doi:10.1017/S1431927611002583
Microsc. Microanal. 17 (Suppl 2), 2011

Rapid Cycling *Brassica rapa*: A Novel Phytomining Plant

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Soil contamination with heavy metals is a major issue facing both industrial and rural regions of the world today. Common soil contaminants include arsenic, lead, cadmium, nickel, copper, zinc, chromium, and mercury (ATSDR 2009). While many of these heavy metals occur naturally in soil in limited amounts, excess accumulation of these elements can be highly toxic to plants and animals. Research has shown that a possible solution to soil contamination may involve growing specific species of plants in the polluted soil [1].

Certain plants, known as hyperaccumulators, have been shown to draw specific heavy metal ions out of contaminated soil and convert them into solid metal nanoparticles by a process known as phytomining. Traditional methods of extracting heavy metals from toxic soil can be difficult, costly and more detrimental to the environment than the metal contaminant itself [1]. Hyperaccumulators may provide an eco-friendly method for remediation of contaminated soil. Although the mechanism for metal ion absorption by plants remains unknown, the predominant theory states that nanoparticles are formed within the plant by the reduction of metal ions to solid metal [2].

The goal of this study was to determine if the Wisconsin Fast Plant® (*Brassica rapa*) is a hyperaccumulator, and if so, whether the plant absorbs pre-formed nanoparticles or forms nanoparticles by reducing absorbed metal ions. *Brassica rapa* was selected for this experiment because it belongs to the same genus as other known hyperaccumulators including *Brassica napus*, *Brassica juncea*, and *Brassica oleracea* [3,1,4]. Heavy metals shown to be taken up by *Brassica* hyperaccumulators include silver, gold and copper [5,1,6].

Brassica rapa plants were grown hydroponically in either varying concentrations of gold ion solution or varying concentrations of gold nanoparticle (AuNP) solution. After 14 days of growth, samples from the root, stem and leaf were collected and prepared for transmission electron microscopy (TEM). AuNPs were only found in the root of the plant grown in gold ion solution. None of the plants grown in AuNP solution showed signs of gold nanoparticles in the roots. Stem and leaf samples did not contain definitive gold nanoparticles under any experimental condition.

Based on these findings, it is believed that *Brassica rapa* is capable of phytomining. Furthermore, since there were no nanoparticles found in the tissue of plants exposed to pre-formed nanoparticles, it can be concluded that the AuNPs found within the root tissue are a result of metal ion reduction by the plant. *Brassica rapa,* with its accelerated lifecycle, has the potential to more efficiently decontaminate heavy metal ion polluted soil than other, slower-growing *Brassica* species. Future studies will look to confirm the presence of AuNPs in the plant tissue using X-ray microanalysis. Studies will also be done to determine if additional metal ions can be reduced by *Brassica rapa.*

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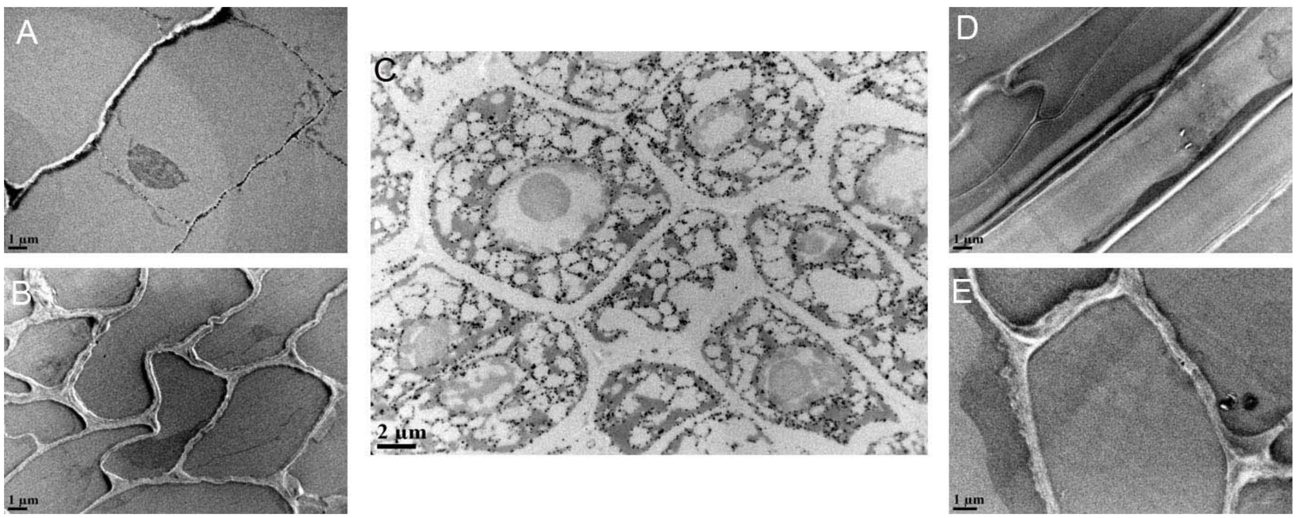

Figure 1: TEM images of root samples. (A) Control: 50% standard Hoagland solution; (B) 50µM $HAuCl_4$ in 50% standard Hoagland solution; (C)* 500µM $HAuCl_4$ in 50% standard Hoagland solution; (D) 5mg/L gold nanoparticles in 50% standard Hoagland solution; (E) 50mg/L $HAuCl_4$ in 50% standard Hoagland solution. *AuNPs were observed in this sample.

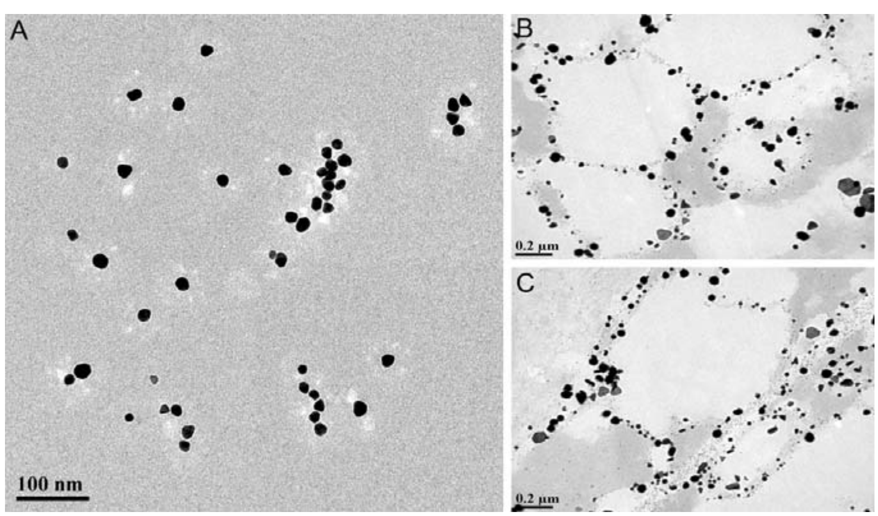

Figure 2: Comparison of synthesized gold nanoparticles to gold nanoparticles observed in plant tissue. (A) Synthesized nanoparticles; (B&C) Nanoparticles found in root tissue (See Figure 1C).

https://doi.org/10.1017/S1431927611002583 Published online by Cambridge University Press