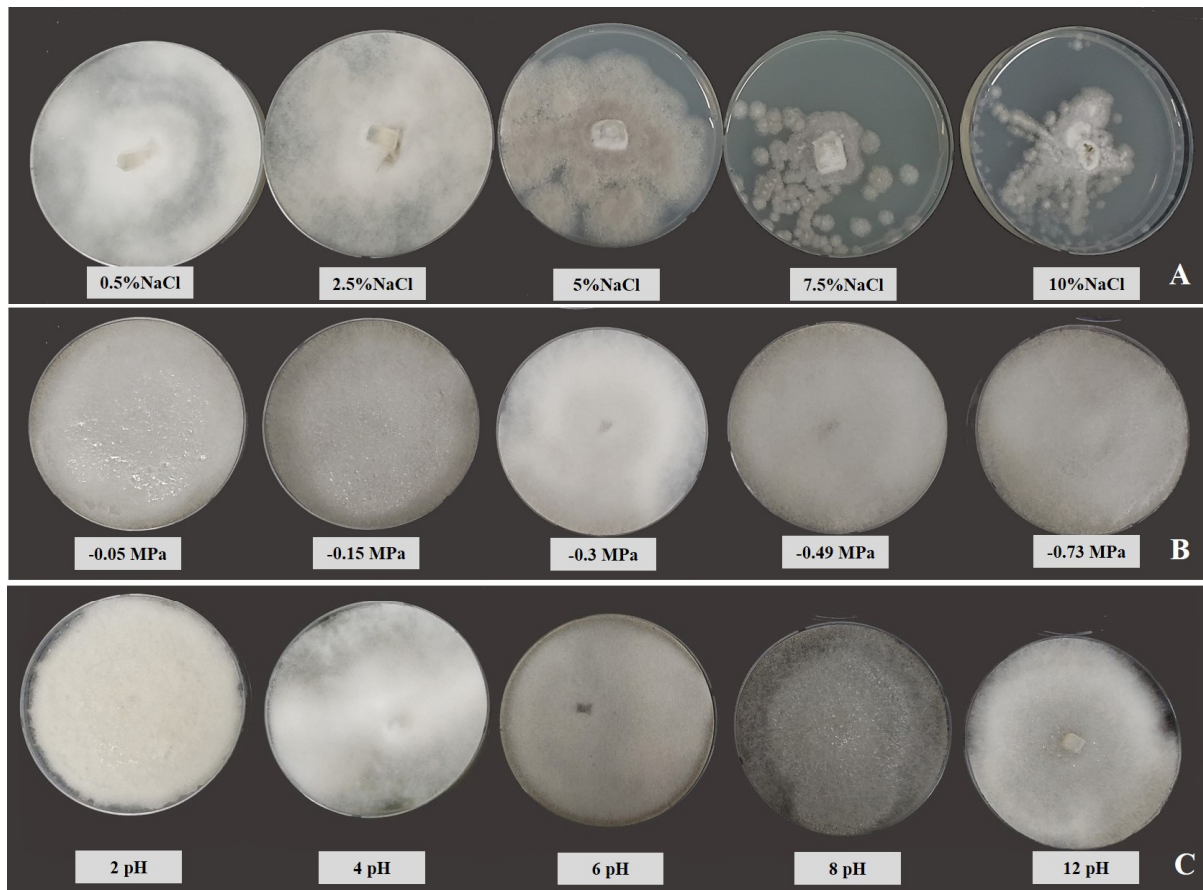


Figure S2. (A) Salinity (sodium chloride; NaCl), (B) Drought (polyethelene glycol; PEG 6000 Da) and (C) pH tolerance ability of the selected fungal strain (*Cunninghamella bertholletiae*) associated with *Solanum lycopersicum* in this study.

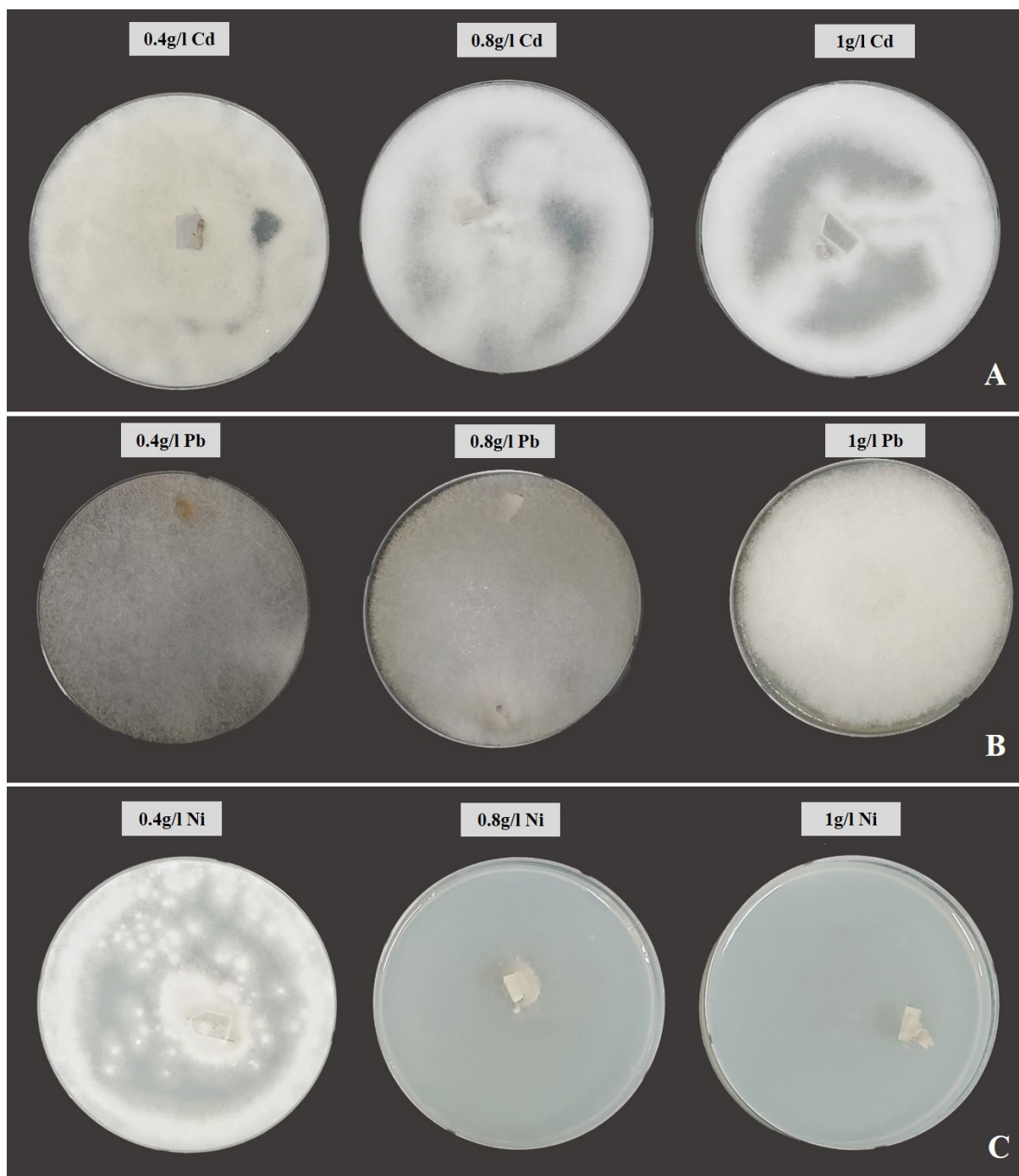


Figure S3. Heavy metal (Cadmium; Cd, Lead; Pb, Nickel; Ni) tolerance ability of the selected fungal strain (*Cunninghamella bertholletiae*) associated with *Solanum lycopersicum* in this study (A–C).

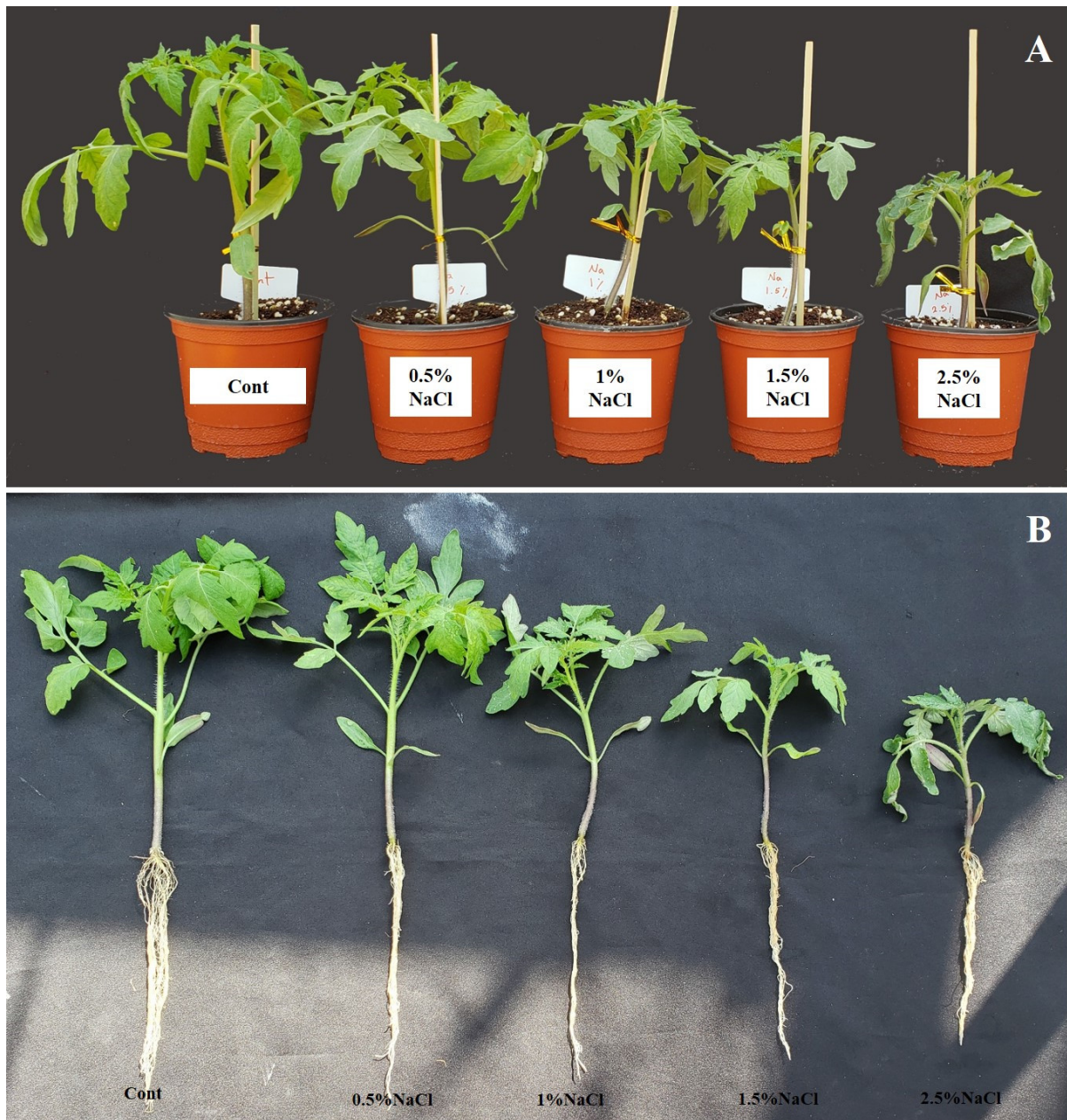


Figure S4. Effects of various sodium chloride (NaCl) concentrations on the growth of tomato seedlings following 10 days of treatment (**A** and **B**). Treatments: Cont (control), 0.5% NaCl, 1% NaCl, 1.5% NaCl, and 2.5% NaCl.

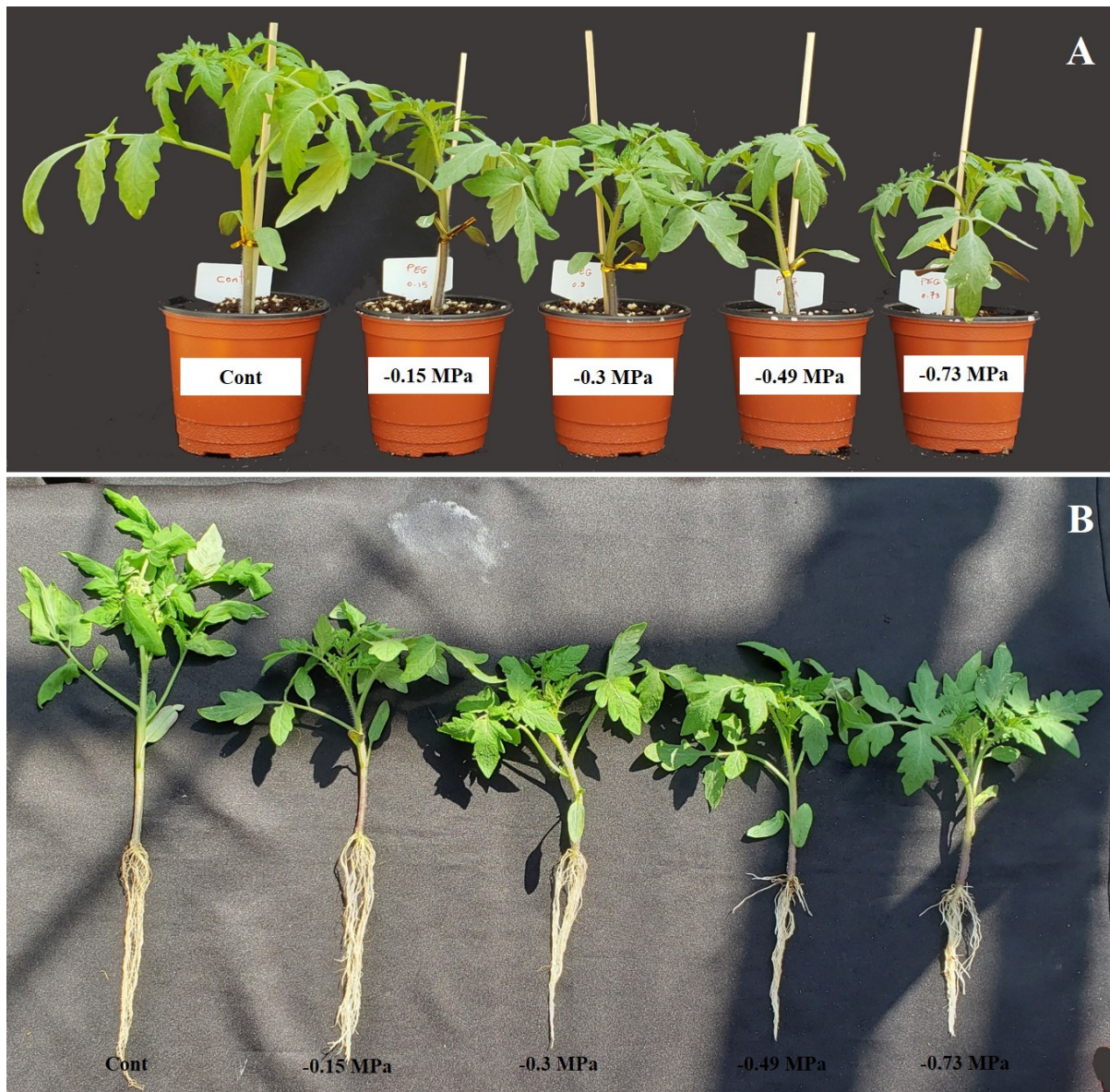


Figure S5. Effects of various polyethylene glycol (PEG 6000 Da) concentrations on the growth of tomato seedlings following 10 days of treatment (A and B). Treatments: Cont (control), PEG 5%; -0.15 MPa), PEG (10%; -0.3 MPa), PEG (15%; -0.49 MPa), and PEG (25%; -0.73 MPa).

Table S1. Effects of various sodium chloride (NaCl) concentrations on the growth of tomato seedlings. Data were calculated after 10 days of treatment.

Treatment	Plant height (cm)	Root length (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)	Chl (Spad)	Plant fresh weight (g)	Plant dry weight (g)	Root fresh weight (g)	Root dry weight (g)	No. leaf
Cont	18.1±0.64a	24.0±0.0a	0.55±0.02a	16.28±0.53a	12.56±0.70a	31.76±0.52a	10.21±0.90a	0.63±0.03a	1.17±0.45a	0.09±0.0a	8.6±0.24a
NaCl (0.5%)	15.0±0.0b	19.5±0.0b	0.45±0.02b	13.5±0.5b	9.7±0.71b	30.03±1.28b	8.39±0.0b	0.48±0.0b	0.9±0.0b	0.07±0.0b	7.2±0.2b
NaCl (1%)	13.8±0.37c	18.0±0.0c	0.40±0.01c	11.9±0.18c	8.3±0.46c	28.64±1.33c	5.52±0.0c	0.36±0.0c	0.82±0.05c	0.06±0.0bc	7.2±0.2b
NaCl (1.5%)	11.7±0.12d	16.0±0.0d	0.34±0.01d	10.6±0.53d	7.7±0.7d	26.9±0.80d	4.36±0.0d	0.32±0.0d	0.51±0.04d	0.05±0.0cd	6.8±0.2c
NaCl (2.5%)	10.0±0.54e	14.0±0.0e	0.30±0.01e	9.1±0.18e	7.1±0.55e	25.3±2.45e	3.22±0.0e	0.26±0.0e	0.49±0.0d	0.04±0.0d	6.2±0.2d

Treatments: Cont (control), 0.5% NaCl, 1% NaCl, 1.5% NaCl, and 2.5% NaCl. Values show the means \pm SD (n = 5) and significant differences at $p < 0.05$ (Tukey test). Data within the same column followed by different lowercase letters are significantly different.

Table S2. Effects of various polyethylene glycol (PEG 6000 Da) concentrations on the growth of tomato seedlings. Data were calculated after 10 days of treatment.

Treatment	Plant height (cm)	Root length (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)	Chl (Spad)	Plant fresh weight (g)	Plant dry weight (g)	Root fresh weight (g)	Root dry weight (g)	No. leaf
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Cont	18.1±0.64a	24.0±0.0a	0.55±0.02a	16.28±0.53 a	12.56±0.70a	31.76±0.52a	10.21±0.90a	0.63±0.03a	1.17±0.45a	0.09±0.0a	8.6±0.24a
PEG (-0.15)	12.2±0.48b	19.0±0.0b	0.44±0.0b	12.5±0.22b	9.3±0.64b	29.7±1.68b	7.05±0.0b	0.45±0.0b	1.13±0.0b	0.07±0.0b	7.2±0.2b
PEG (-0.30)	12.1±0.55c	14.5±0.0c	0.38±0.01c	11.7±0.12b c	9.1±0.18b	28.66±0.57b	7.0±0.0b	0.43±0.0b	1.04±0.06c	0.06±0.0c	7.0±0.0b
PEG (-0.49)	11.8±0.48 d	12.5±0.0 d	0.36±0.01c d	11.4±0.36c	8.5±0.22c	25.32±1.68c	6.14±0.0c	0.41±0.0bc	0.93±0.05d	0.05±0.0d	6.8±0.2c
PEG (-0.73)	10.6±0.53e	11.0±0.0e	0.34±0.02d	10.6±0.4d	8.0±0.31d	21.7±1.38d	5.8±0.0d	0.38±0.01c	0.91±0.0e	0.04±0.0e	6.4±0.24d

Treatments: Cont (control), PEG 5%; -0.15 MPa), PEG (10%; -0.3 MPa), PEG (15%; -0.49 MPa), and PEG (25%; -0.73 MPa). Values show the means ± SD (n = 5) and significant differences at p < 0.05 (Tukey test). Data within the same column followed by different lowercase letters are significantly different.

Table S3. Physiochemical properties of soil samples during 10 days of treatment.

Sample name	Soil texture	pH	EC (mS)	Moisture (%)
Cont	sandy loam	8.0±0.0ab	0.03±0.0f	83.0±0.1e
PGPF	sandy loam	7.95±0.05ab	0.07±0.01f	93.0±0.1c
S	sandy loam	6.7±0.01c	12.0±0.09a	100.0±0.0a
S+PGPF	sandy loam	7.7±0.0b	5.35±0.25b	96.0±0.9b
Dr	sandy loam	7.7±0.1b	0.63±0.05de	45.0±0.0f
Dr+PGPF	sandy loam	8.0±0.0a	0.04±0.0f	85.0±0.1d
Cd	sandy loam	5.5±0.05d	1.08±0.02cd	100.0±0.0a
Cd+PGPF	sandy loam	8.1±0.1a	0.15±0.01ef	96.0±0.18b
Pb	sandy loam	5.0±0.15d	1.25±0.01c	100.0±0.0a
Pb+PGPF	sandy loam	8.0±0.05ab	0.06±0.01f	98.0±0.2ab

Treatments: Cont (control), PGPF (*Cunninghamella bertholletiae*), S (1.5% sodium chloride), S (1.5% sodium chloride) + PGPF (*Cunninghamella bertholletiae*), Dr (25% polyethylene glycol), Dr (25% polyethylene glycol) + PGPF (*Cunninghamella bertholletiae*), Cd (3mM cadmium), Cd (3mM cadmium) + PGPF (*Cunninghamella bertholletiae*), Pb (3mM lead), and Pb (3mM lead) + PGPF (*Cunninghamella bertholletiae*). Values are shown as the means ± SD (n = 5) and significant differences at p < 0.05 (Tukey test). Data within the same column followed by different lowercase letters are significantly different.

Table S4. Primers used for relative gene expression analysis.

Gene symbol	Primers (5'–3') Forward/reverse
SlACCase	5'-CGCGATGAGGTTAGGTAAAAGGCA-3' 5'-GTCGATTCCCTTAAAAGTGGACGCA-3'
SlAOS	5'-CCGGCGGGAAGATCACGATG-3' 5'-TCGAAAACGGCGTCGTGTGA-3'
SlICS	5'-GGCAATAGATGCACTTCAGGCCA-3' 5'-CGCATGGTCCCAAGACGCTTT-3'
SlRBOHD	5'-TCAGGTCAAGCATCAAAGCCGTT-3' 5'-TGGTGAAACCGCAGCACAGT-3'
SlGRAS6	5'-AAACCAAAGAGACCAGCTTCTGCG-3' 5'-AATAAAGTGCACCTGCCTCCTCCT-3'
SlTAF1	5'-CACCATGACAGCAGCTGAATTGC-3' 5'-TCAAAAAGGCTTGTGCAGGTGCA-3'
SlZH13	5'-ATGCCACTGATGGCTGTGGA-3' 5'-TGCGGTGGAAGTTACGGTGA-3'
SlRING1	5'-TTGTGAGATGTCAGCACGAA-3' 5'-TCACCGAAGAAGAACAGCAC-3'
SlCDF3	5'-GCTTGAGGGTCTTCCTCAGTTGA-3' 5'-AAAATCCTAAGACTCCATCAGAATCAG-3'
SlActin	5'-GGGATGGAGAAGTTTGGTGGTGG-3' 5'-CTTCGACCAAGGGATGGTGTAGC-3'