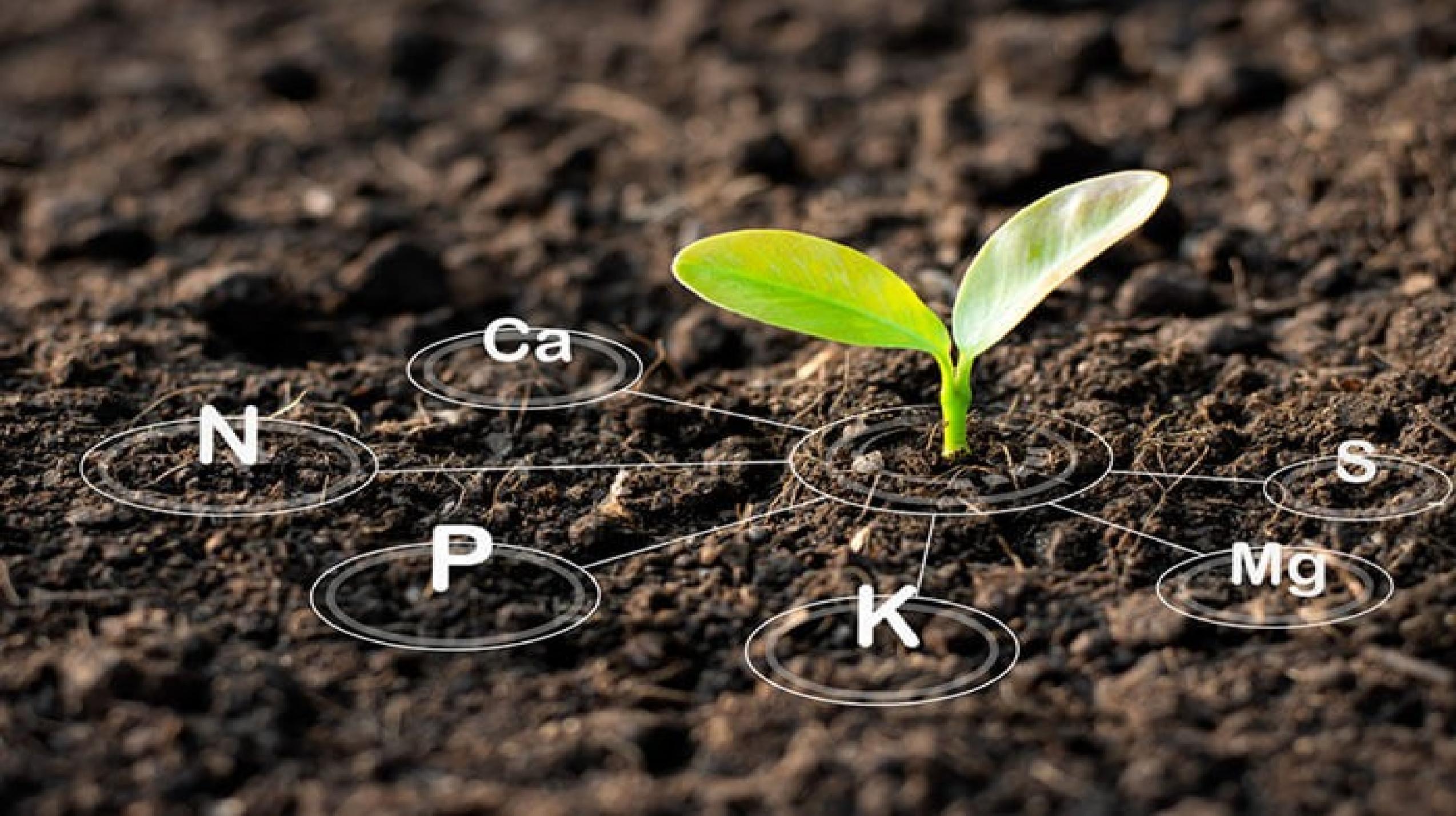


Nanofertilizers for sustainable crop management

Luca Marchiol



**UNIVERSITÀ
DEGLI STUDI
DI UDINE**



N

Ca

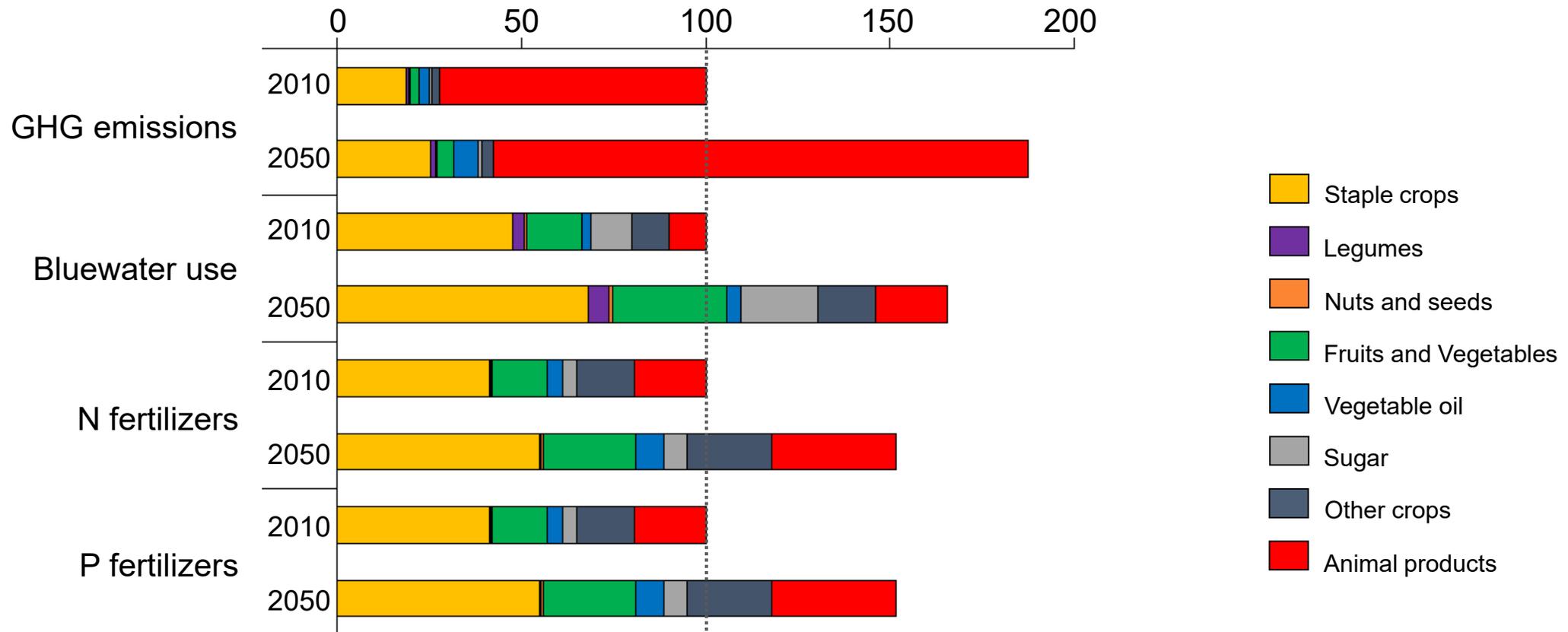
P

K

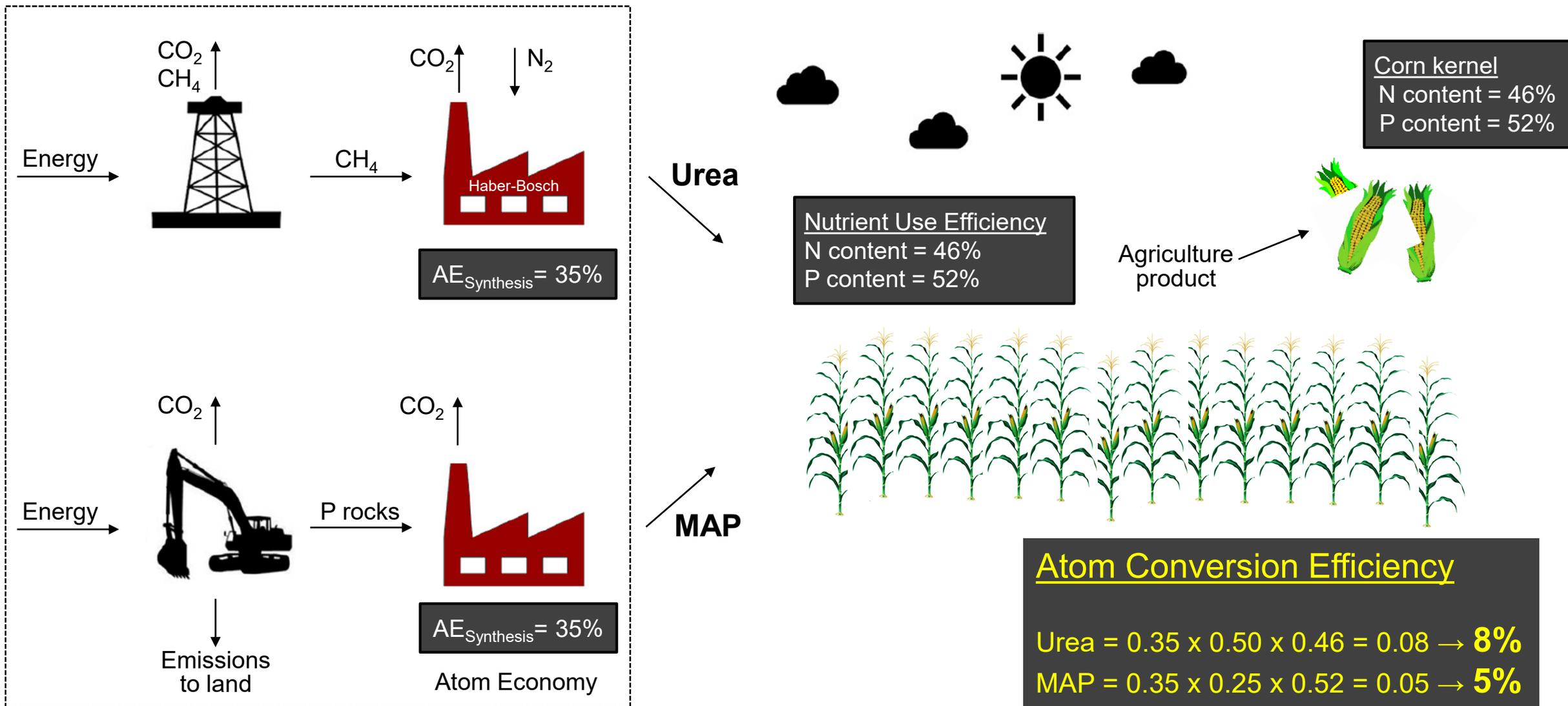
S

Mg

Agriculture environmental pressure (percentage of impact)



Conventional N-, P- Fertilizers

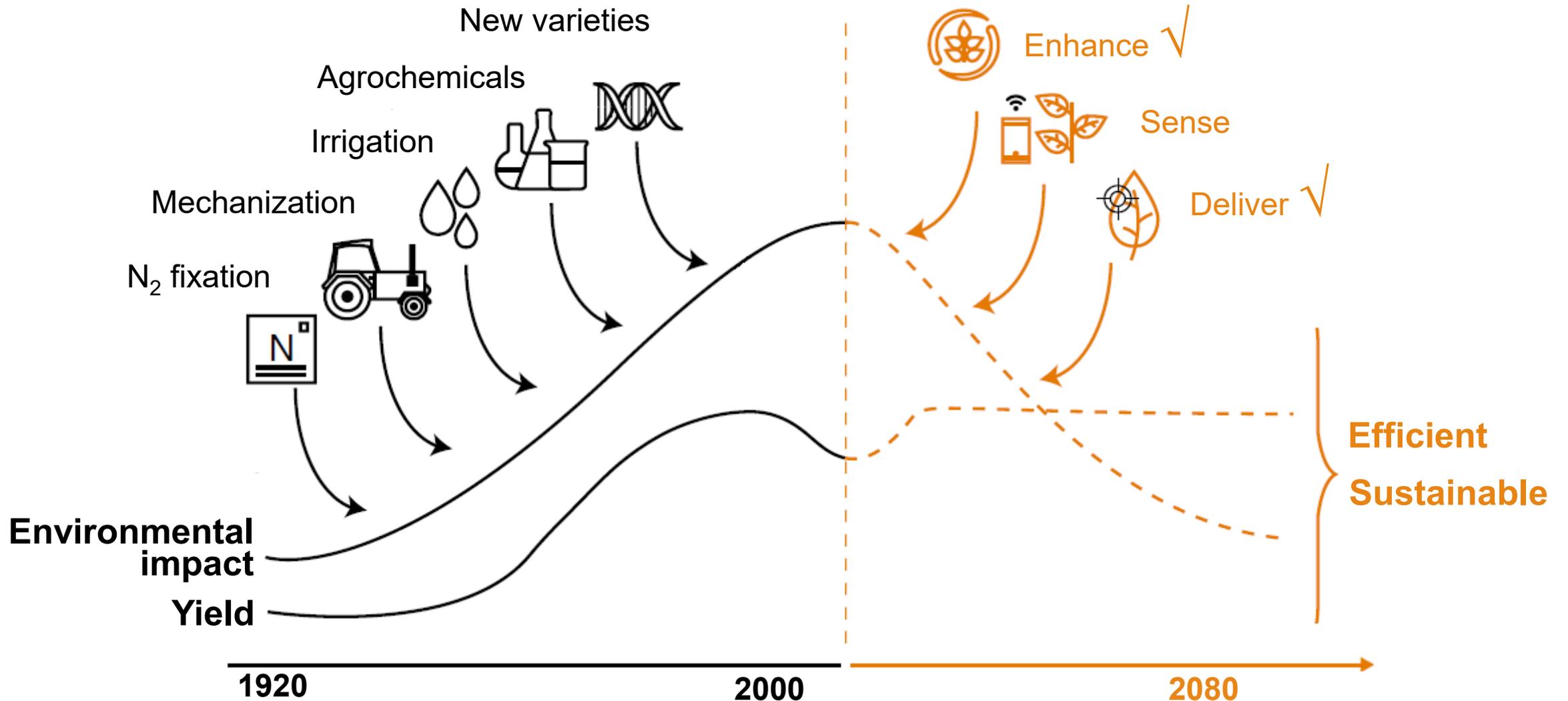


Nano November 14-19 September
2020 Innovation
Conference & Exhibition

NANOTECHNOLOGY

Conventional Agriculture

Nano-enabled Agriculture



modified from: Lowry et al., 2019. Nature Nanotechnol 14, 6, 541–553

Nanofertilizers_Expectations

Nutrient loading capacity →

Nutrient release rate →

Nutrient use efficiency →

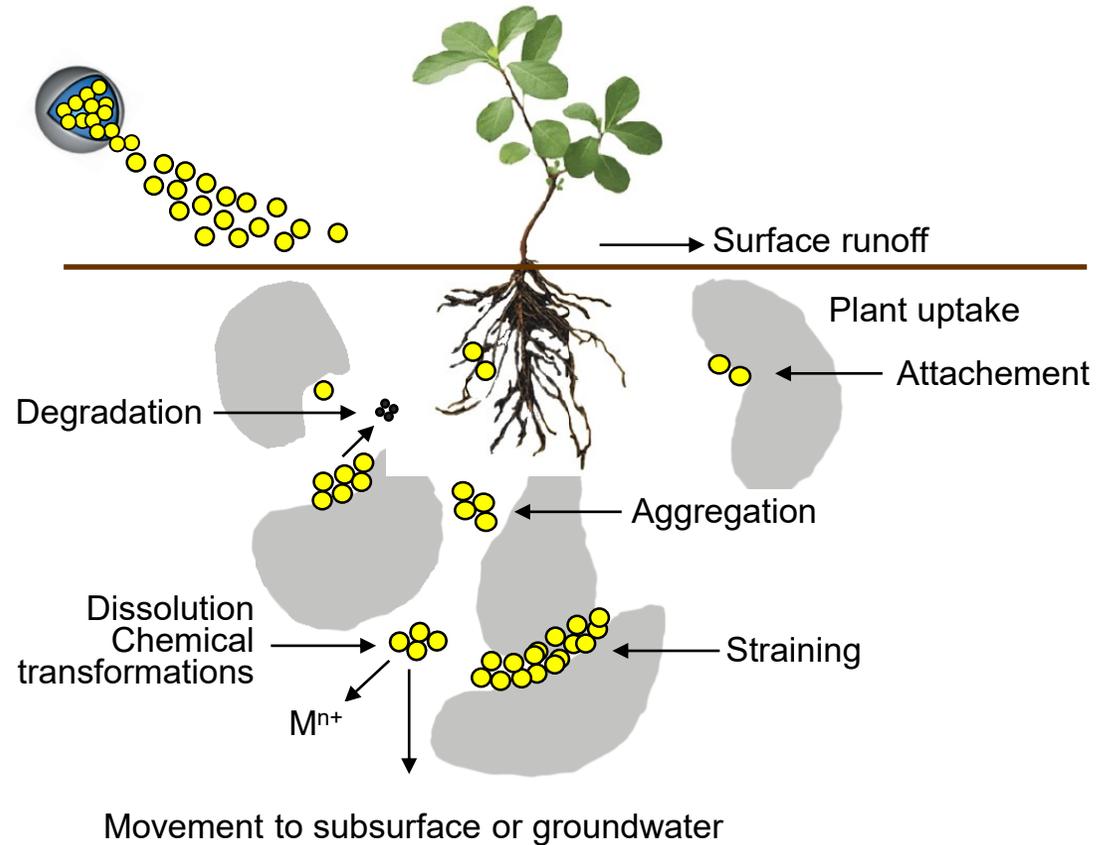
Crop quality and productivity →

Economic feasibility →

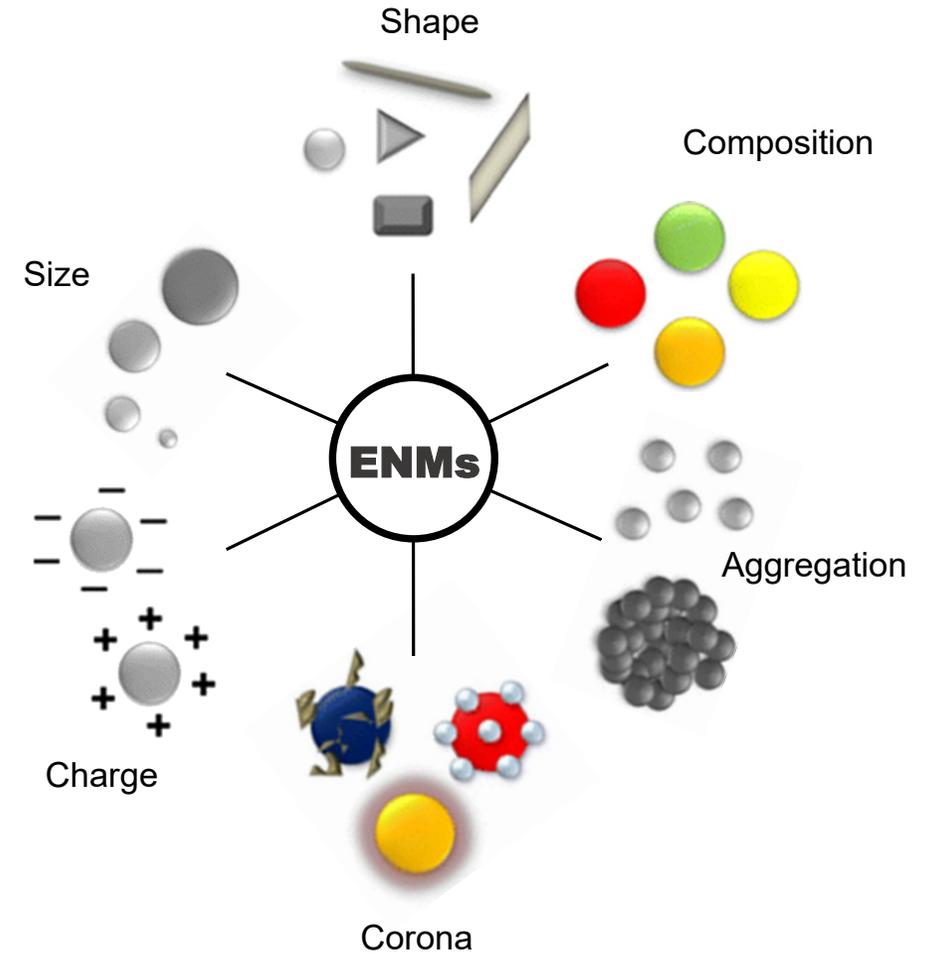
Environmental compatibility →



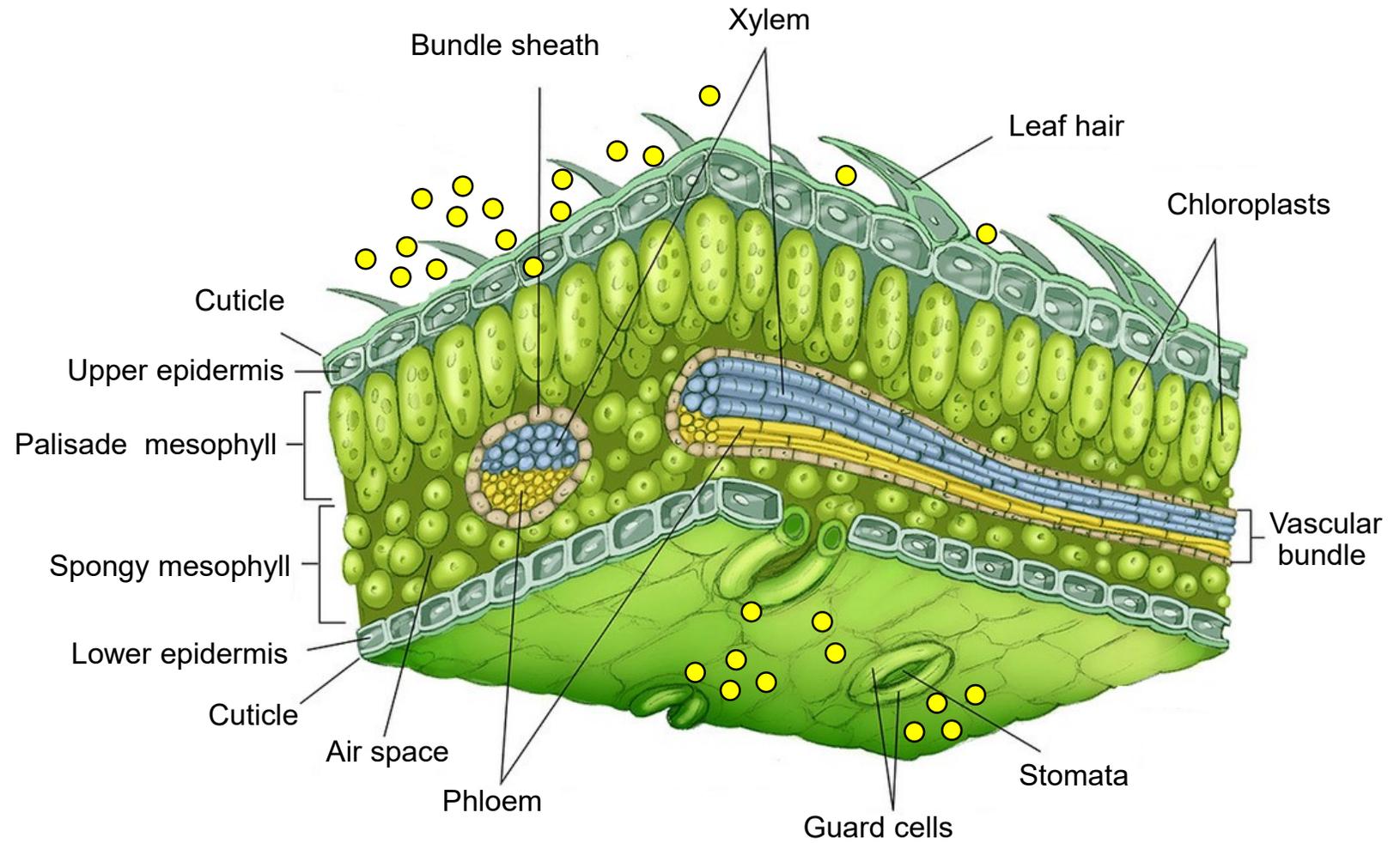
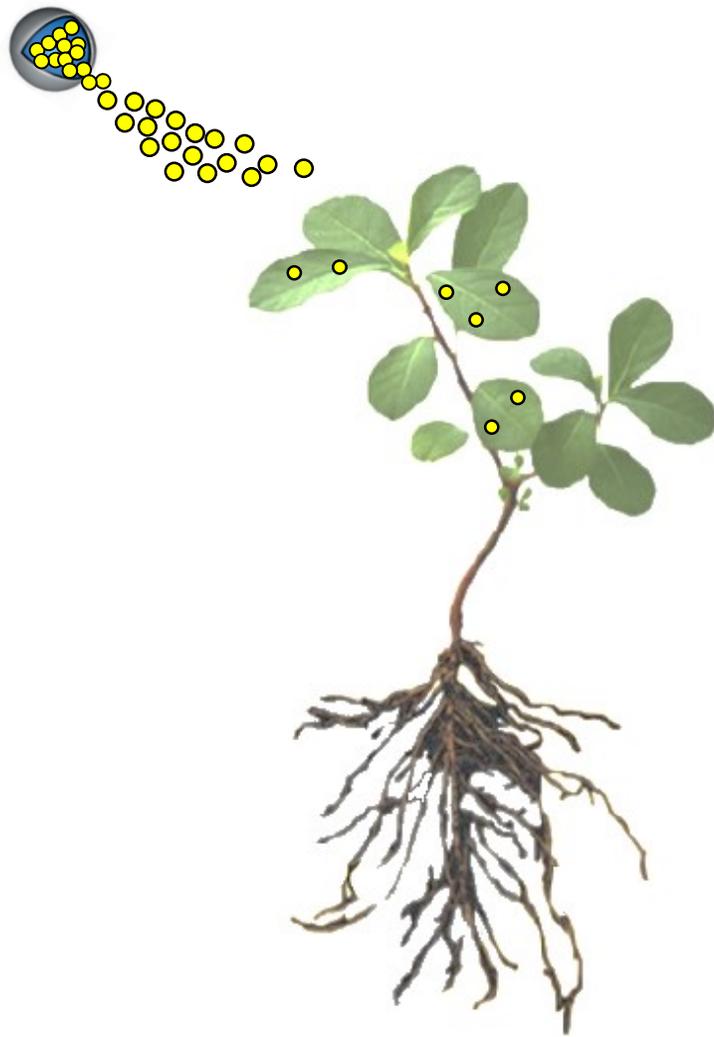
Nanofertilizers_Soil application



Engineered Nanomaterials (ENMs) properties

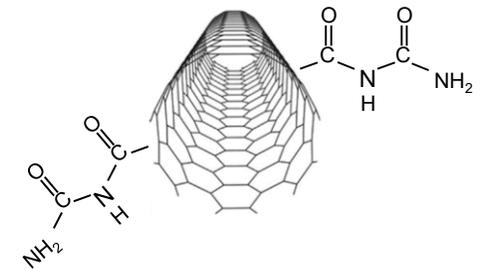
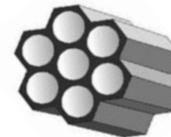
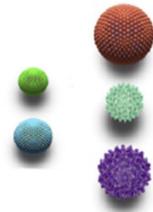
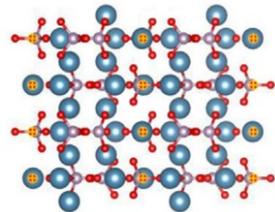


Nanofertilizers_Foliar application



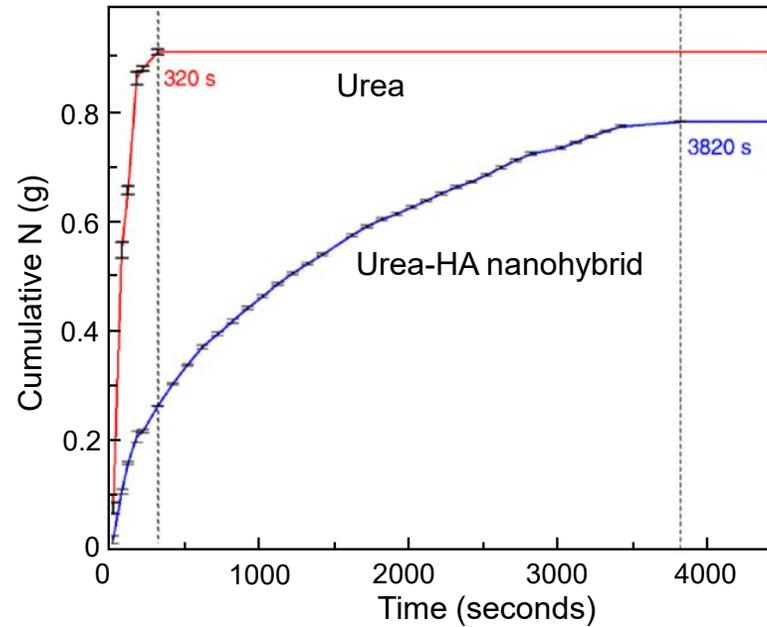
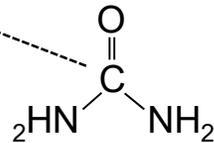
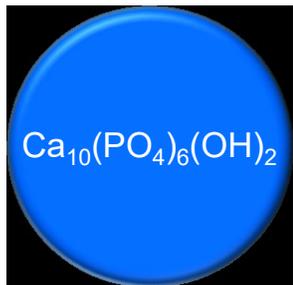
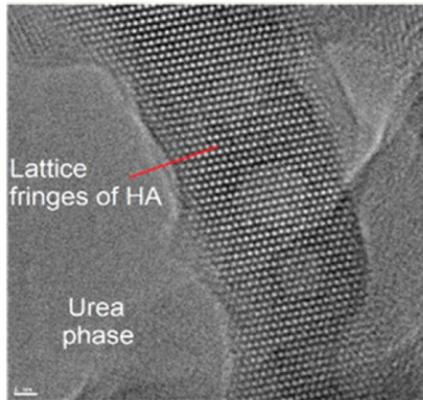
Types of Nanofertilizers

Composition Structure	Macronutrient nanofertilizer	Micronutrient nanofertilizer	Nanomaterial enhanced fertilizer	Plant growth stimulator
Metallic		Cu, Fe, Mn Mo, Zn		
Ceramic	Ca, Mg, Ca-P		Nutrient loaded zeolites Mesoporous $n\text{SiO}_2$	$n\text{CeO}_2$, $n\text{TiO}_2$
Polymeric	N, K		Nano-chitosan fertilizer	SWCNTs, MWCNTs, Graphene, Fullerenes, C containing NPK

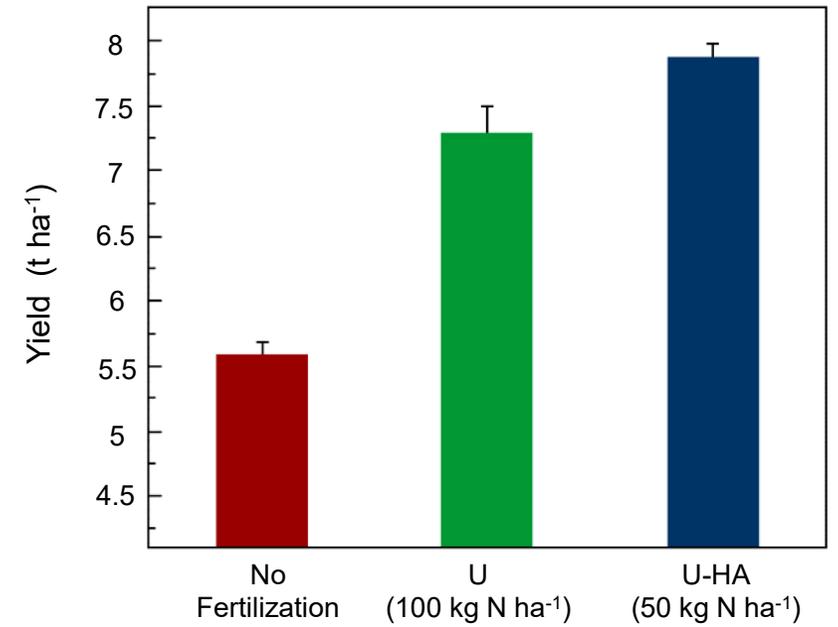


Macronutrient Nanofertilizer

Urea-Hydroxyapatite Nanohybrids for Slow Release of Nitrogen



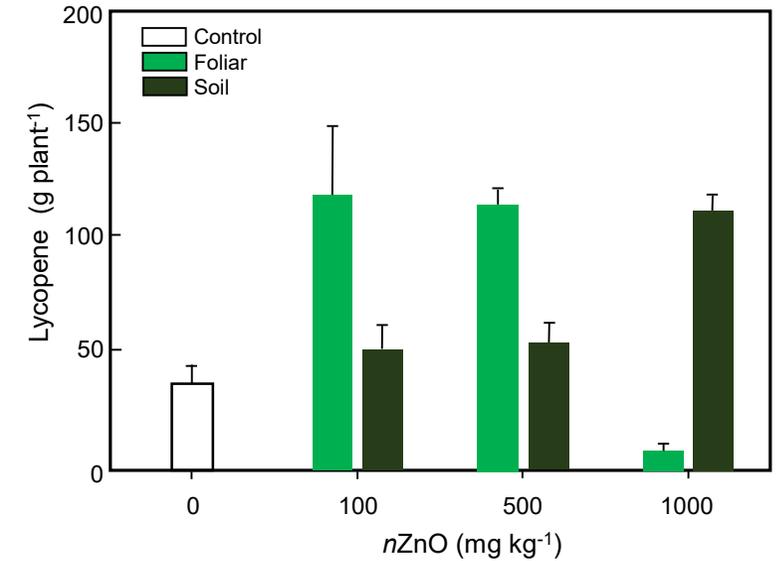
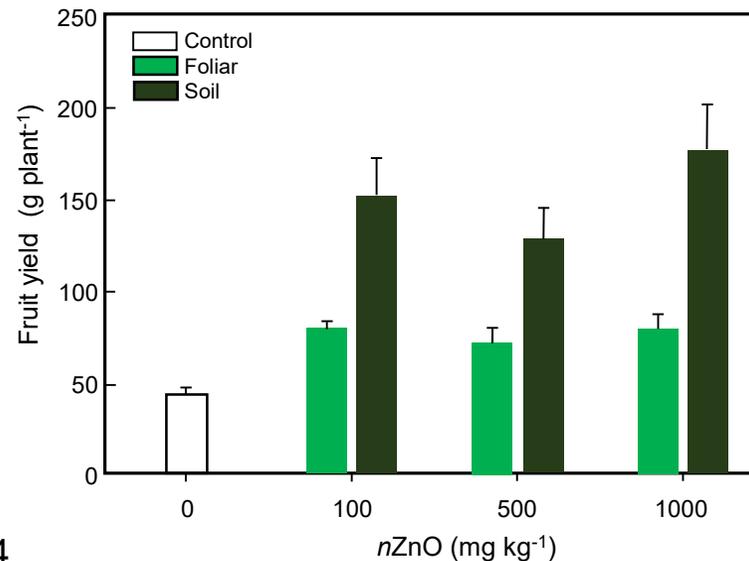
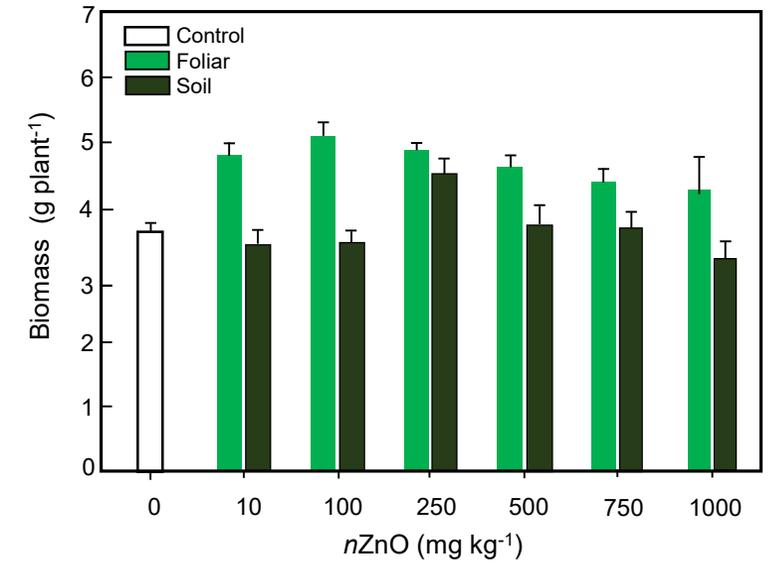
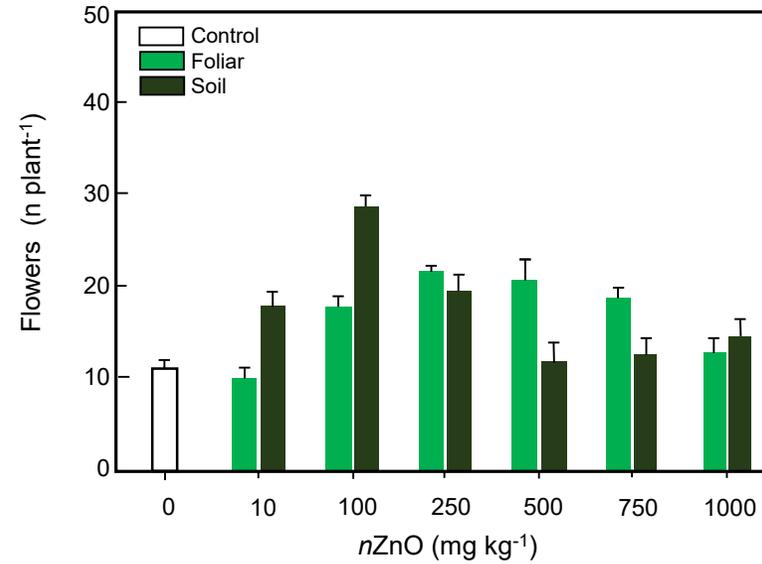
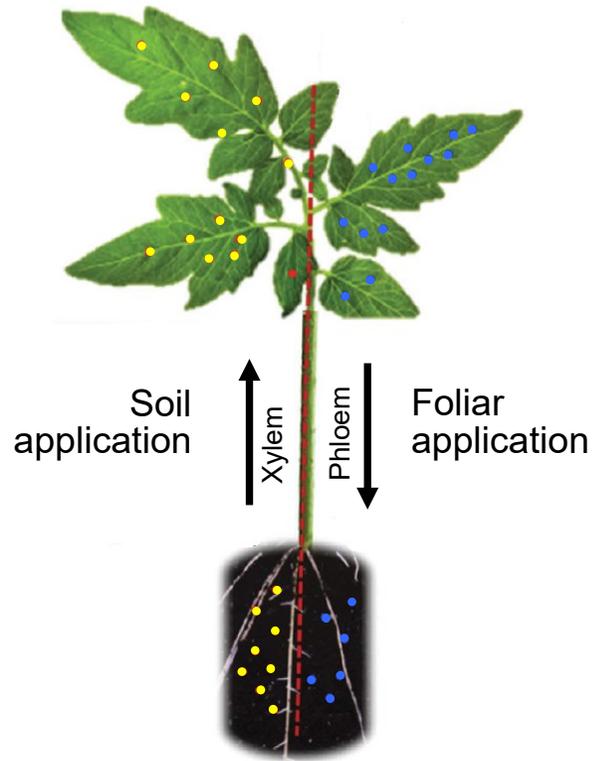
N release behavior in water



Field trial - *Oryza sativa*

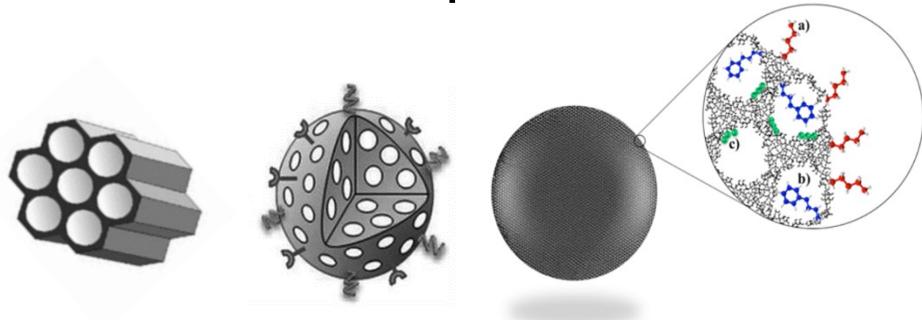
Micronutrient Nanofertilizer

Effects of $n\text{ZnO}$ on tomato growth

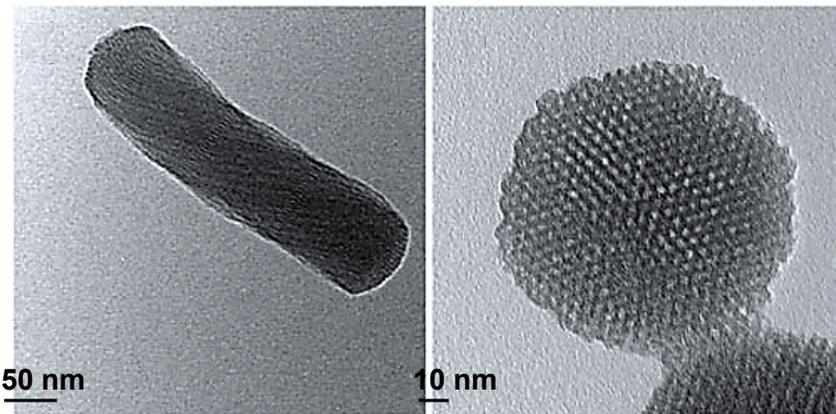


Nanomaterial enhanced fertilizers

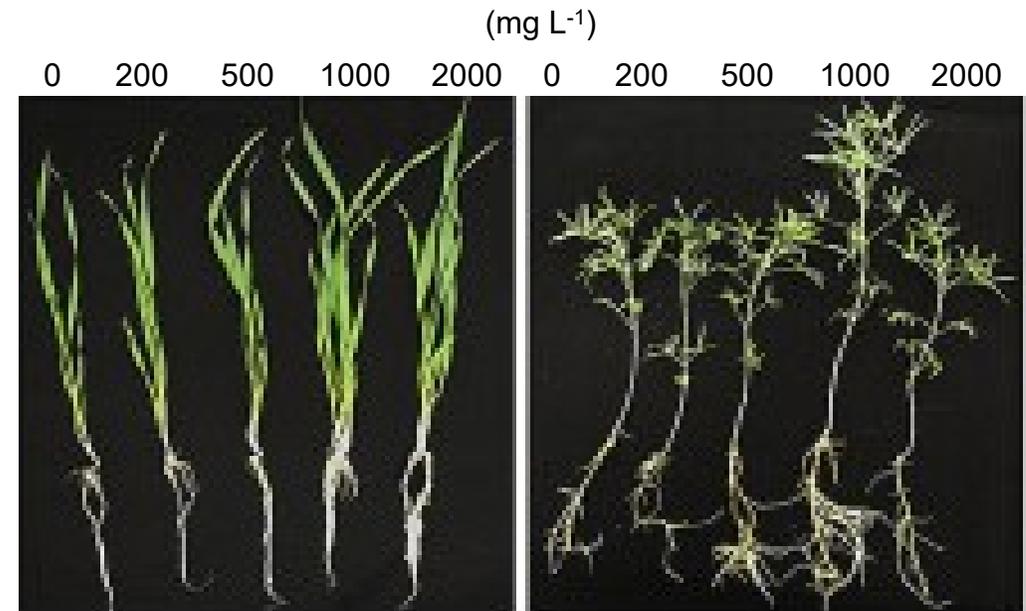
Mesoporous silica nanoparticles - MSNs
enhance seedling growth and photosynthesis
in wheat and lupin



- MSNs uptake/accumulation in different plant fractions
- MSNs stimulated photosynthesis and plant growth

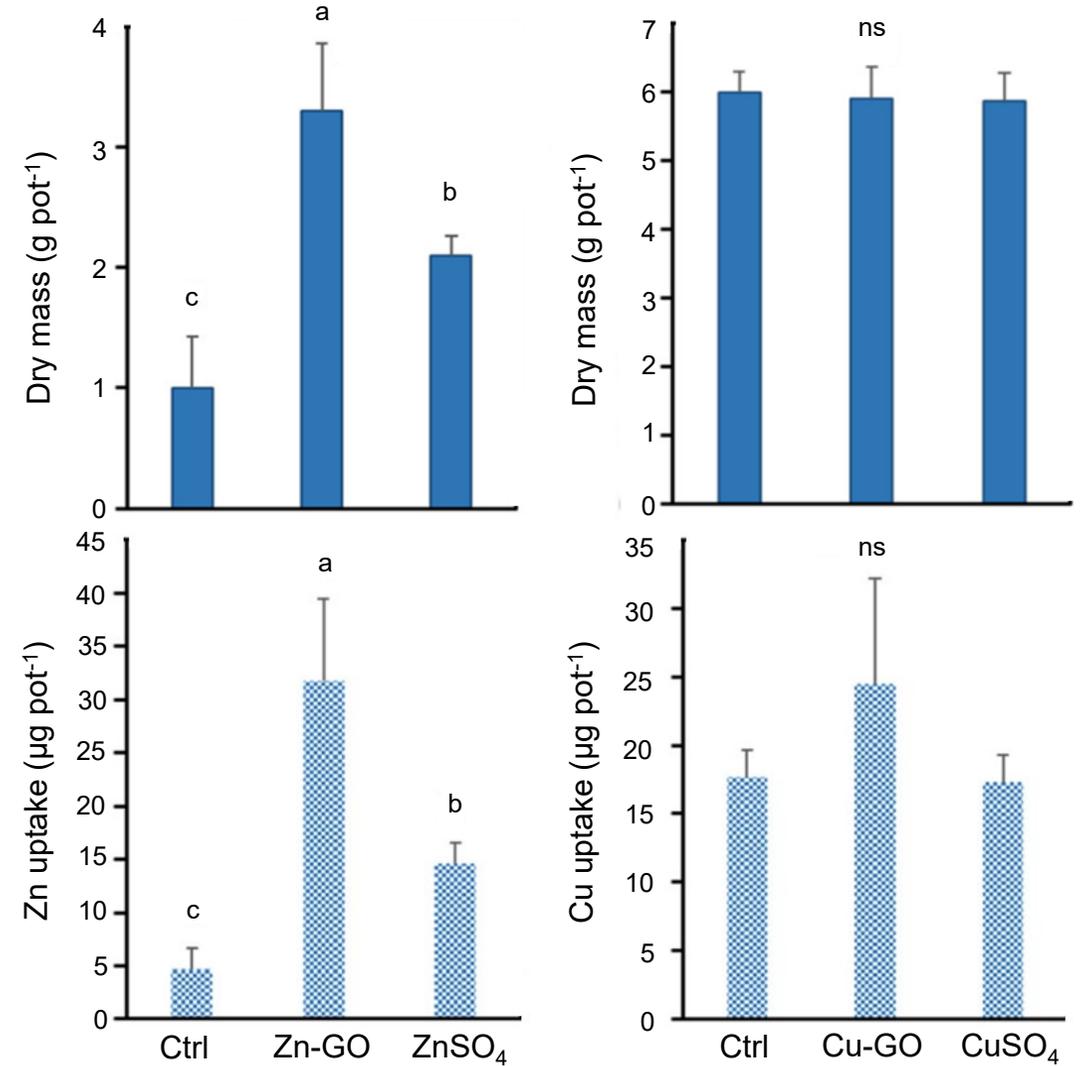
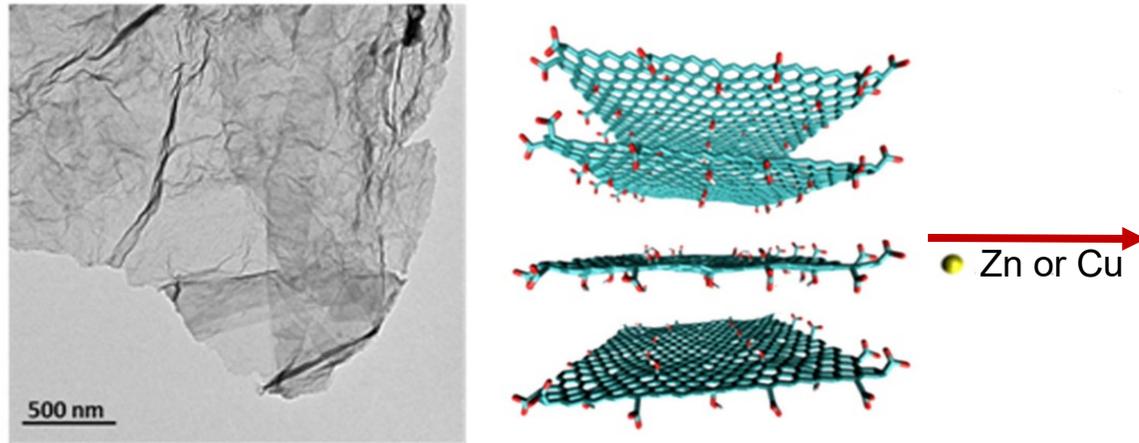


plant uptake
→



Plant Growth Stimulator

Graphene Oxide (GO)
new carrier for slow release of
plant micronutrients



Pot trial - *Triticum durum*



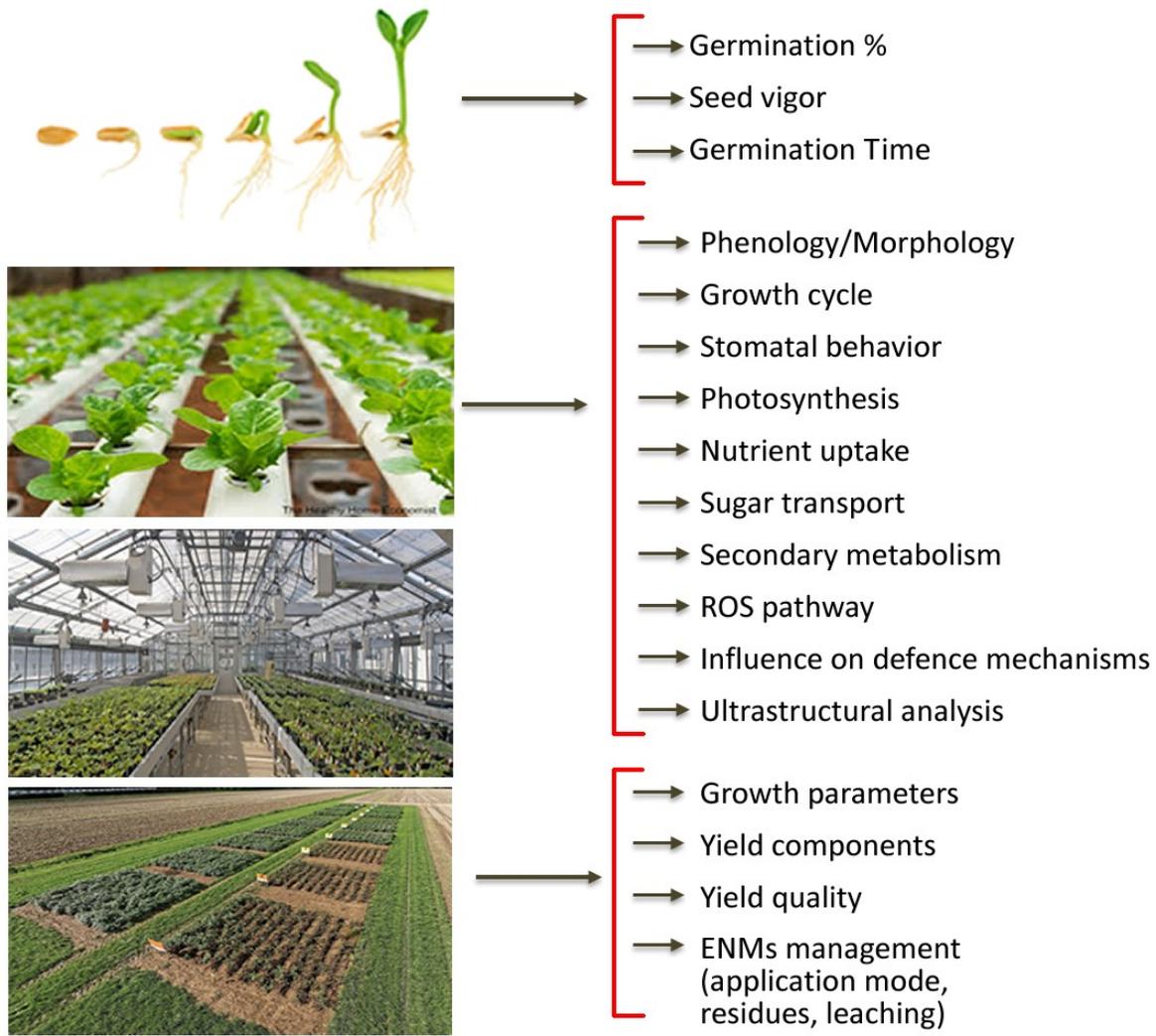






Nanofertilizers_Research needs

Other key drivers

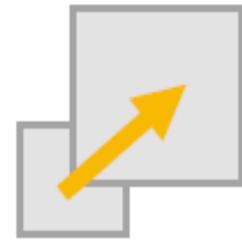


Social acceptance?



Environmental footprint?

Scalability?



Economic viability?

Take-home messages

- Nanofertilizers have a very interesting potentially but very limited published performance data at the field scale, so far. More field studies needed.
- Most of current studies report on the properties of laboratory nanoformulations and not necessarily commercial products;
- Needed implementation of *Safe-by-Design* for nanomaterial development and safe innovation. Environmental implications!
- EFSA Journal 2018, 16, 5327: Guidance on risk assessment of the application of nanoscience and nanotechnologies in the food and feed chain: Part 1, human and animal health. Expected part 2, Agriculture?

Readings

1. Ramírez-Rodríguez et al. 2020. Reducing nitrogen dosage in *Triticum durum* plants with Urea-doped nanofertilizers. *Nanomaterials* 10, 1043. doi.org/10.3390/nano10061043
2. Gilbertson et al. 2020. Guiding the design space for nanotechnology to advance sustainable crop production. *Nat. Nanotechnol.* doi.org/10.1038/s41565-020-0706-5
3. Gomez et al. 2021. Effects of nano-enabled agricultural strategies on food quality: Current knowledge and future research needs. *J. Hazardous Materials.* 401,123385. doi.org/10.1016/j.jhazmat.2020.123385

Nanofertilizers for sustainable crop management

luca.marchiol@uniud.it



**UNIVERSITÀ
DEGLI STUDI
DI UDINE**