

## Supplementary material

Uranium-tolerant soil bacteria protect *Arabidopsis thaliana* seedling growth from uranium toxicity

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**Figure S1.** Effect of U-tolerant soil bacteria on *Arabidopsis* seed germination and seedling development in the presence of U.

**Figure S2.** Distribution of U between bacteria (*Microbacterium* sp. ViU2A or *Stenotrophomonas bentonitica* BII-R7T) and the medium in the absence of *Arabidopsis* seeds.

**Figure S3.** Effect of bacteria on *Arabidopsis* root growth at low U concentrations (<20  $\mu$ M).

**Figure S4.** Distribution of U between *Arabidopsis* seedlings, bacteria (*Microbacterium* sp. ViU2A, *Stenotrophomonas bentonitica* or *E. coli*) and medium.

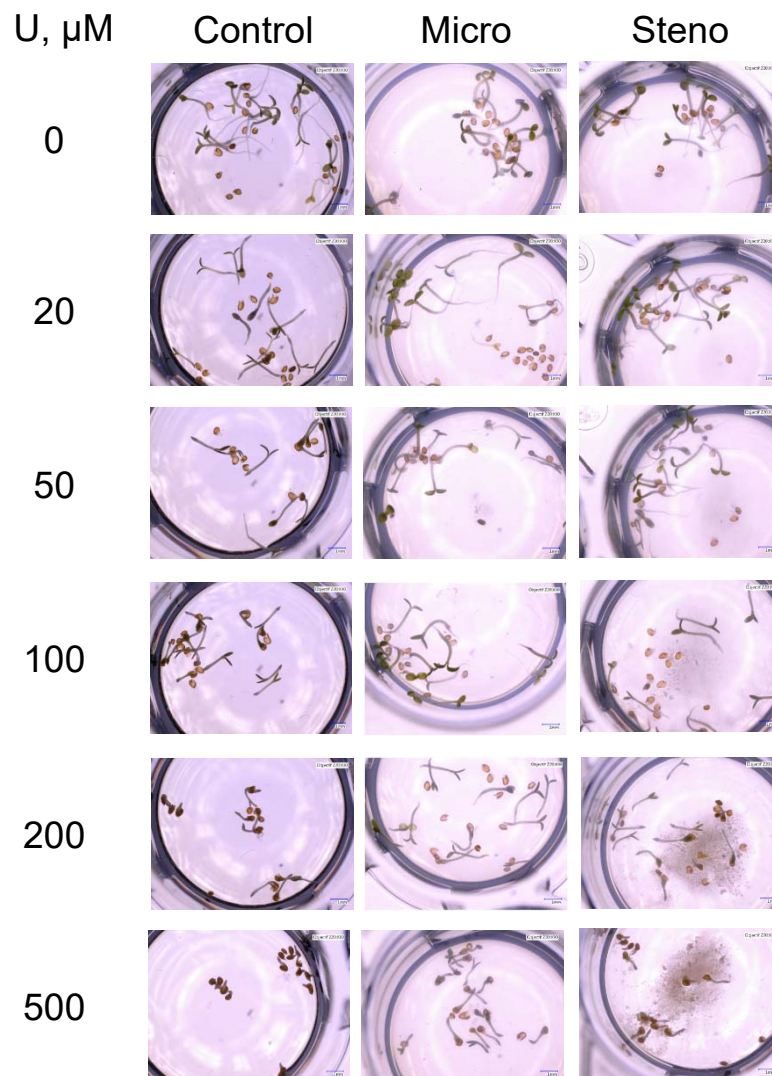
**Figure S5:** Analysis of bacterial cell viability after exposure to U.

**Figure S6.** Protection of *Arabidopsis* seedlings from U toxicity by living and dead *Microbacterium* sp. ViU2A.

**Figure S7.** Protection of *Arabidopsis* seedlings from U toxicity by living or dead *Stenotrophomonas bentonitica*.

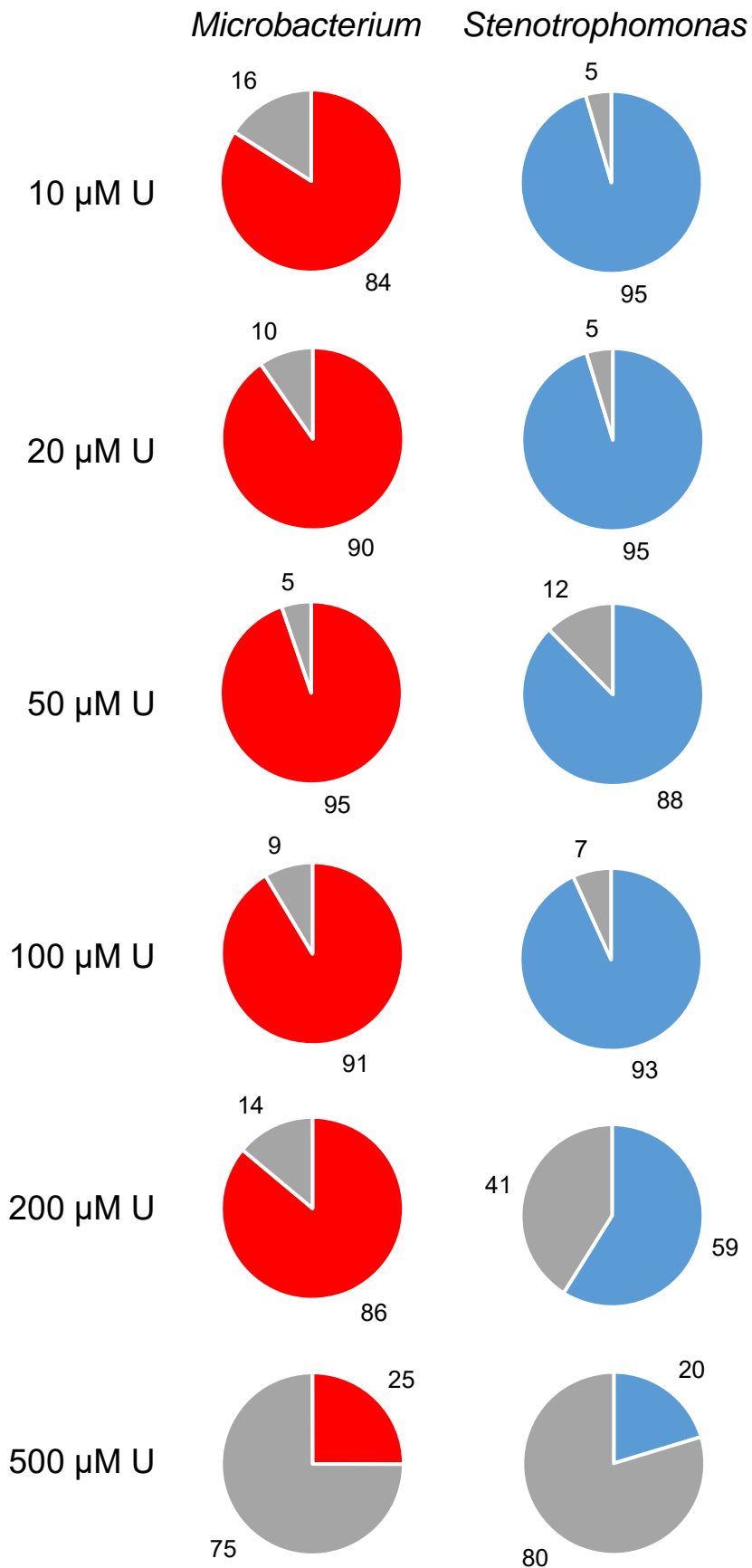
**Table S1:** Prediction of U species distribution in the incubation medium.

**Supplementary data 1\_Statistical analyses** (Excel file)

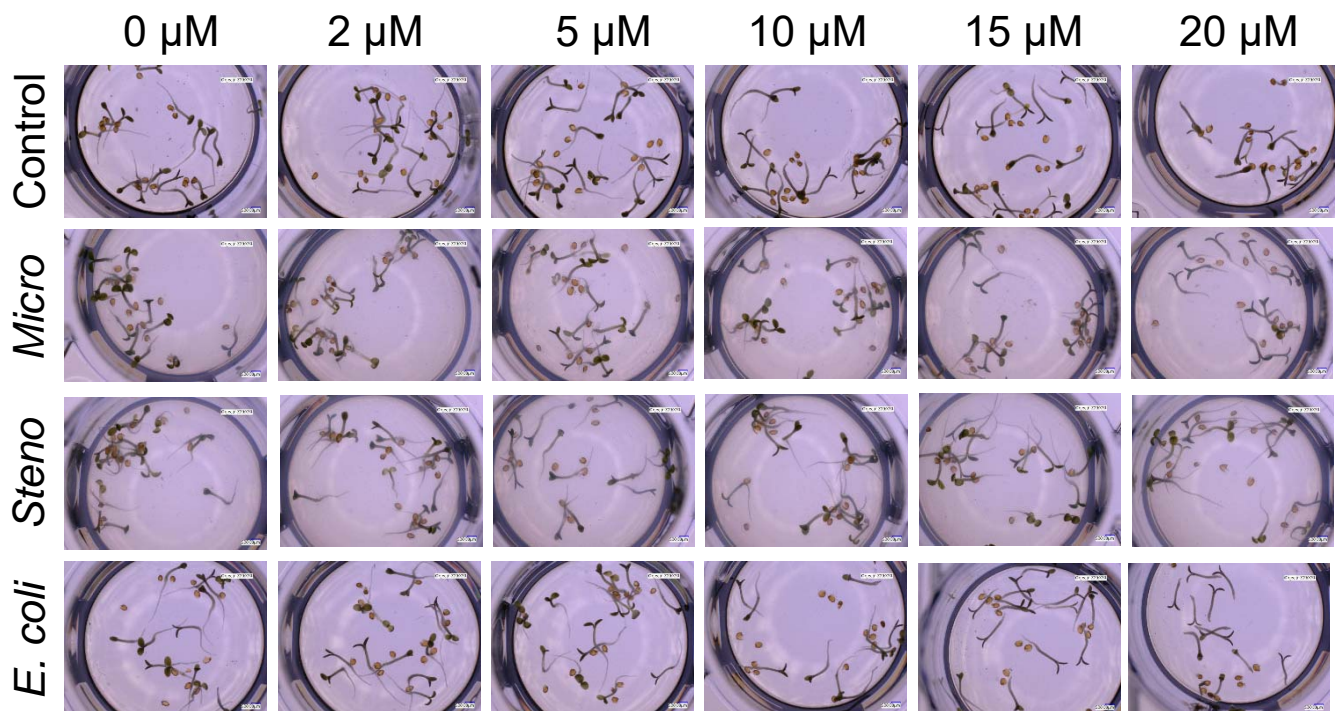


**Figure S1. Effect of U-tolerant soil bacteria on Arabidopsis seed germination and seedling development in the presence of U.**

Arabidopsis seeds (15 seeds/well) were incubated for four days in the presence of different concentrations of uranyl nitrate, in the presence or absence of bacteria, and visualized with a Keyence VHX digital microscope (scale bar 1 mm). Control: in the absence of bacteria; *Micro*: in the presence of *Microbacterium* sp. ViU2A; *Steno*: in the presence of *S. bentonitica*. Bacteria were inoculated at a concentration of  $4\text{-}6 \times 10^7$  CFU/ml.

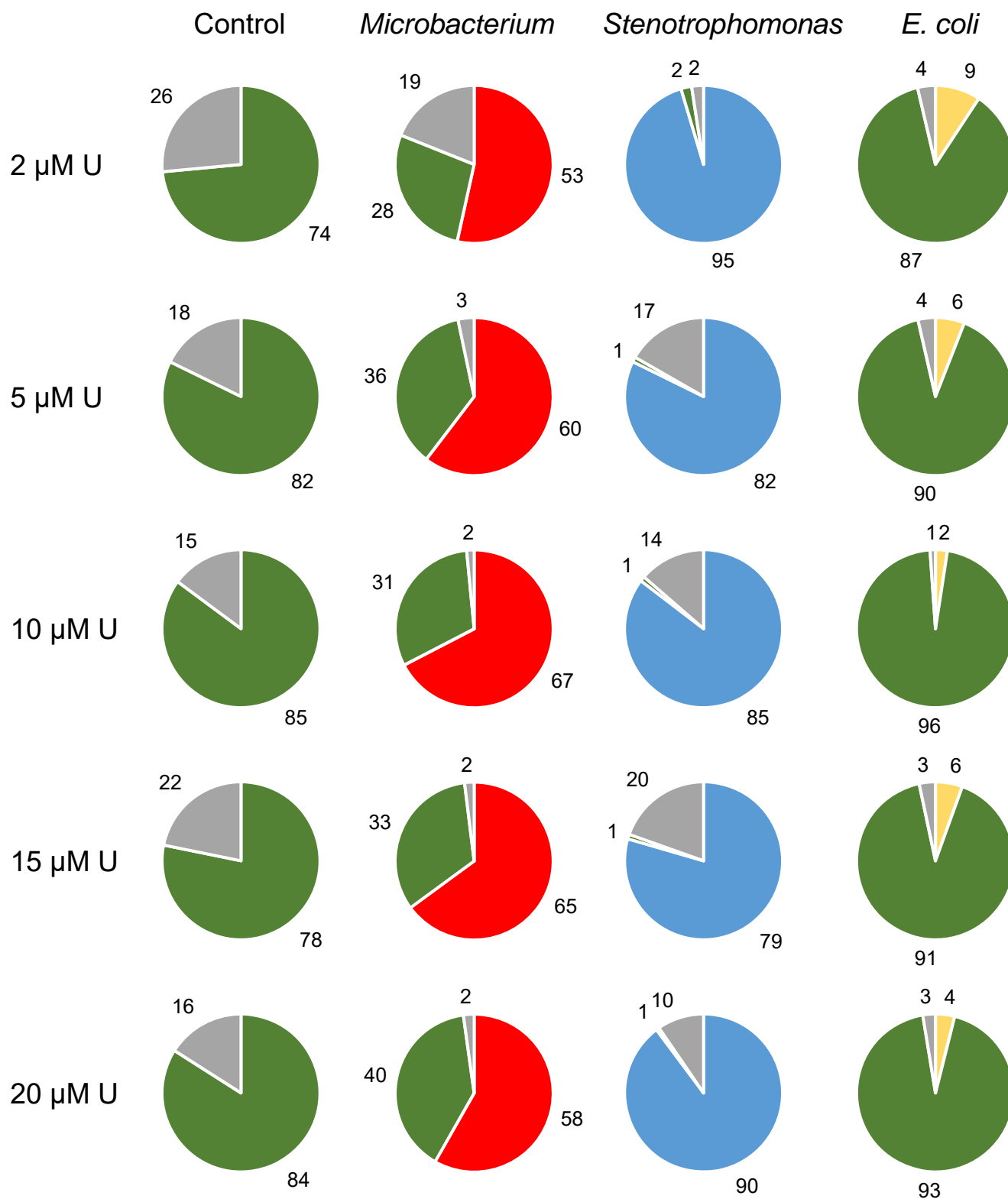


**Figure S2. Distribution of U between bacteria (*Microbacterium* sp. ViU2A or *Stenotrophomonas bentonitica* BII-R7T) and the medium in the absence of *Arabidopsis* seeds.** *Microbacterium* sp. ViU2A and *S. bentonitica* ( $4-6 \times 10^7$  PFU/ml) were incubated for 4 days in the presence of different concentrations of uranyl nitrate (from 0 to 500  $\mu\text{M}$ ) as in Fig. 2. Pie charts show the distribution of U between *Microbacterium* sp. ViU2A (red) and medium (grey), and between *S. bentonitica* (blue) and medium (grey). Numbers represent the % of U present in the fraction.

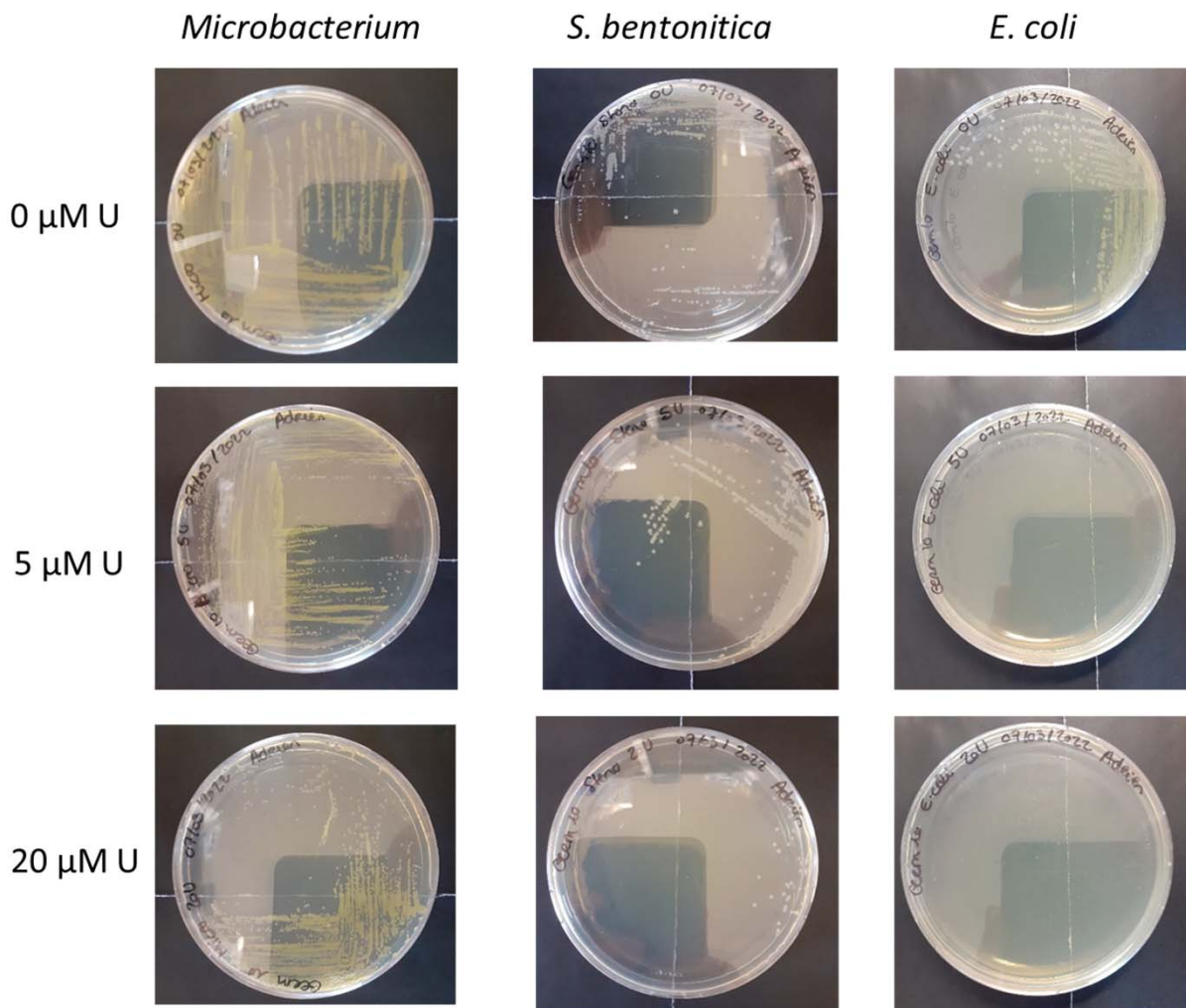


**Figure S3. Effect of bacteria on Arabidopsis root growth at low U concentrations (<20  $\mu\text{M}$ ).**

Arabidopsis seeds were incubated for four days in the presence of different concentrations of uranyl nitrate, in the presence or absence of bacteria, and visualized with a Keyence VHX digital microscope (scale bar 0.5 mm). Control: in the absence of bacteria; *Micro*: in the presence of *Microbacterium* sp. ViU2A; *Steno*: in the presence of *S. bentonitica*, *E. coli*: in the presence of *E. coli*. Bacteria were inoculated at a concentration of  $4\text{-}6 \times 10^7$  CFU/ml.

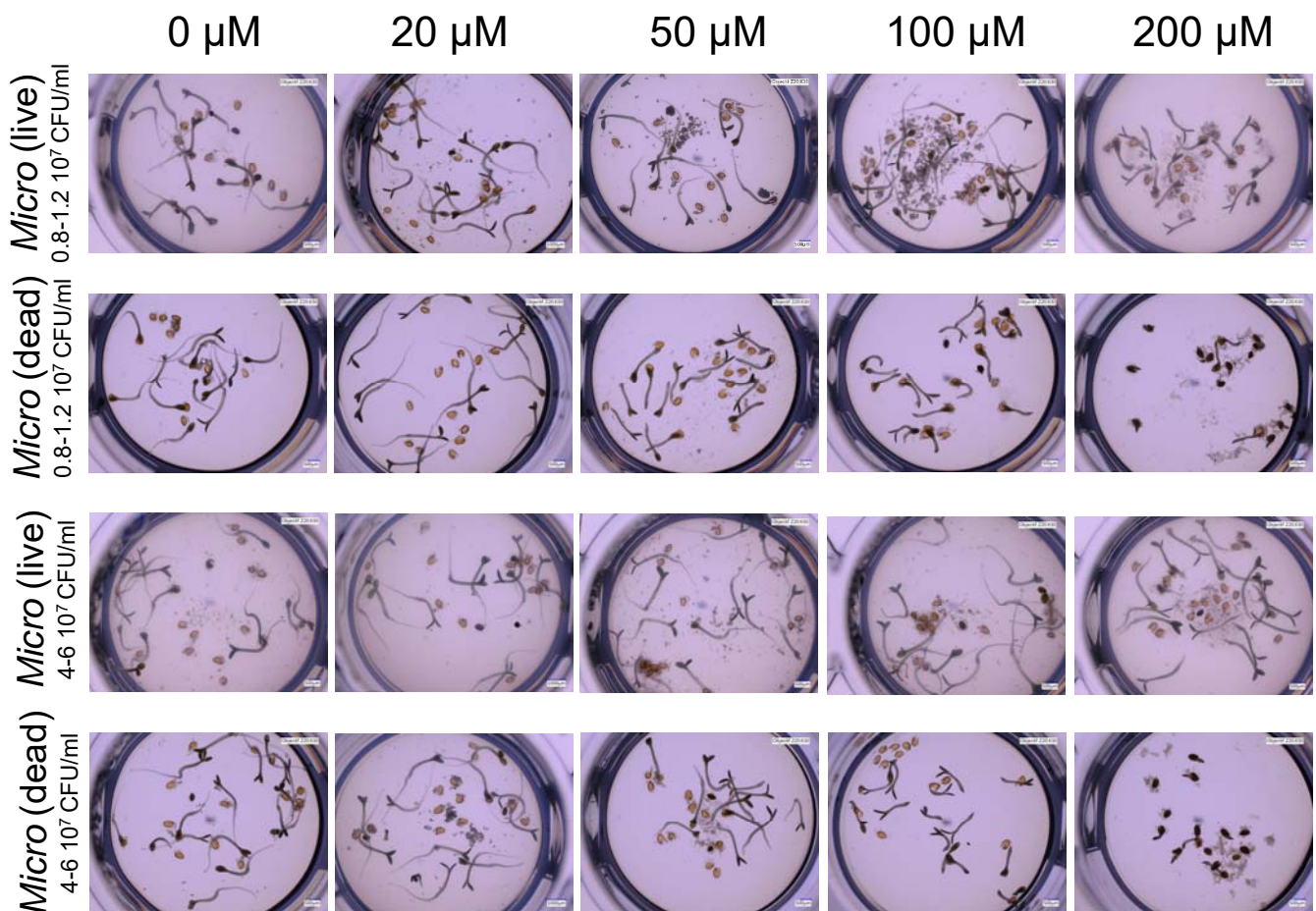


**Figure S4. Distribution of U between Arabidopsis seedlings, bacteria (*Microbacterium* sp. ViU2A, *Stenotrophomonas bentonitica* or *E. coli*) and medium.** Arabidopsis seeds were incubated for four days in the presence of different concentrations of uranyl nitrate, in the presence or absence of bacteria (see also Fig. S1). Pie charts show the distribution of U between seedlings (green) and medium (grey) in the absence of bacteria (control), between *Microbacterium* sp. ViU2A (red), seedlings (green) and medium (grey), between *S. bentonitica* (blue), seedlings (green) and medium (grey), between *E. coli* (yellow), seedlings (green) and medium (grey). Numbers represent the % of U present in the fraction.



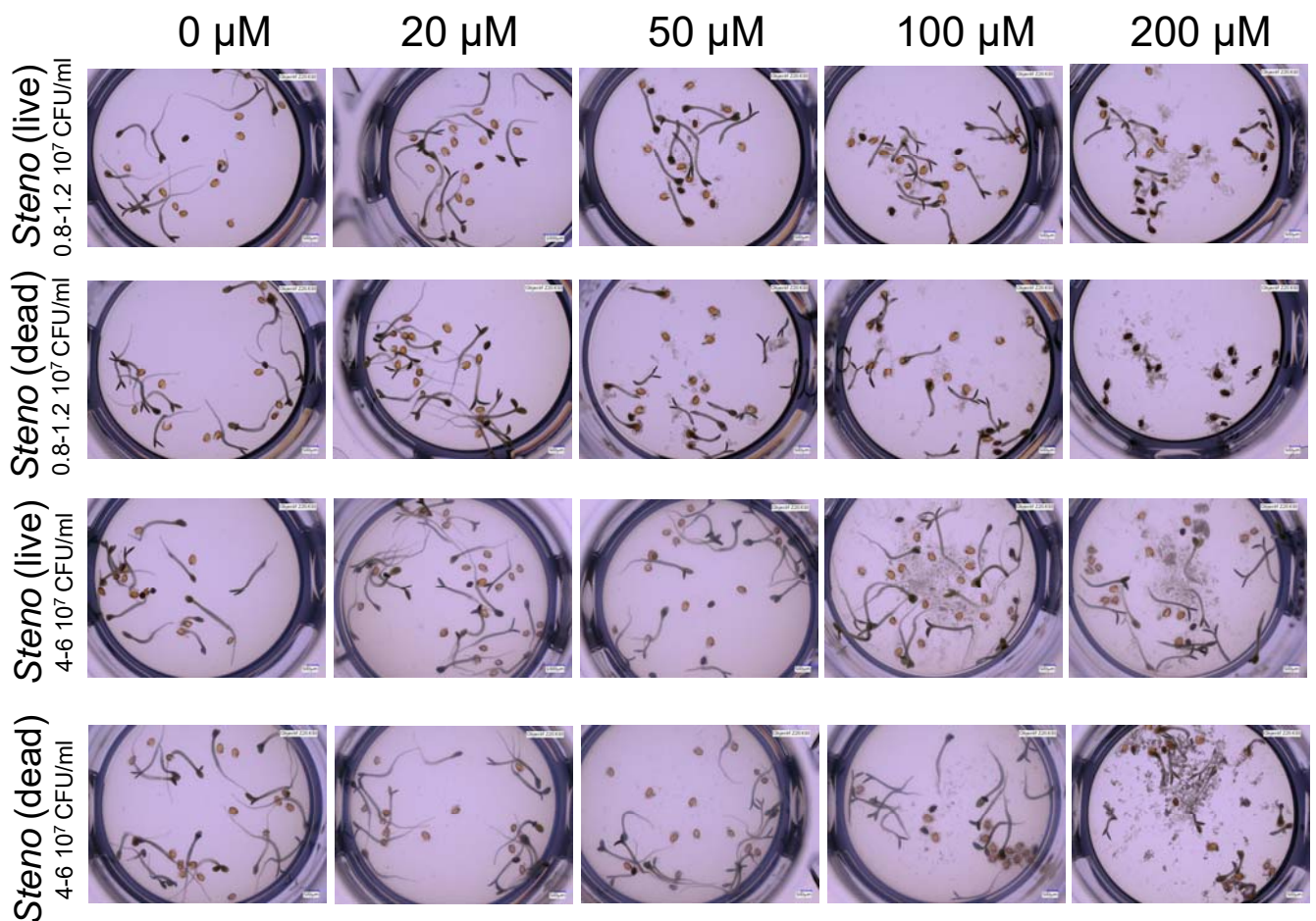
**Figure S5: Analysis of bacterial cell viability after exposure to U.**

At the end of the experiment described in Fig. S2 (4-day incubation in the presence of 0, 5 and 20  $\mu$ M uranyl nitrate), an aliquot of the incubation medium was used to inoculate bacteria onto LB agar plates. Cell growth was observed after 2 days at 37°C for *E. coli* and at 28°C for *Microbacterium* and *S. bentonitica*.



**Figure S6. Protection of Arabidopsis seedlings from U toxicity by living and dead *Microbacterium* sp. ViU2A.**

Arabidopsis seeds were incubated for four days in the presence of different concentrations of uranyl nitrate and two different concentrations of live or dead *Microbacterium* sp. ViU2A (Micro). Seedlings were visualized with a Keyence VHX digital microscope (scale bar 0.5 or 1 mm).



**Figure S7. Protection of Arabidopsis seedlings from U toxicity by living or dead *Stenotrophomonas bentonitica*.**

Arabidopsis seeds were incubated for four days in the presence of different concentrations of uranyl nitrate and two different concentrations of live or dead *S. bentonitica* (Steno). Seedlings were visualized with a Keyence VHX digital microscope (scale bar 0.5 or 1 mm).



**Table S1: Prediction of U species distribution in the incubation medium.** The VISUAL MINTEQ 3.1 software was used to analyze the speciation of U in the incubation medium (100 mM NaCl, pH 5). The % of the main species is indicated.

U [ $\mu\text{M}$ ]	$\text{UO}_2^{+2}$	$\text{UO}_2\text{OH}^+$	$(\text{UO}_2)_2(\text{OH})_2^{+2}$	$(\text{UO}_2)_3(\text{OH})_5^+$	$(\text{UO}_2)_4(\text{OH})_7^+$	$(\text{UO}_2)_3(\text{OH})_4^+$
500	9.5	3.9	14.3	57.6	10.7	3.5
200	16.6	6.8	17.4	49.3	6.4	3
100	24.5	10	19	39.6	3.8	2.4
50	34.6	14.2	19	27.9	1.9	1.7
20	49.2	20.3	15.4	12.9	0,5	0.8
15	53.4	22	13.5	9.2	0.3	0.5
10	58.3	24	10.8	5.3	0.1	0.3
5	64.1	26.4	6.5	1.7	-	-
2	67.7	28	2.9	0.3	-	-