

Supplementary Table 1. Composition of the nutrient solution.

	Stock solution	Half-strength
KNO ₃	101.1 g l ⁻¹	303.0 mg l ⁻¹
Ca(NO ₃) ₂ ·4H ₂ O	236.2 g l ⁻¹	472.0 mg l ⁻¹
NH ₄ H ₂ PO ₄	115.1 g l ⁻¹	115.0 mg l ⁻¹
MgSO ₄ ·7H ₂ O	246.5 g l ⁻¹	123.0 mg l ⁻¹
NaFeEDTA (13.7-18.7% Fe)	30.00 g l ⁻¹	15.00 mg l ⁻¹
KCl	1.864 g l ⁻¹	1.864 mg l ⁻¹
H ₃ BO ₃	0.773 g l ⁻¹	773.0 µg l ⁻¹
MnSO ₄ ·H ₂ O	0.169 g l ⁻¹	169.0 µg l ⁻¹
H ₂ SO ₄ (98%)	54.00 µl l ⁻¹	54.00 µl ml ⁻¹
CuSO ₄ ·5H ₂ O	62.00 mg l ⁻¹	62.00 µg l ⁻¹
H ₂ MoO ₄ (85% MoO ₃)	40.00 mg l ⁻¹	40.00 µg l ⁻¹
pH		5.86
EC (µS)		1243

Modified from⁷².

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Supplementary Table 2. Conductivity and pH of nutrient solutions.

	No plant	[ZnO] (mg l ⁻¹)						χ^2	Source				χ^2
		0	0.1	1	10	100	1000		Bulk	NP100	NP50	NW	
pH													
8 weeks	4.2±0.1	5.8±0.2 ^{ab}	5.6±0.1 ^a	5.6±0.2 ^{ab}	5.8±0.1 ^{ab}	6.2±0.1 ^b	6.8±0.1 ^c	38.9***	5.9±0.1 ^{ab}	6.3±0.1 ^b	5.9±0.2 ^{ab}	5.6±0.2 ^a	9.5*
12 weeks	5.5±0.4	8.1±0.1 ^c	7.6±0.1 ^{ab}	7.6±0.1 ^{ab}	7.5±0.05 ^a	7.9±0.1 ^{bc}	8.2±0.1 ^c	28.2***	7.9±0.1	7.9±0.1	7.8±0.1	7.7±0.1	3.1
EC (μS)		43.2±0.2 ^{ab}	44.0±0.1 ^b	42.9±0.2 ^a	43.4±0.8 ^{ab}	41.8±1 ^a	42.5±0.6 ^a	14.5*	5.9±0.2 ^a	6.3±0.8 ^{ab}	5.9±1 ^a	5.6±0.6 ^a	3.1

3 Plants were grown in four different ZnO sources: micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50
4 nm diameter (NW). Each source was provided at six concentrations (0, 0.1, 1, 10, 100, and 1000 mg l⁻¹) except NW (only up to 10 mg l⁻¹). Data represent
5 means ±SE, where n = 4 and df= 5 for the ZnO concentration factor and df = 3 for the source factor. Concentration data are expressed in mg l⁻¹ for the growth
6 solutions and in μg g⁻¹ for plant samples. Different letters indicate statistically significant groups according to Dunn's test with Benjamini-Hochberg
7 correction. The Chi-square value (χ^2) corresponds to the Kruskal-Wallis rank-sum test and is indicated as significant at $P < 0.05$ (*), $P < 0.01$ (**), or $P <$
8 0.001(***).

Supplementary Table 3. Neptune multicollector typical operational settings.

Extraction [V]:	-2000
Focus [V]:	-666.3
SourceQuad1 [V]:	248.7
Rot-Quad1 [V]:	0
Foc-Quad1 [V]:	-17.6
Rot-Quad2 [V]:	29.5
Source Offset [V]:	-6
Matsuda Plate [V]:	17.5
Cool Gas [l/min]:	15.1
Aux Gas [l/min]:	0.9
Sample Gas [l/min]:	1
Add Gas [l/min]:	0
Org Gas [l/min]:	0
Operation Power [W]:	1308
X-Pos [mm]:	2.5
Y-Pos [mm]:	1.5
Z-Pos [mm]:	2.9
Ampl.-Temp [°C]:	47.23
Fore Vacuum [mbar]:	4.17E-04
High Vacuum [mbar]:	3.91E-07
Ion Getter-Press [mbar]:	2.48E-08

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Supplementary Table 4. Elemental composition of ZnO materials.

	Source			
	Bulk	NP100	NP50	NW
[Al] $\mu\text{g g}^{-1}$	0.6 $\pm$ 0.3	0.9 $\pm$ 0.3	22400 $\pm$ 2500	6.2 $\pm$ 1.9
[Cd] $\mu\text{g g}^{-1}$	1.2 $\pm$ 0.5	0.9 $\pm$ 0.4	1.1 $\pm$ 0.1	0.0 $\pm$ 0.0
[Cr] $\mu\text{g g}^{-1}$	0.1 $\pm$ 0.0	0.1 $\pm$ 0.0	0.3 $\pm$ 0.0	0.7 $\pm$ 0.1
[Cu] $\mu\text{g g}^{-1}$	4.5 $\pm$ 1.7	3.1 $\pm$ 1.4	3.2 $\pm$ 0.5	0.4 $\pm$ 0.0
[Fe] $\mu\text{g g}^{-1}$	1.3 $\pm$ 0.3	0.9 $\pm$ 0.4	8.4 $\pm$ 1.0	8.5 $\pm$ 1.1
[Ni] $\mu\text{g g}^{-1}$	0.1 $\pm$ 0.0	0.1 $\pm$ 0.0	0.5 $\pm$ 0.1	3.4 $\pm$ 0.3
[Pb] $\mu\text{g g}^{-1}$	3.7 $\pm$ 1.4	2.7 $\pm$ 1.2	27.2 $\pm$ 3.9	0.2 $\pm$ 0.0
[Zn] mg g^{-1}	756.8 $\pm$ 7.2	773.9 $\pm$ 1.6	724.9 $\pm$ 15.2	759.6 $\pm$ 15.1

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13 ZnO materials were: micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50 nm diameter (NW). Data

14 represent means $\pm$ SE, n =3. Data are expressed in mg g^{-1} for Zn and in $\mu\text{g g}^{-1}$ for the rest of the elements.

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Supplementary Table 5. Zinc and aluminium concentrations in solutions and plants.

	[ZnO] (mg l ⁻¹)							Source				
	0	0.1	1	10	100	1000	χ^2	Bulk	NP100	NP50	NW	χ^2
[Zn]												
solution	0.73±0.02 ^a	0.92±0.03 ^{ab}	1.12±0.05 ^b	2.71±0.17 ^c	5.01±0.6 ^{cd}	14.76±1.8 ^d	84.6***	3.53±1.0	3.57±0.8	5.92±1.5	1.31±0.2	6.6
root	33.1±3.0 ^a	50.7±3.4 ^{ab}	150±14.0 ^b	1537±133 ^{bc}	3705±581 ^{cd}	7630±932 ^d	86.3***	1869±555	1799±537	3073±791	376±125	6.7
shoot	31.5±3.6 ^a	48.5±4.4 ^a	143±15 ^b	601±46 ^c	868±89 ^c	1880±370 ^c	82.6***	467±94	512±123	821±252	211±69	4.1
[Al]												
solution	0.14±0.01 ^{bc}	0.17±0.01 ^c	0.15±0.01 ^c	0.11±0.02 ^{ab}	0.07±0.01 ^a	0.10±0.01 ^a	39.0***	0.13±0.01	0.13±0.01	0.12±0.01	0.14±0.01	3.0
root	31.4±3.5 ^a	23.8±3.1 ^a	39.4±4.7 ^{ab}	32.9±4.9 ^a	32.0±5.3 ^a	110.4±28.6 ^b	19.2**	35.1±4.2 ^{ab}	36.2±8.9 ^a	67.4±15 ^b	28.6±3.1 ^a	9.6*
shoot	19.7±3.4 ^{ab}	14.7±1.6 ^a	15.4±1.6 ^a	25.4±2.1 ^c	21.9±2.7 ^{abc}	26.1±3.5 ^{bc}	25.1***	22.2±2.5	16.3±1.4	21.6±2.4	20.8±2.3	5.0
[Al]/[Zn]												
solution	0.19±0.01 ^d	0.19±0.01 ^{cd}	0.14±0.01 ^c	0.044±0.006 ^b	0.017±0.003 ^{ab}	0.009±0.002 ^a	80.6***	0.1±0.01	0.1±0.02	0.09±0.02	0.14±0.01	4.4
root	0.66±0.06 ^e	0.32±0.04 ^{de}	0.14±0.03 ^{cd}	0.046±0.005 ^{bc}	0.026±0.003 ^{ab}	0.016±0.002 ^a	81.6***	0.23±0.06	0.19±0.05	0.17±0.04	0.33±0.06	6.9
shoot	1.0±0.1 ^c	0.46±0.04 ^{bc}	0.31±0.05 ^b	0.022±0.003 ^a	0.0090±0.0008 ^a	0.015±0.004 ^a	81.6***	0.32±0.08	0.26±0.06	0.32±0.1	0.44±0.09	4.6

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23 Plants were grown in four different ZnO sources: micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50
24 nm diameter (NW). Each source was provided at six concentrations (0, 0.1, 1, 10, 100, and 1000 mg l⁻¹) except NW (only up to 10 mg l⁻¹). Data represent
25 means ±SE, where n = 4 and df= 5 for the ZnO concentration factor and df = 3 for the source factor. Concentration data are expressed in mg l⁻¹ for the growth
26 solutions and in µg g⁻¹ for plant samples. Different letters indicate statistically significant groups according to Dunn's test with Benjamini-Hochberg

correction. The Chi-square value (χ^2) corresponds to the Kruskal-Wallis rank-sum test and is indicated as significant at $P < 0.05$ (*), $P < 0.01$ (**), or $P < 0.001$ (***).

Supplementary Table 6. $\delta^{66}\text{Zn}_{\text{JMC}}$ of plant tissues and ZnO sources.

	Control	Bulk	NP100	NP50	NW	test	value
$\delta^{66}\text{Zn}_{\text{shoot}}$ (‰)	0.27 ± 0.01^b	-0.61 ± 0.05^a	-0.50 ± 0.06^{ab}	-0.44 ± 0.08^{ab}	-0.32 ± 0.02^{ab}	KW	11.0*
$\delta^{66}\text{Zn}_{\text{root}}$ (‰)	0.35 ± 0.05^b	0.04 ± 0.06^a	0.02 ± 0.07^a	0.13 ± 0.04^{ab}	0.38 ± 0.01^b	AOV	9.1**
$\delta^{66}\text{Zn}_{\text{ZnO}}$ (‰)		0.35 ± 0.01^a	0.34 ± 0.00^a	0.31 ± 0.01^a	0.31^a	KW	6.7

Plants were grown in four different ZnO sources: micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50 nm diameter (NW). Each source was provided at 100 mg l⁻¹ except NW (10 mg l⁻¹). Data represent means $\pm$ SE, where n =3 and df= 4. Different letters indicate statistically significant groups according to either paired-t-tests with Bonferroni correction (ANOVA, AOV) or Dunn's test with Benjamini-Hochberg correction (Kruskal-Wallis, KW). The F-value (AOV) or Chi-square value (KW) is indicated as significant at $P < 0.05$ (*), $P < 0.01$ (**), or $P < 0.001$ (***).

Supplementary Table 7. Plant growth and evapotranspiration (ET) in response to ZnO.

	[ZnO] (mg l ⁻¹)						test	value	Source				test	value
	0	0.1	1	10	100	1000			Bulk	NP100	NP50	NW		
FW _{plant}	56.8±8.2 ^d	53.4±9.7 ^d	34.4±5.0 ^{cd}	26.9±3.1 ^{bc}	18.7±2.4 ^{ab}	15.0±0.9 ^a	KW	37.3***	27.1±3.8	41.8±6.5	38.2±7.5	36.0±4.0	KW	5.3
FW _{root}	36.4±4.5 ^c	34.9±5.6 ^{bc}	25.5±3.6 ^{bc}	20.4±2.1 ^{ab}	14.7±1.8 ^a	12.5±0.7 ^a	KW	32.6***	19.9±2.3	28.4±3.5	25.6±4.6	26.8±2.6	KW	6.3
FW _{shoot}	15.5±3.6 ^c	12.2±3.5 ^{bc}	6.4±1.2 ^{abc}	4.9±0.9 ^{ab}	2.9±0.6 ^{ab}	1.8±0.3 ^a	AOV	35.6***	5.0±1.2	10.7±2.9	8.4±2.2	6.4±1.1	AOV	4.3
FW _{root} /FW _{shoot}	3.4±0.4 ^a	4.6±0.6 ^{ab}	5.2±0.7 ^{abc}	6.1±1.1 ^{bc}	6.4±1.0 ^{bc}	8.8±1.0 ^c	KW	23.0***	5.6±0.5	4.7±0.6	6.3±1.0	5.9±0.8	KW	3.4
DW _{root}	5.3±0.6 ^d	4.7±0.6 ^{cd}	3.8±0.5 ^{bcd}	2.9±0.4 ^{abc}	2.5±0.4 ^{ab}	2.0±0.2 ^a	KW	26.5***	3.0±0.4	4.1±0.4	3.6±0.6	4.0±0.4	KW	6.1
DW _{shoot}	4.2±0.8 ^d	3.2±0.8 ^{cd}	1.9±0.4 ^{bc}	1.6±0.3 ^{bc}	1.1±0.1 ^{ab}	0.7±0.1 ^a	KW	36.4***	1.6±0.3	2.8±0.7	2.4±0.5	2.0±0.3	KW	3.4
Dw _{root} /DW _{shoot}	1.6±0.2 ^a	2.2±0.3 ^{ab}	2.3±0.2 ^b	2.0±0.1 ^{ab}	2.4±0.2 ^{bc}	3.4±0.3 ^c	KW	23.2***	2.3±0.2	2.3±0.2	2.2±0.2	2.4±0.2	KW	1.1
Height	56.2±3.4 ^d	50.2±4.4 ^{cd}	46.3±2.9 ^{cd}	42.7±2.9 ^{bc}	32.3±1.7 ^{ab}	28.5±1.9 ^a	KW	37.0***	40.6±2.9	45.7±3.0	45.3±3.7	43.1±2.7	KW	1.6
Root length	38.6±2.5 ^c	38.0±2.2 ^c	33.6±2.7 ^{bc}	30.2±2.8 ^{bc}	23.9±2.7 ^{ab}	14.8±1.3 ^a	AOV	12.0***	28.5±2.3 ^{ab}	31.4±2.2 ^{ab}	27.6±2.7 ^a	37.7±2.8 ^b	AOV	4.6**
ET	2656±266 ^d	2336±282 ^{cd}	1769±192 ^{bc}	1683±128 ^{bc}	1373±82 ^{ab}	1078±41 ^a	KW	40.4***	1594±139	2093±220	1851±223	1962±152	KW	5.9

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36 FW = fresh weight; DW = dry weight; and ET = Evapotranspiration, all in g. Height and root length in cm. Plants were grown in four different ZnO sources:
37 micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50 nm diameter (NW). Each source was provided at
38 six concentrations (0, 0.1, 1, 10, 100, and 1000 mg l⁻¹) except NW (only up to 10 mg l⁻¹). Data represent means ±SE, where n = 4 and df= 5 for the ZnO
39 concentration factor and df = 3 for the source factor. Different letters indicate statistically significant groups according to either paired-t-tests with Bonferroni
40 correction (ANOVA, AOV) or Dunn's test with Benjamini-Hochberg correction (Kruskal-Wallis, KW). The F-value (AOV) or Chi-square value (KW) is
41 indicated as significant at $P < 0.05$ (*), $P < 0.01$ (**), or $P < 0.001$ ***).

Supplementary Table 8. Carbon and Nitrogen content and isotopic composition of plant samples.

		[ZnO] (mg l ⁻¹)						Source						value	
		0	0.1	1	10	100	1000	test	value	Bulk	NP100	NP50	NW		
C															
	root	42.1±0.2 ^a	43.4±0.2 ^b	44.1±0.9 ^{ab}	44.4±0.7 ^b	43.3±0.9 ^{ab}	44.3±0.7 ^b	K	13.1*	44.2±0.6	44.3±0.6	42.8±0.4	42.8±0.3	K	4.9
	shoot	43.2±0.2 ^{ab}	44.0±0.1 ^b	42.9±0.2 ^a	43.4±0.8 ^{ab}	41.8±1 ^a	42.5±0.6 ^a	K	14.5*	42.8±0.4	43.6±0.4	42.4±0.4	43.5±0.4	K	3.1
	root/shoot	0.98±0.01 ^a	0.99±0.005 ^{ab}	1.03±0.02 ^{bc}	1.03±0.02 ^{bc}	1.04±0.03 ^{bc}	1.05±0.03 ^c	K	13.0*	1.03±0.02	1.02±0.02	1.01±0.01	0.99±0.01	K	1.8
N															
	root	2.8±0.1 ^a	3.1±0.1 ^b	3.0±0.1 ^a	3.1±0.2 ^{ab}	2.7±0.1 ^a	2.8±0.2 ^a	K	1.5**	2.9±0.1	2.9±0.1	2.9±0.1	3.0±0.1	K	0.4
	shoot	3.3±0.1 ^a	3.7±0.1 ^b	3.6±0.1 ^b	3.7±0.2 ^b	3.8±0.2 ^b	4.1±0.2 ^b	K	23.5***	3.7±0.1	3.7±0.2	3.7±0.1	3.6±0.1	K	0.4
	root/shoot	0.85±0.02	0.83±0.02	0.83±0.03	0.85±0.06	0.74±0.06	0.71±0.07	K	7.4	0.81±0.03	0.82±0.05	0.78±0.03	0.83±0.03	K	2.1
C/N															
	root	15.3±0.3 ^{ab}	14.2±0.3 ^a	14.9±0.5 ^{ab}	15.2±0.9 ^{ab}	16.1±0.6 ^{ab}	16.8±1.0 ^b	K	13.2*	15.5±0.5	15.7±0.7	15.2±0.4	14.7±0.5	K	2.1
	shoot	13.2±0.3 ^c	11.9±0.2 ^b	11.8±0.2 ^b	12.0±0.5 ^b	11.2±0.7 ^{ab}	11.0±0.9 ^a	K	27.1***	11.9±0.4	12.1±0.5	11.6±0.4	12.2±0.3	K	1.3
δ ¹³ C															
	root	-28.0±0.1	-27.9±0.2	-27.7±0.1	-27.8±0.2	-27.6±0.2	-27.3±0.2	K	6.9	-27.9±0.1	-27.7±0.2	-27.7±0.1	-27.6±0.1	K	3.0
	shoot	-28.9±0.2 ^a	-29.3±0.2 ^a	-28.9±0.1 ^a	-29.0±0.2 ^a	-28.6±0.3 ^{ab}	-28.0±0.2 ^b	A	6.4***	-28.8±0.2	-28.8±0.2	-28.9±0.1	-28.8±0.2	A	0.2
	root/shoot	0.97±0.003	0.95±0.004	0.96±0.01	0.96±0.01	0.97±0.01	0.98±0.01	K	5.2	0.97±0.01	0.96±0.01	0.96±0.004	0.96±0.01	K	1.3
δ ¹⁵ N															
	root	-0.87±0.33	-0.66±0.29	-0.21±0.37	-0.36±0.31	-0.48±0.40	0.13±0.18	A	6.5	-0.24±0.27	-0.56±0.26	-0.53±0.26	-0.34±0.28	A	1.5
	shoot	0.35±0.20	0.46±0.21	0.34±0.26	0.39±0.19	0.62±0.39	1.06±0.2	A	2.2	0.61±0.18	0.12±0.24	0.68±0.17	0.68±0.14	A	2.5
	root/shoot	3.41±1.9	0.56±2.4	-3.74±3.0	0.38±1.5	-0.21±0.4	0.39±0.3	K	3.8	-0.7±2.03	0.92±1.33	0.75±1.11	-0.7±2.59	K	2.4

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43 Plants were grown in four different ZnO sources: non-nano (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50 nm
44 diameter (NW). Each source was provided at six concentrations (0, 0.1, 1, 10, 100, and 1000 mg l⁻¹) except NW (only up to 10 mg l⁻¹). Data represent means
45 $\pm$ SE, where n = 4 and df = 5 for the ZnO concentration factor and df = 3 for the source factor. Concentration data are expressed in mg l⁻¹ for the growth
46 solutions, in % for the C and N content of plant samples, and in ‰ for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ of plant samples. Different letters indicate statistically significant groups
47 according to either paired-t-tests with Bonferroni correction (ANOVA, A) or Dunn's test with Benjamini-Hochberg correction (Kruskal-Wallis, K). The F-
48 value (ANOVA) or Chi-square value (Kruskal-Wallis) is indicated as significant at $P < 0.05$ (*), $P < 0.01$ (**), or $P < 0.001$ (***)).

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Supplementary Table 9. Photosynthetic performance

	[ZnO] (mg l ⁻¹)						value	test
	0	0.1	1	10	100	1000		
SPAD	40.3±1.6 ^{bc}	43.8±1.3 ^c	42.2±1.6 ^c	38.4±1.4 ^{bc}	34.0±2.3 ^{ab}	30.8±1.1 ^a	35.9***	KW
Fv/Fm	0.77±0.007 ^b	0.77±0.007 ^b	0.77±0.008 ^b	0.76±0.01 ^b	0.73±0.012 ^a	0.72±0.01 ^a	19.1**	KW
ΦPSII	0.21±0.019 ^d	0.22±0.017 ^d	0.19±0.014 ^{cd}	0.14±0.017 ^{bc}	0.10±0.022 ^{ab}	0.04±0.016 ^a	11.7***	ANOVA
qP	0.48±0.033 ^c	0.47±0.026 ^c	0.46±0.025 ^{bc}	0.36±0.037 ^{abc}	0.29±0.052 ^{ab}	0.13±0.068 ^a	27.1***	KW
ETR	107404±9611 ^{cd}	109922±8578 ^d	97758±7282 ^{cd}	71174±8749 ^{bc}	51170±11389 ^{ab}	21403±8172 ^a	11.7***	ANOVA
qN	361±194 ^a	430±195 ^a	469±208 ^{ab}	404±211 ^{ab}	401±263 ^b	205±204 ^b	13.8*	KW
NPQ	894±343 ^a	1083±347 ^a	1681±462 ^{ab}	1257±502 ^{ab}	3130±1196 ^b	3890±997 ^b	16.6**	KW
Fv'/Fm'	2.1±0.06	2.1±0.07	2.3±0.15	2.5±0.23	2.3±0.09	2.5±0.21	9.7	KW
ΦCO ₂	0.016±0.002 ^{bc}	0.018±0.002 ^c	0.015±0.001 ^{bc}	0.01±0.001 ^{ab}	0.008±0.002 ^a	0.004±0.001 ^a	25.8***	KW
A	15.1±2.0b ^c	17.1±2.1 ^c	14.7±1.4 ^{bc}	9.0±1.5 ^{ab}	7.3±1.7 ^a	3.1±0.6 ^a	26.1***	KW
g _s	0.18±0.026 ^{bc}	0.22±0.033 ^c	0.2±0.026 ^{bc}	0.11±0.025 ^{abc}	0.08±0.019 ^{ab}	0.04±0.006 ^a	27.8***	KW
E	4.3±0.58 ^{bc}	4.8±0.61 ^c	5.2±0.51 ^{bc}	2.9±0.53 ^{ab}	1.9±0.42 ^a	1.2±0.16 ^a	29.2***	KW
VPD	2.5±0.08 ^{ab}	2.4±0.1 ^a	2.8±0.12 ^{ab}	2.8±0.16 ^{ab}	2.4±0.09 ^{ab}	3.0±0.18 ^b	4.4**	ANOVA

	Source				value	test
	Bulk	NP100	NP50	NW		
SPAD	38.3±1.6	39.7±1.2	37.1±1.6	40.0±1.9	1.3	KW
Fv/Fm	0.75±0.008 ^a	0.77±0.006 ^{ab}	0.75±0.008 ^a	0.78±0.008 ^b	8.4*	KW
ΦPSII	0.13±0.014 ^a	0.20±0.018 ^c	0.15±0.021 ^{ab}	0.19±0.019 ^{bc}	5.5**	ANOVA
qP	0.35±0.027 ^a	0.47±0.036 ^b	0.36±0.044 ^{ab}	0.44±0.034 ^{ab}	10.6*	KW
ETR	68288±7376 ^a	102297±9244 ^c	78128±10905 ^{ab}	98936±9789 ^{bc}	5.5**	ANOVA

qN	225±122	613±193	457±182	240±163	3.9	KW
NPQ	2392±586	1000±405	1714±460	1590±427	4.1	KW
Fv'/Fm'	2.3±0.06	2.3±0.14	2.2±0.11	2.3±0.17	2.9	KW
ΦCO ₂	0.010±0.002 ^a	0.015±0.002 ^b	0.013±0.002 ^{ab}	0.015±0.002 ^b	8.0*	KW
A	9.4±1.7	14.6±1.6	12.1±1.9	14.2±1.9	7.8	KW
g _s	0.12±0.023	0.19±0.025	0.14±0.024	0.19±0.034	6.4	ANOVA
E	2.9±0.42	4.3±0.52	3.6±0.59	4.6±0.62	5.8	KW
VPD	2.7±0.11	2.4±0.1	2.7±0.08	2.7±0.15	1.7	ANOVA

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57 Plants were grown in four different ZnO sources: micron-size (Bulk), nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50
58 nm diameter (NW). Each source was provided at six concentrations (0, 0.1, 1, 10, 100, and 1000 mg l⁻¹) except NW (only up to 10 mg l⁻¹). Data represent
59 means ±SE, where n = 4 and df= 5 for the ZnO concentration factor and df = 3 for the source factor. Variables SPAD, Fv/Fm, ΦPSII, qP, qN, NPQ, Fv'/Fm',
60 and ΦCO₂ are dimensionless. Electron transmission rate (ETR) is expressed in mol m⁻² s⁻¹, net photosynthetic rate (A) in μmol CO₂ m⁻² s⁻¹, stomatal
61 conductance (gs) in mol H₂O m⁻² s⁻¹, transpiration (E) in mmol H₂O m⁻² s⁻¹, and vapour pressure deficit of the leaf (VPD) in kPa. Different letters indicate
62 statistically significant groups according to either paired-t-tests with Bonferroni correction (ANOVA) or Dunn's test with Benjamini-Hochberg correction
63 (Kruskal-Wallis, KW). The F-value (ANOVA) or Chi-square value (KW) is indicated as significant at *P* <0.05 (*), *P* <0.01 (**), or *P* <0.001(***)

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Supplementary Table 10. Element content in plant tissues.

	[ZnO] (mg l ⁻¹)						value	test	Source				value	test
	0	0.1	1	10	100	1000			Bulk	NP100	NP50	NW		
Root														
[Ca]	9.8±1.0	10.0±0.7	10.4±0.6	9.1±0.9	8.2±1.4	8.4±0.9	8	KW	9.8±0.8	8.4±0.7	10.1±0.6	9.3±0.7	3	KW
[Cu]	22.1±2.3	23.6±2.2	25.6±1.3	25.6±1.6	21.2±1.7	20.2±1.3	9	KW	25.8±1.7	21.2±1.3	21.9±1.3	24.5±1.5	6	KW
[K]	17.5±1.1 ^c	16.6±1.1 ^{bc}	15.2±0.8 ^{bc}	15.2±1.2 ^{bc}	12.3±0.7 ^{ab}	10.3±0.7 ^a	7***	AV	14.8±1.0	15.5±0.9	13.7±0.9	15.3±0.9	1	AV
[Fe]	354±28 ^a	395±34 ^{ab}	526±65 ^{abc}	583±90 ^{bc}	395±32 ^{abc}	705±134 ^c	17**	KW	598±89	464±62	460±36	423±31	2	KW
[Mg]	1.1±0.1 ^{ab}	1.1±0.05 ^{ab}	1.3±0.1 ^b	1.3±0.1 ^{ab}	1.1±0.1 ^{ab}	1.1±0.1 ^a	14*	KW	1.3±0.1	1.1±0.1	1.2±0.1	1.3±0.1	5	KW
[Mn]	30.3±3.4 ^a	32.4±3.8 ^a	41.1±4.8 ^{ab}	43.8±5.9 ^{ab}	44.3±8.2 ^{ab}	54.1±4.9 ^b	15*	KW	40.5±3.7	33.8±3.5	49.9±5.4	34.7±2.9	6	KW
[P]	6.5±0.3 ^b	8.2±0.3 ^c	8.0±0.2 ^c	7.0±0.3 ^{bc}	6.2±0.6 ^{ab}	4.9±0.3 ^a	15***	AV	6.9±0.3	6.4±0.4	7.1±0.3	7.3±0.3	2	AV
[S]	3.3±0.1	2.9±0.1	3.1±0.1	3.0±0.1	2.9±0.1	2.8±0.2	10	KW	3.1±0.1	3.0±0.1	2.9±0.1	3.0±0.1	1	KW
Shoot														
[Ca]	6.5±0.9	6.5±0.7	6.0±0.4	7.1±0.5	7.9±0.7	7.1±0.7	8	KW	7.4±0.7	6.4±0.4	6.5±0.4	6.9±0.7	1	KW
[Cu]	12.5±1.0 ^b	17.6±1.5 ^c	15.8±0.7 ^c	13±0.9 ^{bc}	10.3±0.5 ^{ab}	8.8±0.7 ^a	42***	KW	13.9±1.0	13.1±1.3	11.9±0.6	15.1±1.0	7	KW
[K]	32.5±1.2 ^a	32.4±0.9 ^a	32.6±0.9 ^a	36.0±0.9 ^b	37.2±1.8 ^b	32.4±1.5 ^a	3*	AV	33.5±0.9	34.7±1.1	33.8±0.9	32.2±1.2	1	AV
[Fe]	98.7±12.9	89.5±7.1	91.4±5.0	102.1±12.1	68.4±5.2	92.1±9.7	9	KW	96.7±9.7	83.1±6.3	87.1±5.6	102.1±9.7	3	KW
[Mg]	1.7±0.1	1.7±0.1	1.6±0.1	1.6±0.1	1.8±0.1	1.6±0.1	1	KW	1.7±0.1	1.7±0.1	1.6±0.1	1.7±0.1	0	KW
[Mn]	101.2±12.7 ^b	112.9±16.2 ^b	109.9±11.3 ^b	54.7±3.2 ^a	35.2±3.3 ^a	34.3±3.3 ^a	50***	KW	79.1±10.3 ^{ab}	61.5±8.3 ^a	69.7±9.0 ^a	117.8±16.3 ^b	12**	KW
[P]	3.2±0.3 ^a	3.0±0.1 ^a	3.3±0.1 ^{ab}	4.3±0.3 ^c	4.3±0.2 ^c	3.7±0.2 ^{bc}	37***	KW	3.8±0.2	3.5±0.2	3.7±0.2	3.4±0.2	2	KW
[S]	7.6±0.4 ^a	8.3±0.4 ^{ab}	8.4±0.3 ^{ab}	9.7±0.5 ^b	10.1±0.7 ^b	7.3±0.5 ^a	27***	KW	8.8±0.4	8.5±0.4	8.2±0.4	8.5±0.4	1	KW

67 Concentrations are provided in mg g^{-1} except for Cu, Fe, and Mn in roots (in $\mu\text{g g}^{-1}$). Plants were grown in four different ZnO sources: micron-size (Bulk),
68 nanoparticles < 100 nm (NP100), nanoparticles < 50 nm (NP50), and nanowires of 50 nm diameter (NW). Each source was provided at six concentrations (0,
69 0.1, 1, 10, 100, and 1000 mg l^{-1}) except NW (only up to 10 mg l^{-1}). Data represent means $\pm\text{SE}$, where $n = 4$ and $\text{df} = 5$ for the ZnO concentration factor and df
70 $= 3$ for the source factor. Different letters indicate statistically significant groups according to either paired-t-tests with Bonferroni correction (ANOVA) or
71 Dunn's test with Benjamini-Hochberg correction (Kruskal-Wallis, KW). The F-value (ANOVA) or Chi-square value (KW) is indicated as significant at $P <$
72 0.05 (*), $P < 0.01$ (**), or $P < 0.001$ (***)).

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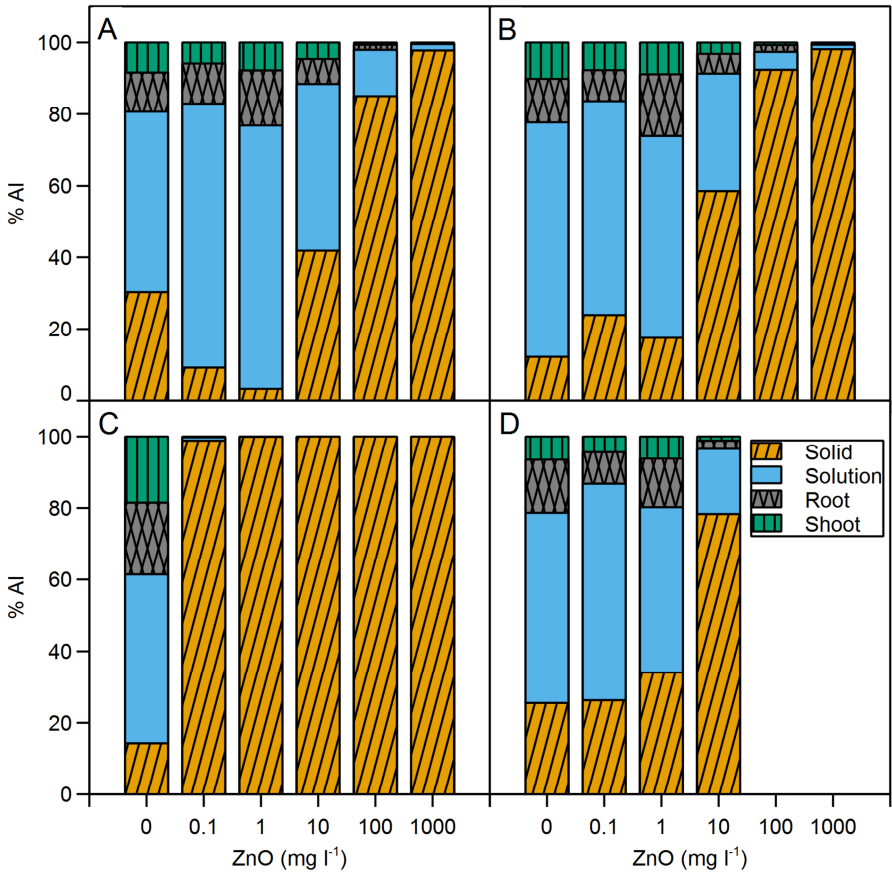
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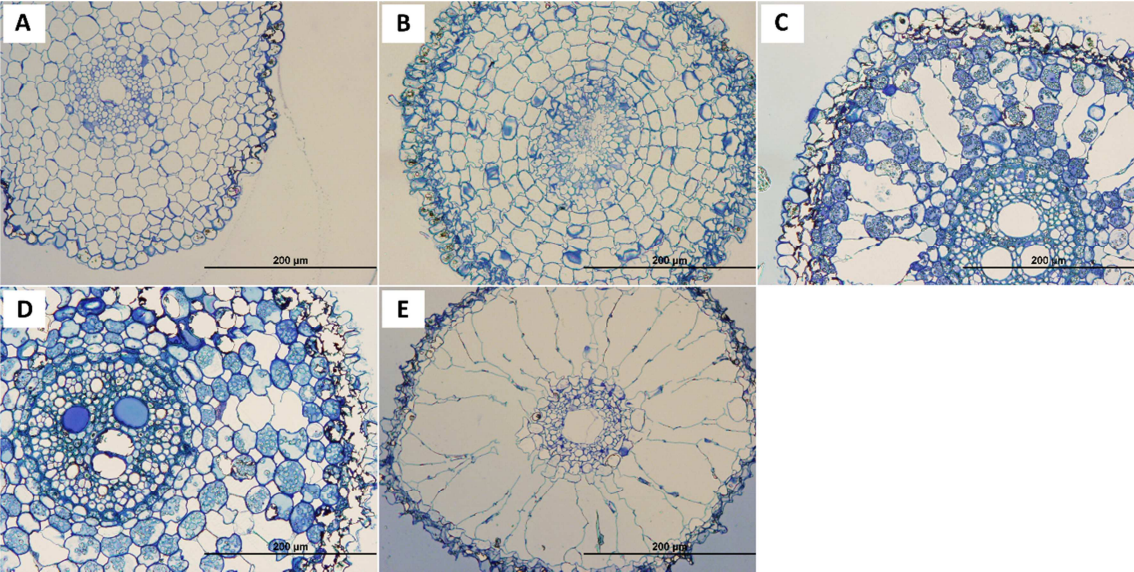
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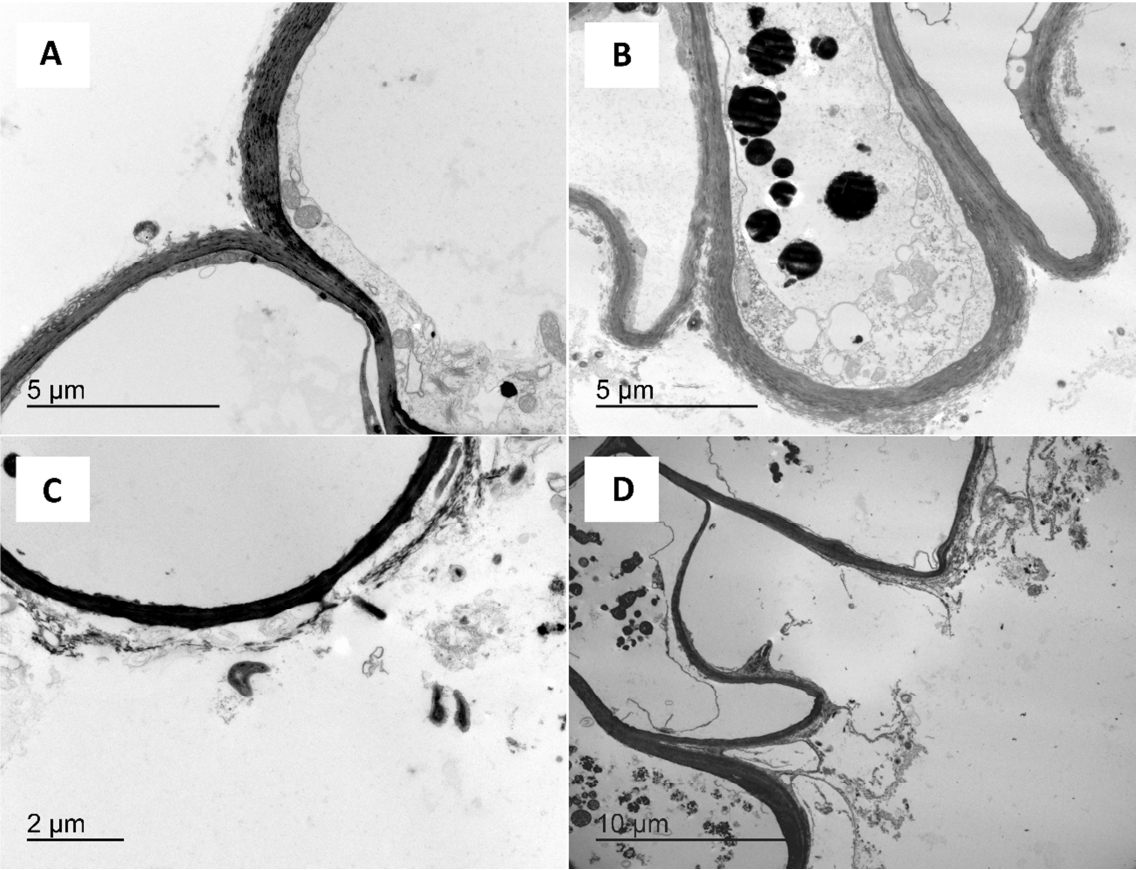
Supplementary Fig. 1. Distribution of Al across the different pools. Plants were treated with four different ZnO sources: A) micron-size (Bulk), B) NP < 100 nm (NP100), C) NP < 50 nm (NP50), and D) nanowires of 50 nm diameter (NW). Data represent means, where n = 4, expressed as Al % relative to the total Al incorporated to the system from the nutritive solution and ZnO treatments.



Supplementary Fig. 2. Light microscopy images of cross 1 μm sections of the root. A) Control; B) Bulk, 1000 mg l^{-1} ZnO; C) NP100, 1000 mg l^{-1} ZnO; D) NP50, 1000 mg l^{-1} ZnO; E) NW, 10 mg l^{-1} ZnO.



Supplementary Fig. 3. Transmission electron microscopy images of the root epidermis. A) Control; B) Bulk, 1000 mg l⁻¹ ZnO; C) NP100, 1000 mg l⁻¹ ZnO; D) NP50, 1000 mg l⁻¹ ZnO.



Supplementary Fig. 4. Transmission electron microscopy images of the root cortex. A) Control;
B) Bulk, 1000 mg l⁻¹ ZnO; C) NP100, 1000 mg l⁻¹ ZnO; D) NP50, 1000 mg l⁻¹ ZnO.

