Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supplementary Information

Plant Species Dependant Transformation and Translocation of Ceria Nanoparticles

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FIGURES AND TABLES

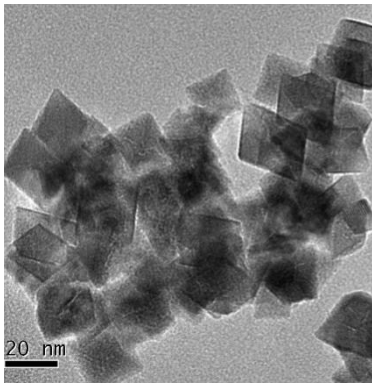

Figure S1. TEM image of $nCeO_2$. Size averaged from 100 particles in the TEM images is 25 ± 4 nm, and shape is octahedral.

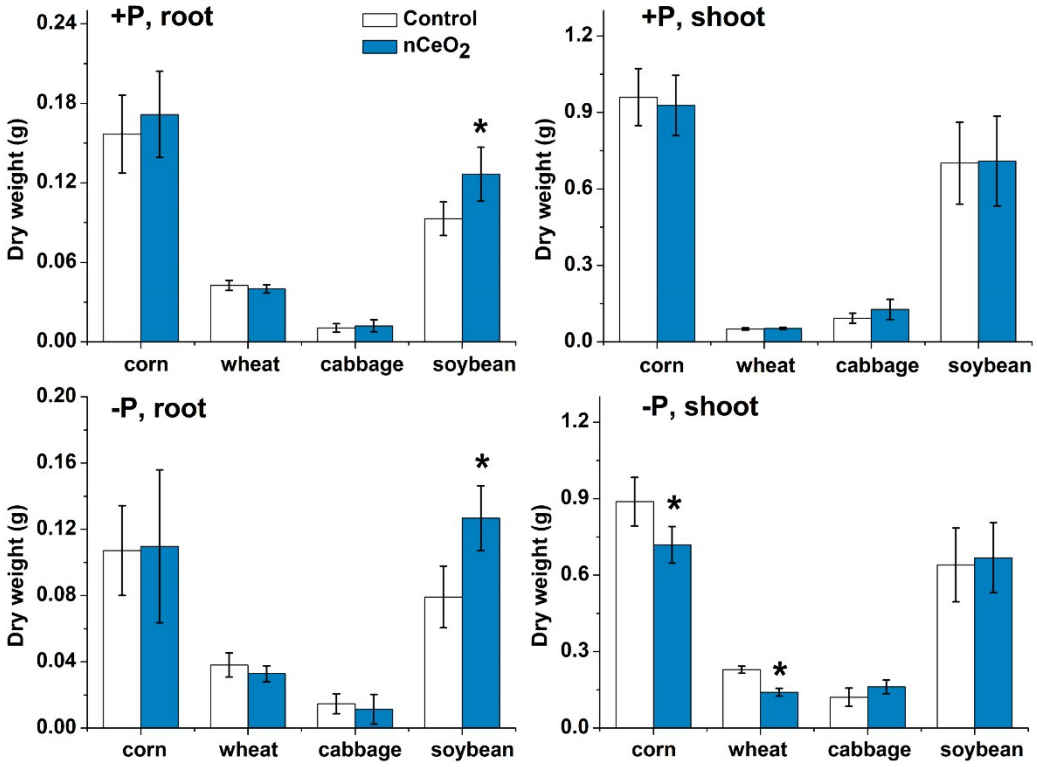

Figure S2. Dry weight of the plants treated with 2000 mg/L $nCeO_2$ in hydroponic solution. * indicates significant difference between control and $nCeO_2$ treatment. Data are expressed as mean ± SD (n = 8). * indicates significant difference between +P and –P treatment ($p < 0.05$).

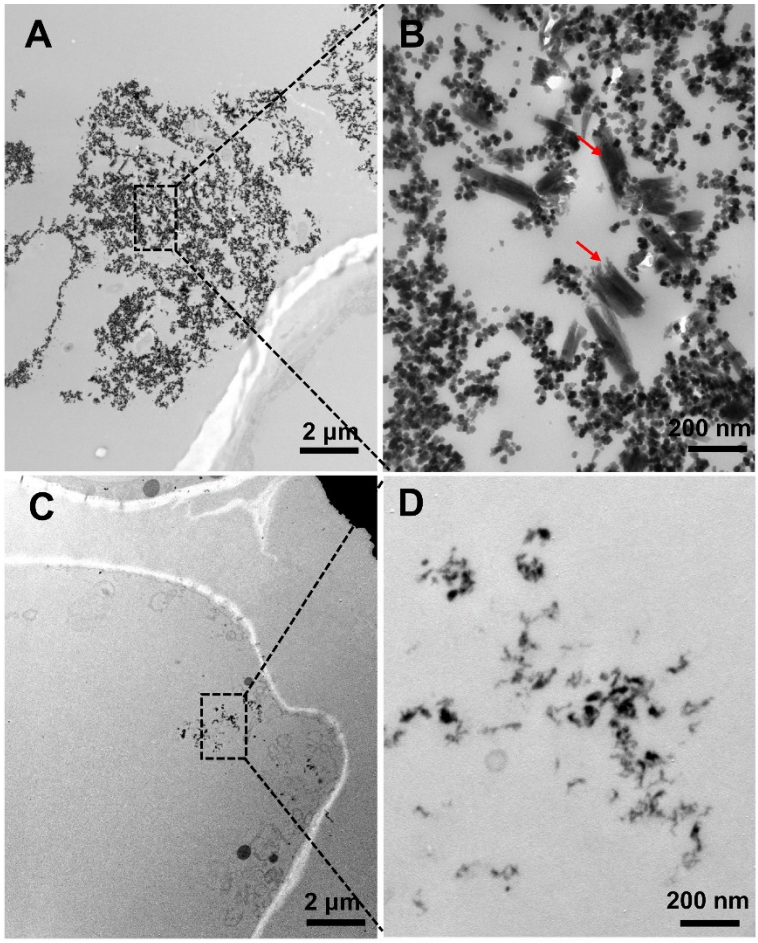

Figure S3. TEM images of corn roots. (A) and (B) show the root surface, (C) and (D) show the inside of a single cell. (B) and (D) are magnifications of the areas highlighted in the rectangles in (A) and (C).

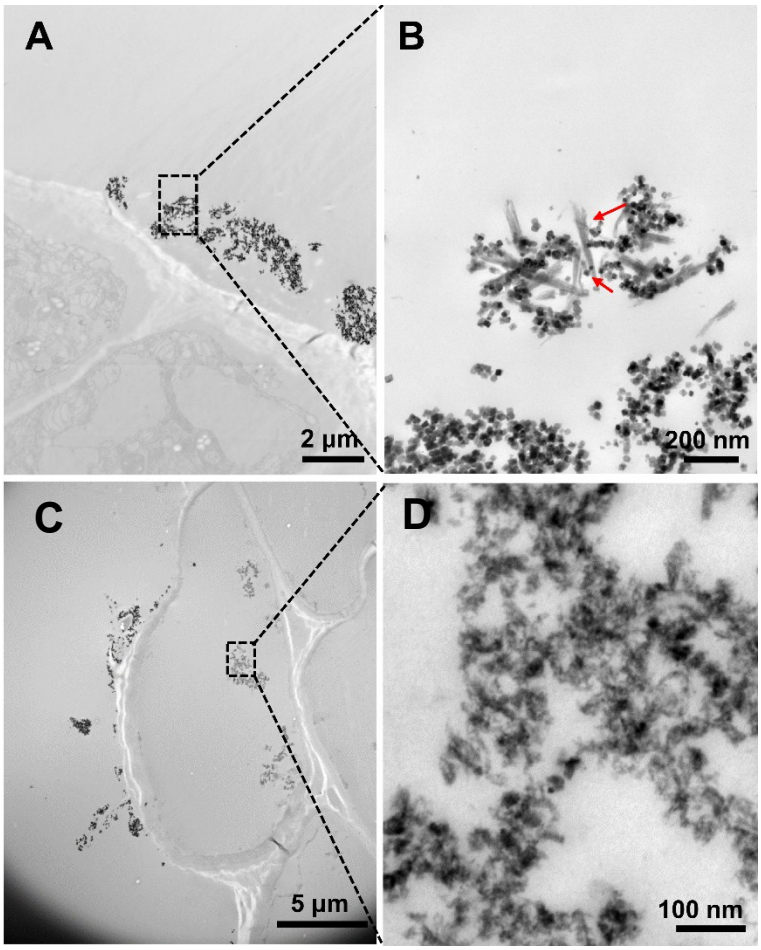

Figure S4. TEM images of wheat roots. (A) and (B) show the root surface, (C) and (D) show the inside of a single cell. (B) and (D) are magnifications of the areas highlighted in the rectangles in (A) and (C).

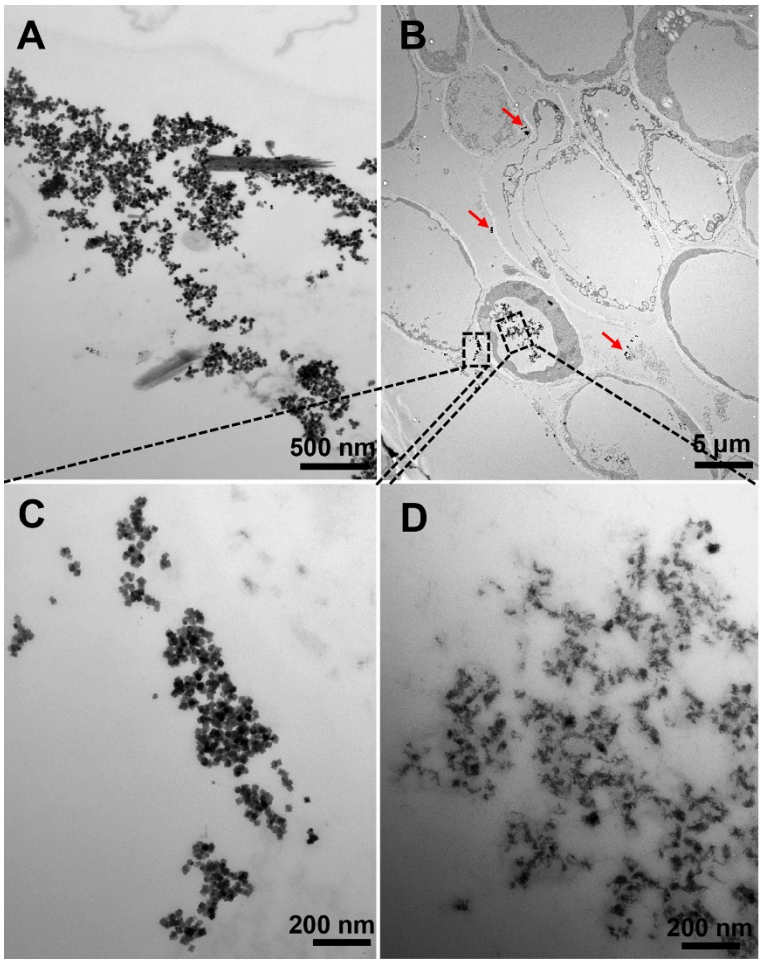

Figure S5. TEM images of soybean roots. (A) shows the root surface, (B) shows a low magnification image of the root section, (C) and (D) are magnifications of the areas highlighted in the rectangles in (B). Arrows in (B) indicate the $nCeO_2$ aggregates.

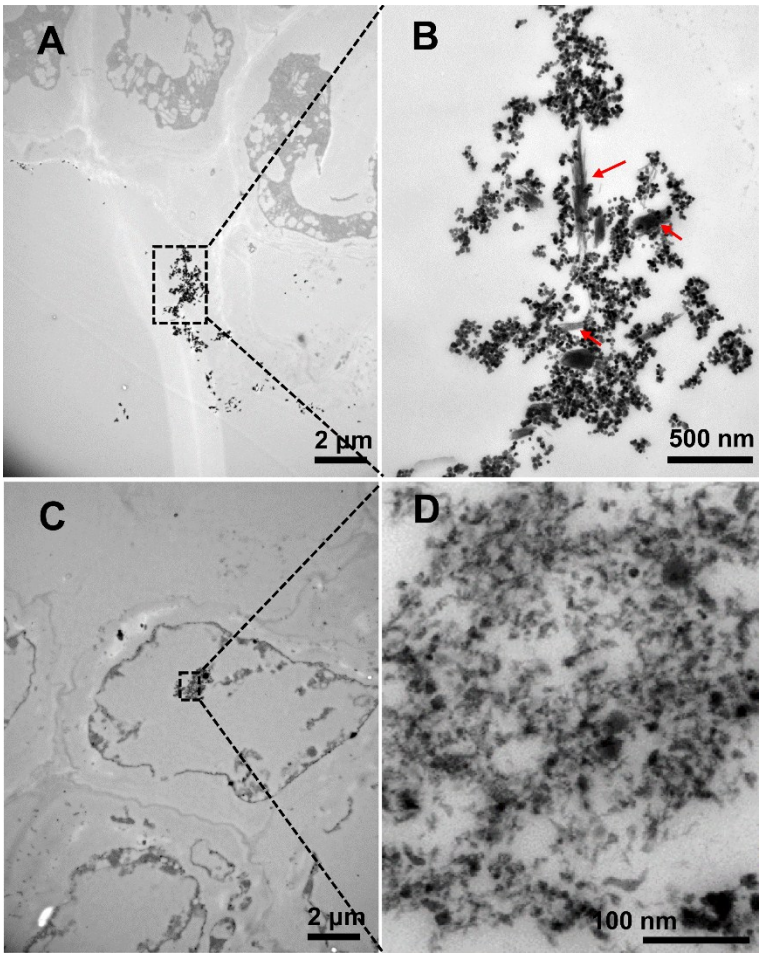

Figure S6. TEM images of cabbage roots. (A) and (B) show the root surface, (C) and (D) show the inside of a single cell. (B) and (D) are magnifications of the areas highlighted in the rectangles in (A) and (C). Arrows in (B) indicate the rod like particles.

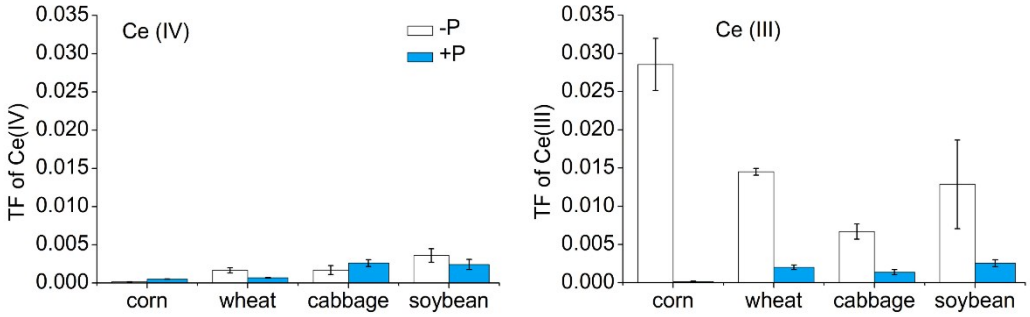

Figure S7. Translocation factors of Ce(IV) and Ce(III) in different plant species.

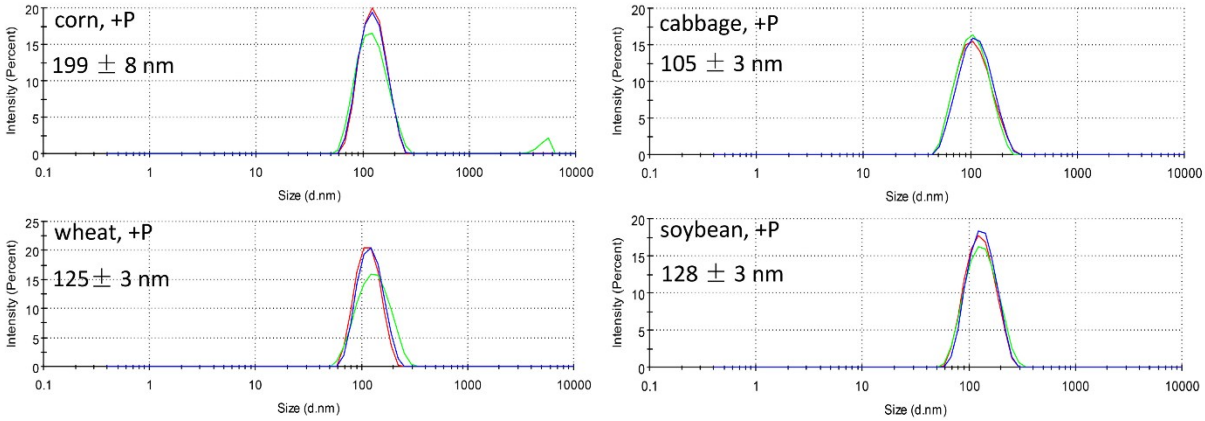

Figure S8. Size distributions of $nCeO_2$ (100 mg/L) in root exudates extracted from plants cultured in the +P condition.

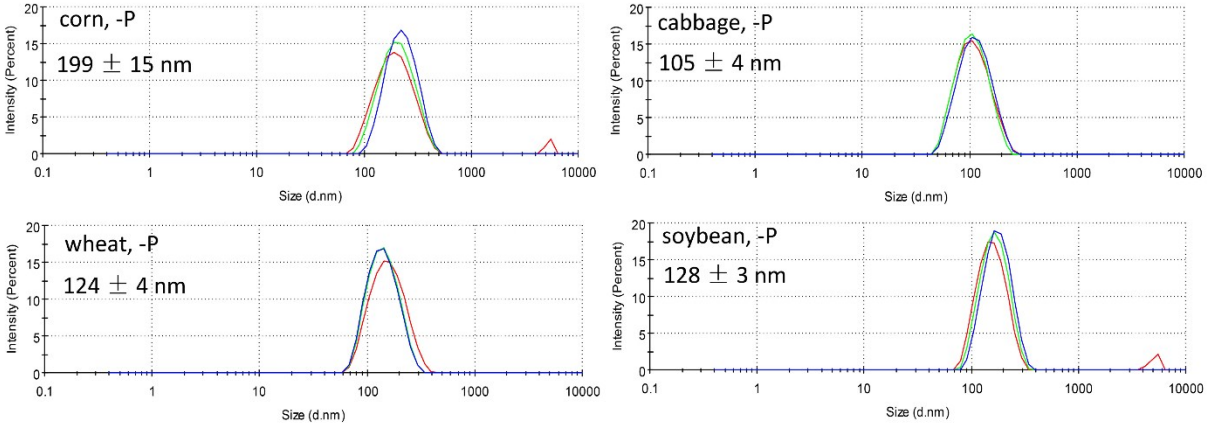

Figure S9. Size distributions of $nCeO_2$ in root exudates extracted from plants cultured in the -P condition.

Table S1. Hydrodynamic sizes and Zeta potential of $nCeO_2$ (100 mg/L) in deionized water (ddH_2O) and nutrient solutions (NS).

	Hydrodynamic sizes	Zeta potentials (mV)
dd H_2O	135 ± 24	30.6 ± 5.1
+P NS	1578 ± 240	-8.9 ± 4.0
–P NS	1367± 198	-7.1 ± 3.2

Table S2. Fraction of Ce species in roots and fitting parameters from LCF analysis.

Root (%)	CeO_2	$Ce(CH_3COO)_3$	$Ce_2(C_2O_4)_3$	$CePO_4$	R-factor	Chi-square
+P-corn	82		2.4	15.6	0.000040	0.00656
-P-corn	92.4		5.3	2.3	0.000785	0.01326
+P-wheat	91.2		2.3	6.5	0.000428	0.06281
-P-wheat	85.1		10.8	4.1	0.004597	0.00114
+P-cabbage	82.1		5.5	12.4	0.000333	0.05219
-P-cabbage	74.1		19.5	6.4	0.000117	0.01780
+P-soybean	92.2		0.7	7.1	0.000123	0.02181
-P-soybean	83.2		11.7	5.1	0.000152	0.02343

Table S3. Fraction of Ce species in shoots and fitting parameters from LCF analysis.

Shoot (%)	CeO_2	$Ce(CH_3COO)_3$	$Ce_2(C_2O_4)_3$	$CePO_4$	R-factor	Chi-square
+P-corn	94.7	0.9	4.4		0.00271	0.0305
-P-corn	6.7		93.3		0.00151	0.0206
+P-wheat	78.2		21.6		0.00212	0.0281
-P-wheat	39.5		60.5		0.00110	0.0140
+P-cabbage	89.7	0.8	9.5		0.00007	0.0008
-P-cabbage	42.1		57.9		0.00176	0.0219
+P-soybean	91.8		8.2		0.00213	0.0281
-P-soybean	58.1		43.3		0.00250	0.0343

Table S4. Contents of Ce(IV) and Ce(III) species (mg/kg) in shoots and roots of plants calculated

by multiplying the percentage of the Ce(IV) or Ce(III) species by the total Ce contents.

		Ce(IV)		Ce(III)	
		-P	+P	-P	+P
shoot	corn	10.61	5.27	147.74	0.29
	wheat	55.43	21.83	84.89	6.09
	cabbage	73.47	67.69	101.03	7.77
	soybean	104.96	70.46	75.69	6.29
root	corn	62918.28	10249.75	5175.097	2249.945
	wheat	33418.26	31301.83	5851.14	3020.352
	cabbage	43211.62	25794.26	15103.66	5623.84
	soybean	29122.64	29068.46	5880.533	2459.154

Table S5. Zeta potential of nCeO2 (100 mg/L) in root exudates extracted from plants cultured in the +P and –P conditions.

	Corn	Wheat	Cabbage	Soybean
+P	-16.1 ± 2.2	-15.5 ± 2.5	-21.4 ± 4	-18.7 ± 1
-P	-18.6 ± 2.1	-12.9 ± 1.2	-20.4 ± 5	-19.1 ± 2