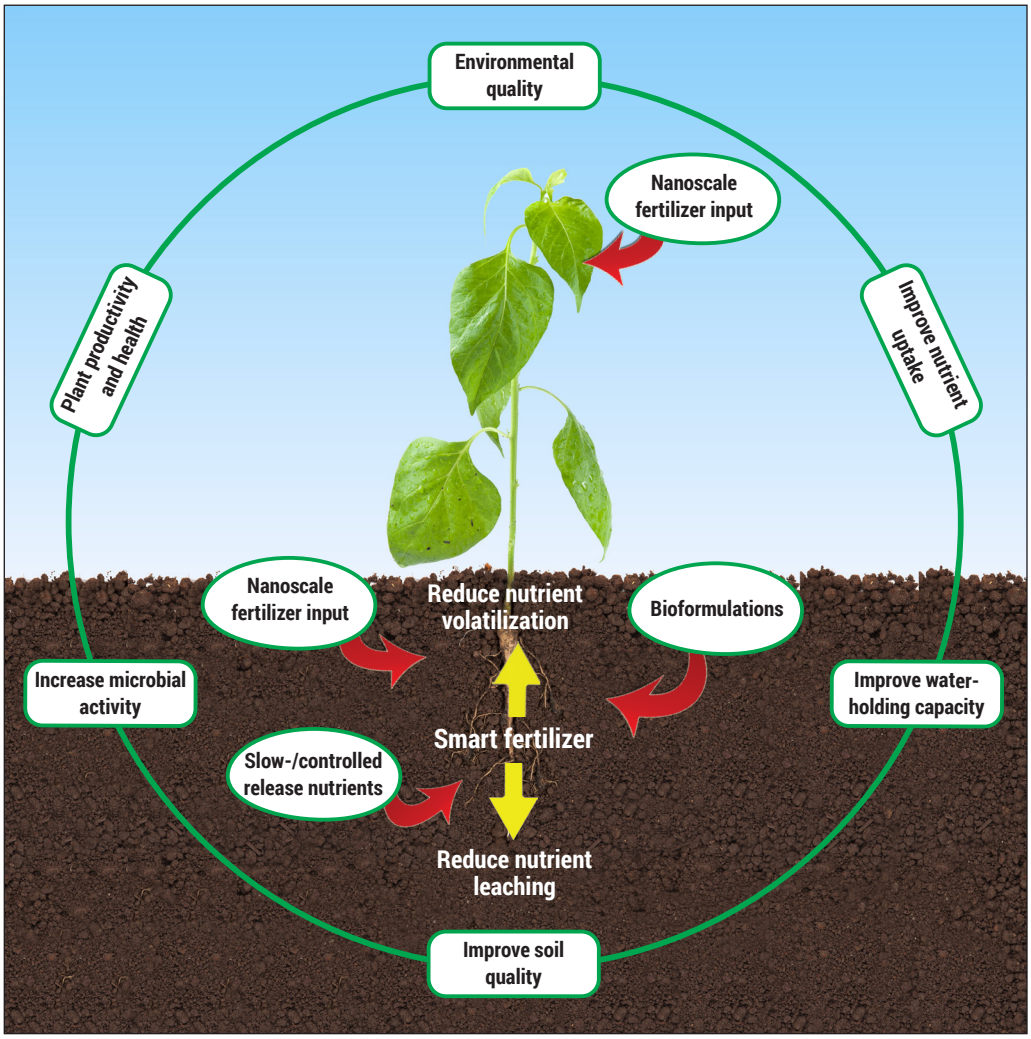
Nanofertilizer and Nanotechnology: A quick look

By Robert Mikkelsen

The word "Nano" means one-billionth, so nanotechnology refers to materials that are measured in a billionth of a meter (nm). A nanometer is so small that the width of a human hair is 80,000 nanometers. The field of nanotechnology has resulted from advances in chemistry, physics, pharmaceuticals, engineering, and biology. The size of a nanomaterial is typically about 1 to 100 nanometers. They can be naturally occurring or engineered. Due to their extremely minute size, they have many unique properties that are now being explored for new opportunities in agriculture.

There are naturally occurring nanoparticles that have been previously proposed for agricultural use, such as zeolite minerals. However, engineered nanomaterials can now be synthesized with a range of desired chemical and physical properties to meet various applications.



Schematic diagram of potential smart fertilizer effects in the soil-plant system. Adapted from Calabi-Floody et al. 2017.

Nanofertilizers are being studied as a way to increase nutrient efficiency and improve plant nutrition, compared with traditional fertilizers. A nanofertilizer is any product that is made with nanoparticles or uses nanotechnology to improve nutrient efficiency.

Three classes of nanofertilizers have been proposed:

1. nanoscale fertilizer (nanoparticles which contain nutrients),
2. nanoscale additives (traditional fertilizers with nanoscale additives), and
3. nanoscale coating (traditional fertilizers coated or loaded with nanoparticles)

Nanomaterial coatings (such as a nanomembrane) may slow the release of nutrients or a porous nanofertilizer may include a network of channels that retard nutrient solubility. The use of nanotechnology for fertilizers is still in its infancy but is already adopted for medical and engineering applications.

Another promising application of nanotechnology is the encapsulation of beneficial microorganisms that can improve plant root health. These could include various bacteria or fungi that enhance the availability of nitrogen, phosphorus, and potassium in the root zone. The development of nanobiosensors to react with specific root exudates is also being explored.

SUMMARY
There is more talk and publications about nanofertilizers in recent years, but these materials are still new for many agronomists. Because these fertilizers are still in the early stage of development, a brief review of their potential is useful.

KEYWORDS:
fertilizer technology; nutrient use efficiency.

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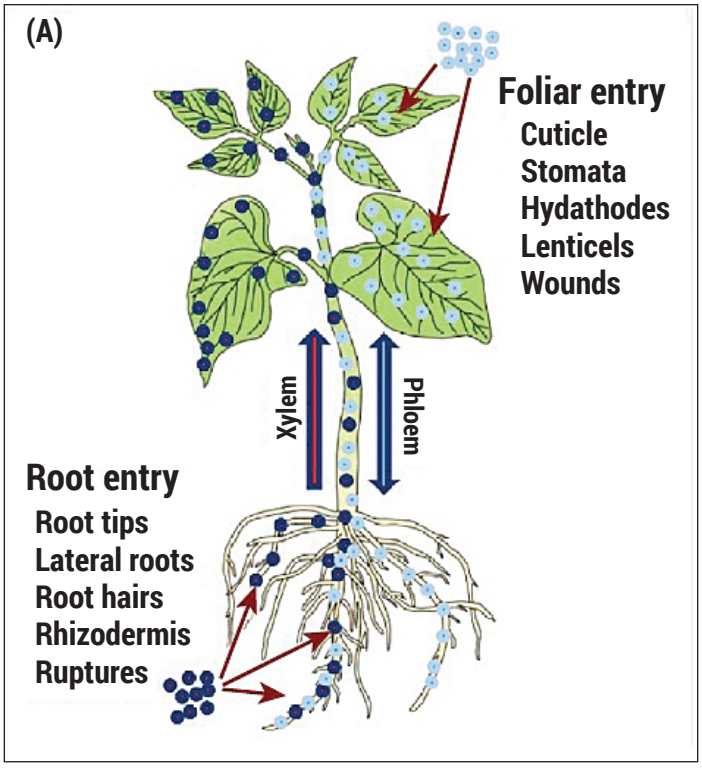


Potential entry points of nanoparticles into plants. Wang et al. 2016.

Examples of potential nanofertilizer designs (adapted from Manjunatha et al., 2016)

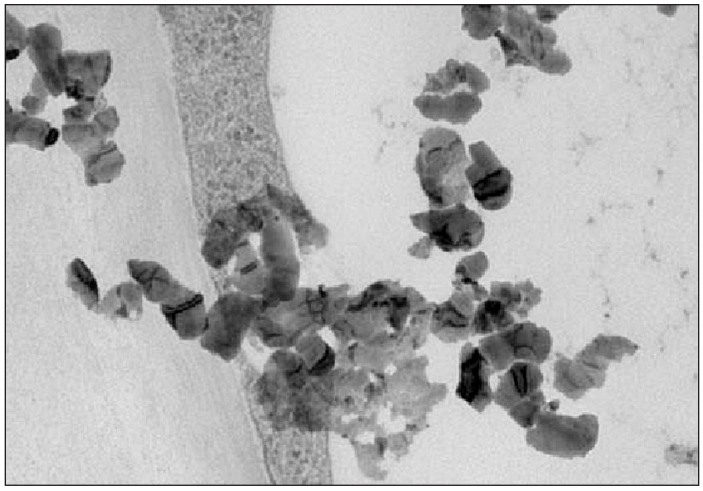
Slow release: the nanocapsule slowly releases nutrients over a specified period of time.

Quick release: the nanoparticle shell breaks upon contact with a surface (such as striking a leaf).

Specific release: the shell breaks open when it encounters a specific chemical or enzyme.

Moisture release: the nanoparticle degrades and releases nutrients in the presence of water.

Heat release: the nanoparticle releases nutrients when the temperature exceeds a set point.



A corn root surrounded with copper oxide nanoparticles that are penetrating through the cell wall. Tapan et al. 2016.

pH release: the nanoparticle only degrades in specified acid or alkaline conditions.

Ultrasound release: the nanoparticle is ruptured by an external ultrasound frequency.

Magnetic release: a magnetic nanoparticle ruptures when exposed to a magnetic field.

Many of these nanotechnologies are still in the early development stage for both medical and agricultural uses. However, the next time you hear about nanofertilizers, you will have a better idea of where this field is headed. **BC**

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Additional Reading

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