

Supplementary File

Measurement of Experimental Parameters

The study entails a comprehensive analysis of the morphological attributes and endogenous phytohormonal profiles of seedling roots. Specifically, the research methodology is delineated as follows:

1. Root System Imaging and Archival:

Three individual plant roots from treated seedlings were selected for scanning.

Utilizing an Epson digital scanner (model Expression 10000 XL1.0), high-resolution (300 dots per inch, dpi) scans were performed in a monochromatic (black-and-white) color mode.

The resultant images were digitally preserved for subsequent morphometric analysis.

2. Quantitative Morphometric Analysis:

Morphological parameters were quantitatively assessed using the WinRhizo 2013E root analysis system software.

Metrics computed included total root length, projected area, total root surface area, total root volume, number of root tips, connectivity count, average count of first-order lateral roots, and the angle of emergence for first-order lateral roots.

3. Endogenous Phytohormone Detection and Quantification:

Gas Chromatography-Mass Spectrometry (GC-MS; Agilent-7890A/5975C) was employed for the detection and quantification of endogenous phytohormones such as Gibberellic Acid (GA), Indole-3-Acetic Acid (IAA), Zeatin Riboside (ZR), and Abscisic Acid (ABA).

4. Sample Preparation Protocol:

In adherence to the manufacturer's protocol, 3 grams of test samples from *Pinus massoniana* (roots with a diameter of less than 2 millimeters, stems, and leaves) were pulverized into a fine powder using liquid nitrogen.

The powdered sample was extracted with 20 milliliters of pre-cooled 80% methanol supplemented with 100 microliters of 1 mmol/L ascorbic acid, and the mixture was stored overnight at 4°C.

The following day, the extraction process was conducted in an ultrasonic ice bath for 2 hours under dark conditions.

Centrifugation at 10,000 revolutions per minute (rpm) at -10°C for 15 minutes was performed to separate the supernatant from the pellet.

The pellet was re-extracted with 2 milliliters of pre-cooled 80% methanol, followed by ultrasonic extraction at 4°C for an additional 2 hours.

A second centrifugation step at 10,000 rpm at -10°C for 15 minutes was conducted to separate the supernatant.

5. Sample Purification and Concentration Adjustment:

The combined supernatants were subjected to purification via polyvinylpyrrolidone (PVPP) and DEAE Sephadex A-25 columns.

Subsequent to purification, the samples were lyophilized using nitrogen gas to remove solvents.

The dried samples were then reconstituted to a final volume of 1 milliliter with chromatographically pure methanol.

Finally, the samples were filtered through a 0.22 micrometer organic membrane filter in preparation for GC-MS analysis.

Table S1 Basic physical and chemical properties of the soil used in the experiment

pH	Total element (g.kg ⁻¹)			Effective element (mg.kg ⁻¹)			Exchangeable element (%)			Organic matter (g.kg ⁻¹)
	N	P	K	N	P	K	Ca	Mg	Zn	
5.0	0.16	0.36	14.96	65.77	10.99	164.26	0.29	0.04	5.58	5.88

Table S2 Table of soil root growth and development parameters

Root morphology	Tackle	ND	LD	MD	SD
Total root length (cm)	NM	215.56±0.91c	758.57±0.10c	169.55±0.93c	149.47±1.04c
	S12	1646.90±0.09b	2689.73±0.13c	1252.45±0.08b	500.67±0.09b
	S13	2469.74±0.09a	2757.92±0.08a	1326.74±0.11a	508.84±0.10a
Projection area (cm ²)	NM	94.58±0.10c	261.17±0.09c	80.46±0.08c	77.85±0.49c
	S12	656.36±0.10b	1042.66±0.11b	541.37±0.11a	249.76±0.10b
	S13	831.28±0.10a	1069.93±0.07a	499.86±0.12b	272.95±0.07a
Total root surface area (cm ²)	NM	296.96±0.05c	820.08±0.06c	233.24±0.12c	285.84±0.55c
	S12	2060.95±0.05b	3273.85±0.12a	1715.66±0.09a	784.18±0.10b
	S13	2610.24±0.10a	3206.56±0.10b	1569.45±0.08b	857.14±0.11a
Total root volume (cm ³)	NM	43.45±0.11c	149.72±0.11c	36.35±0.09c	34.37±1.18c
	S12	373.58±0.13b	619.47±0.10b	383.76±0.12a	161.59±0.10a
	S13	506.58±0.10a	628.14±0.13a	248.75±0.12b	143.56±0.10b
Connection count	NM	131.00±1.00c	271.00±1.00c	89.00±1.00c	75.67±1.15c
	S12	1549.00±1.00b	2182.00±1.00a	908.00±1.73a	363.67±4.93a
	S13	1734.33±3.06a	2010.00±2.00b	790.00±2.00b	142.33±2.52b
Root tip number	NM	26.00±2.00c	69.33±1.53c	24.00±1.00c	21.33±0.58c
	S12	135.00±1.00b	230.67±2.52a	124.00±2.00a	60.00±2.00a
	S13	150.67±2.52a	207.67±1.53b	111.33±1.53b	24.67±1.53b
Average number of first-order lateral roots	NM	7.67±0.58b	6.67±1.15b	6.67±2.08b	4.67±0.58b
	S12	11.67±1.53a	11.67±1.53a	11.00±1.00a	9.00±1.00a
	S13	13.00±1.00a	12.00±1.00a	10.00±1.00a	8.00±1.00a
Angle of first-order lateral root	NM	43.50±0.10c	43.30±0.10c	42.67±1.53a	41.63±0.59b
	S12	45.53±0.21b	46.57±0.15b	44.10±0.10a	43.37±0.15a
	S13	45.87±0.06a	47.27±0.25a	43.27±0.25a	42.87±0.06a

Note: Different lowercase letters above the bars indicate significant differences among the treatments under the same drought stress condition (Duncan test at $P < 0.05$).