

Laser and plasma treatments of seeds to improve germination ability

Christian Andreasen

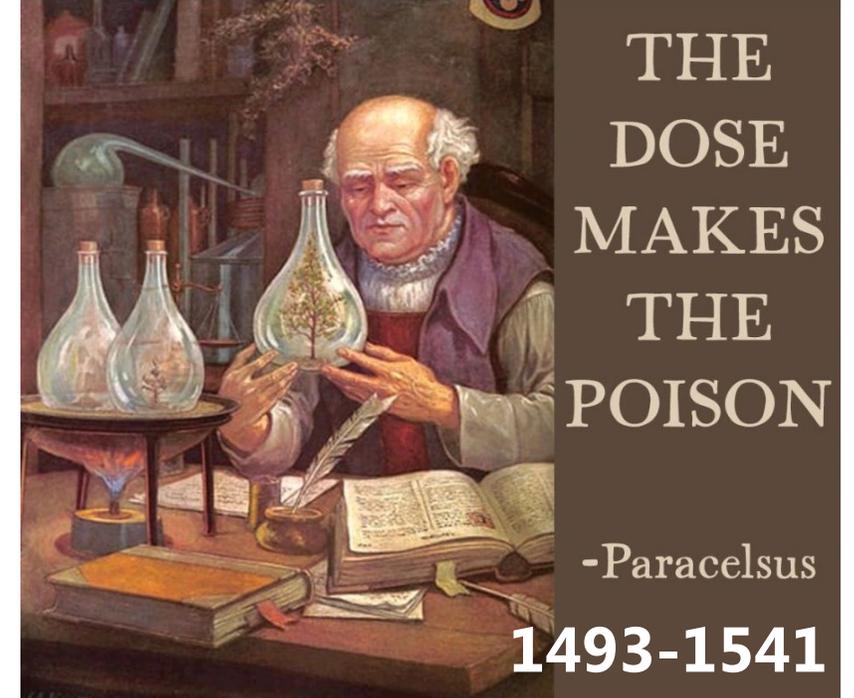
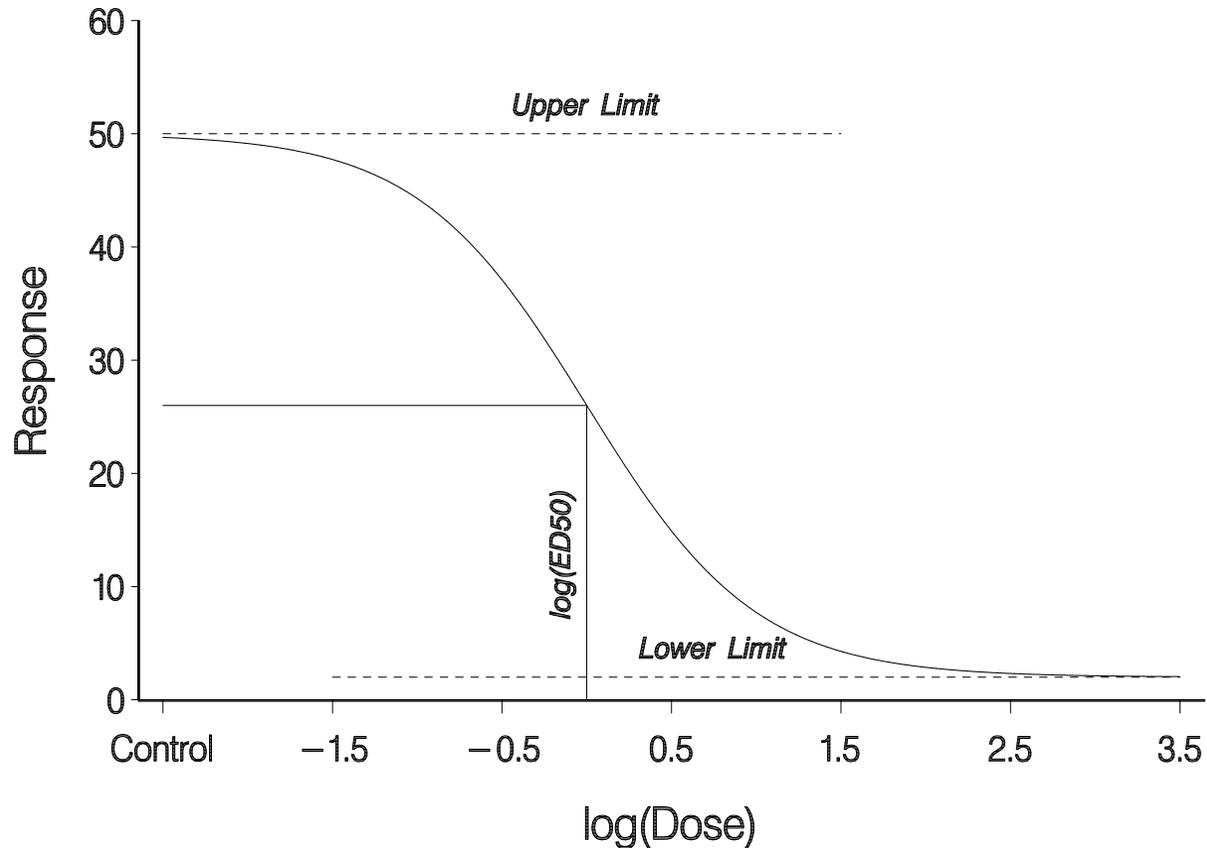
Department of Plant and Environmental Sciences

KØBENHAVNS UNIVERSITET



Log-Logistic Dose Response curve

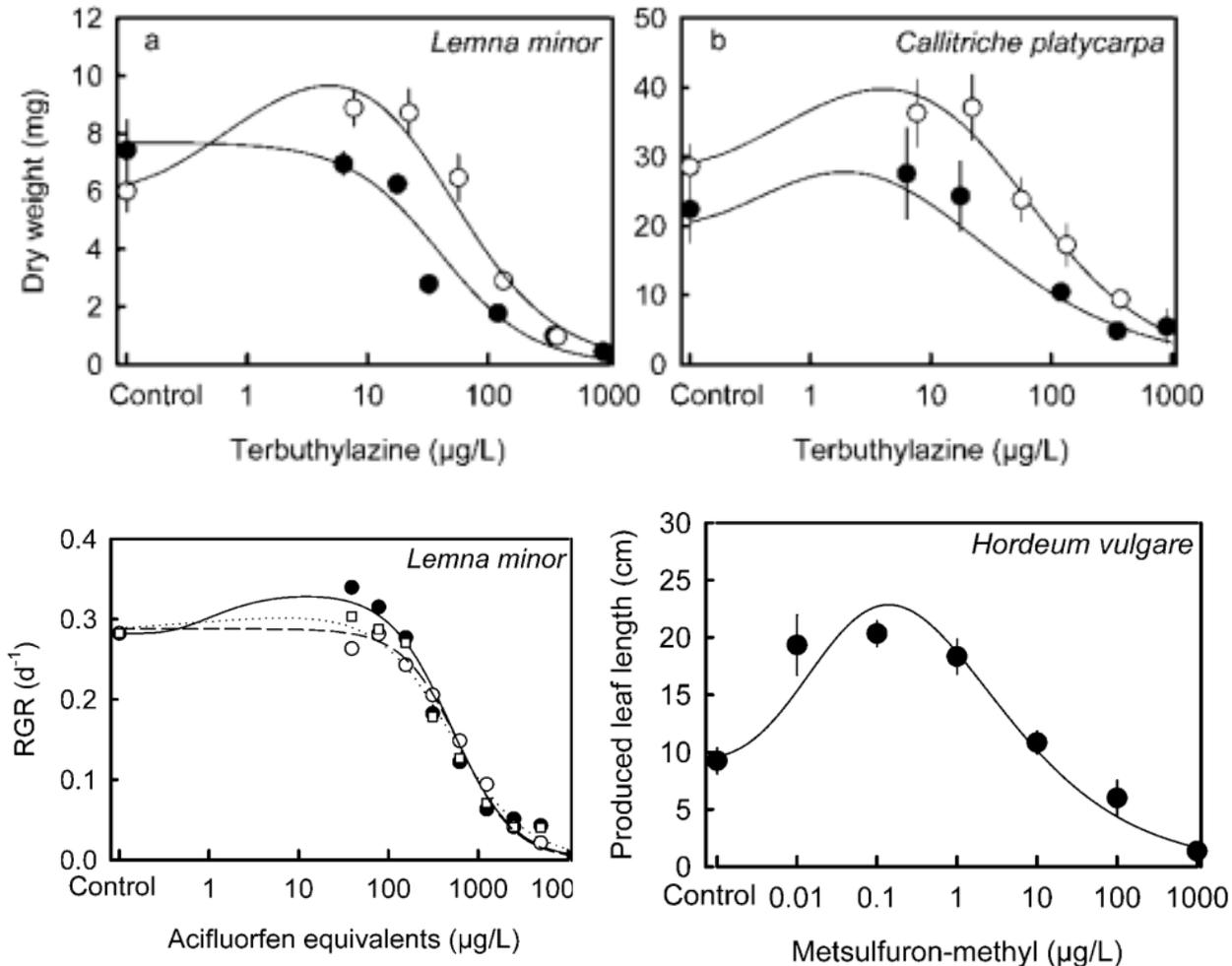
Germination rate



Nearly 500 years ago, Swiss physician and chemist Paracelsus expressed the basic principle of toxicology: “All things are poison and nothing is without poison; only the dose makes a thing not a poison.”

Examples from Cedergren et al. (2005) Improved empirical models describing hormesis

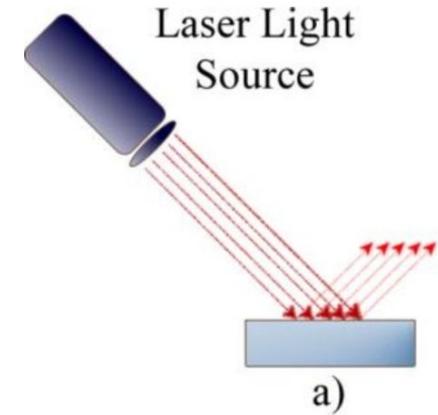
Environ. Toxicol. Chem. 24, 2005



Can we improve seed germination by exposing the seeds to tiny doses of laser and plasma treatments?



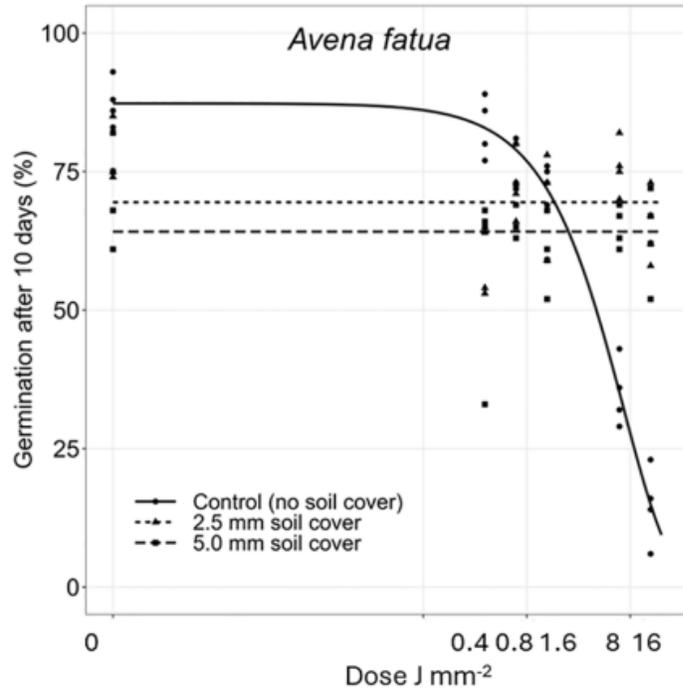
The first 4 colour single camera optical sorter



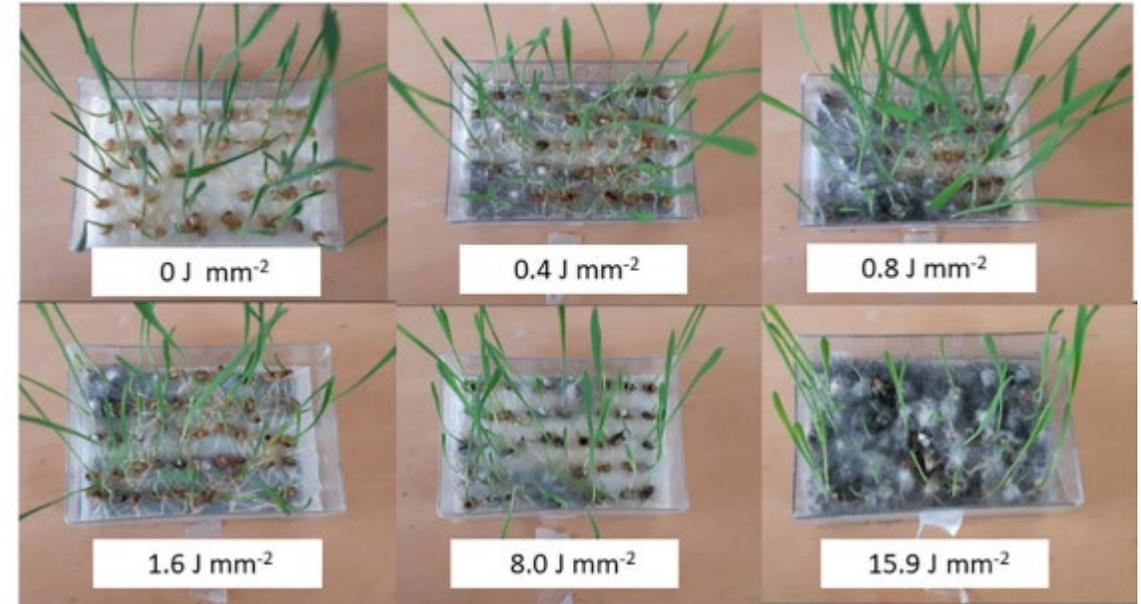
A laser is a device that emits light through optical amplification based on the stimulated emission of electromagnetic radiation



Laser treatment of seeds with a fibre laser with a wavelength of 2 μm



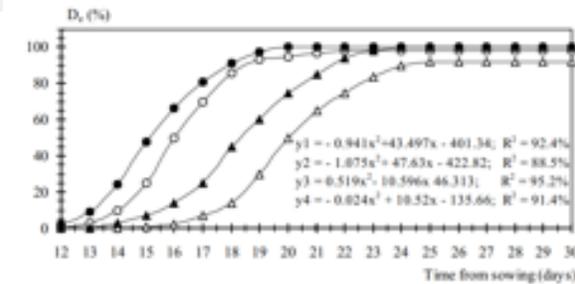
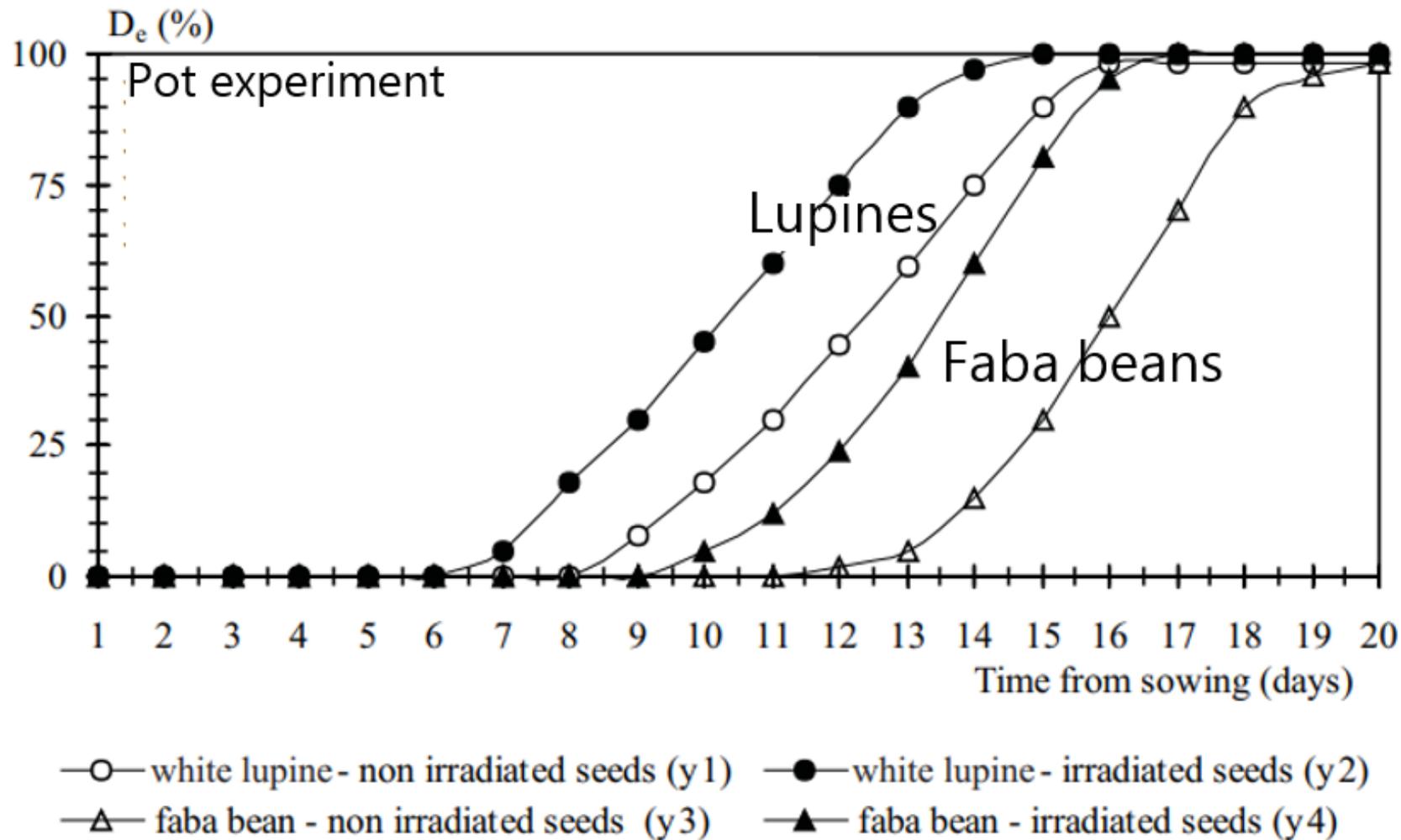
Seeds were treated directly on the seed surface, and thereafter covered with 2.5 or 5 mm of soil



Increasing energy exposure to the wheat (*Triticum aestivum*) seed surfaces resulting in increasing infection with fungi. At the highest dose (15.9 J mm⁻²) all seeds became black after 10 days, but the germination percentage remained high.

Andreasen et al. (2024) Laser weed seed control: challenges and opportunities

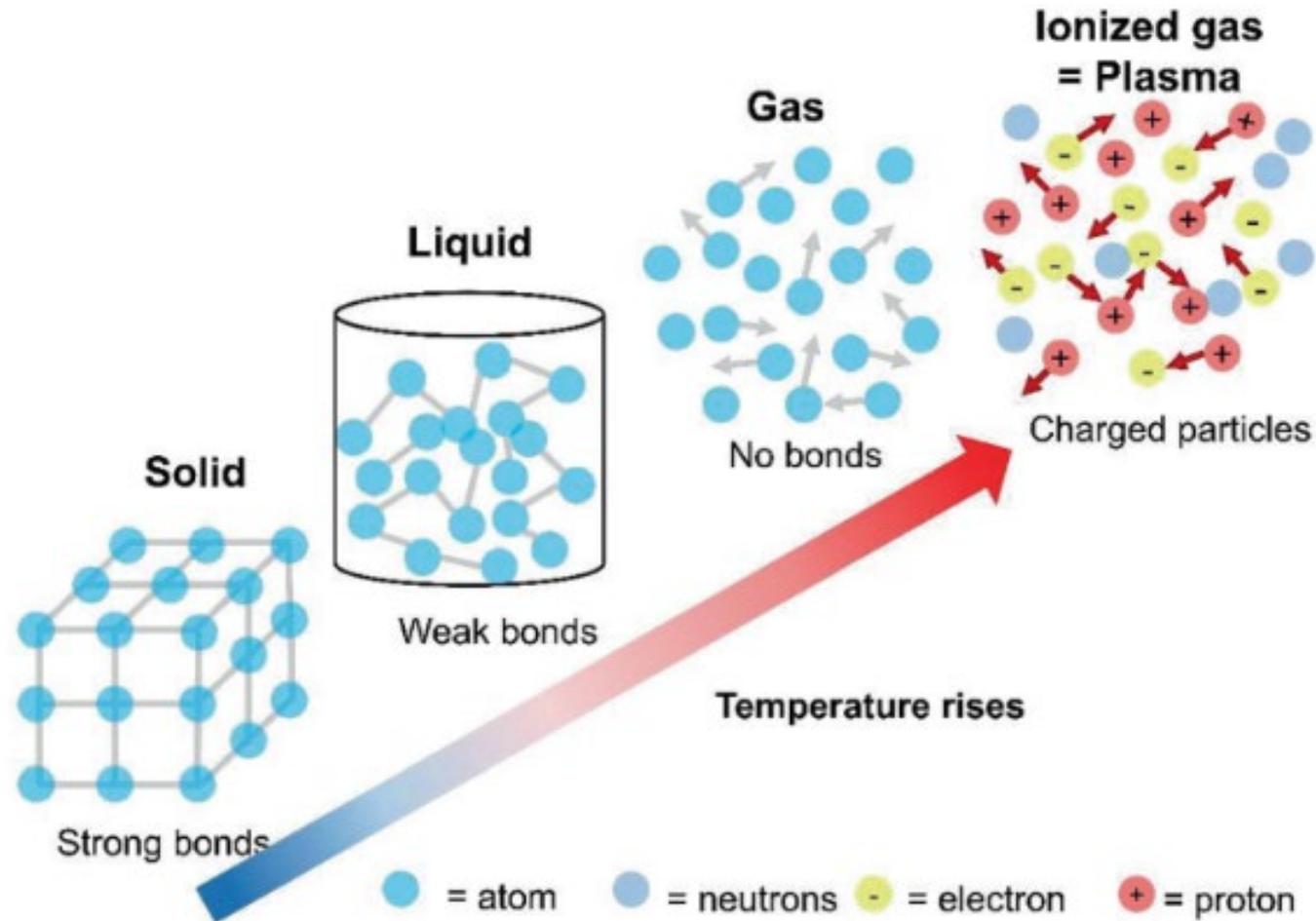
Helium-neon laser treatment of seeds



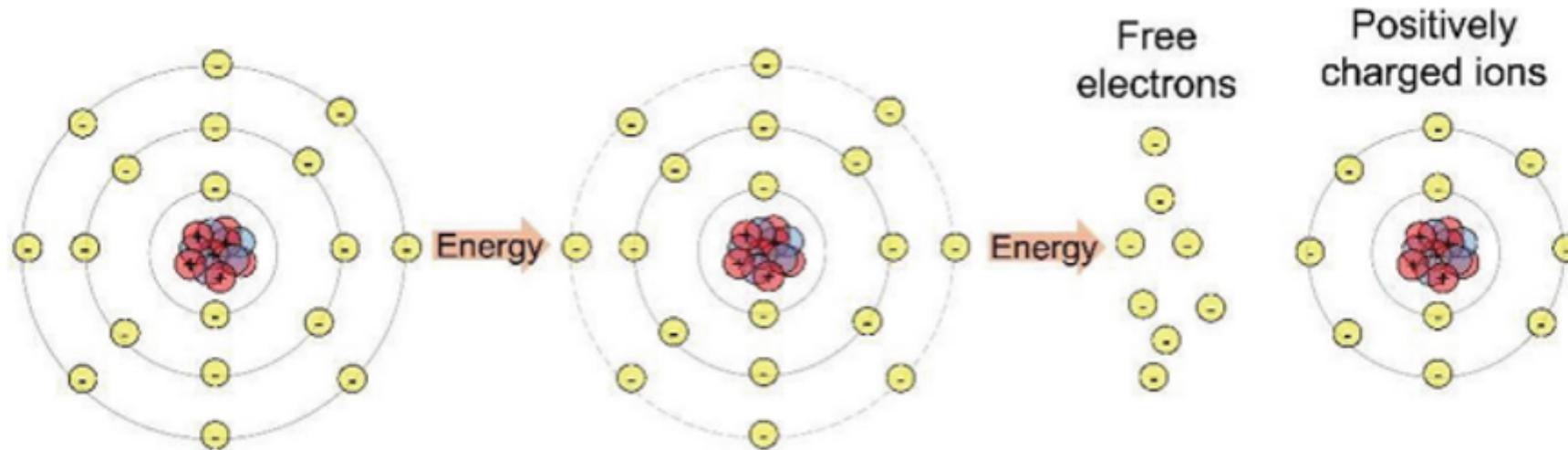
(From Podlesny and Podlesna, (2004), Int. Agrophysics, 18, 253-260)

Plasma

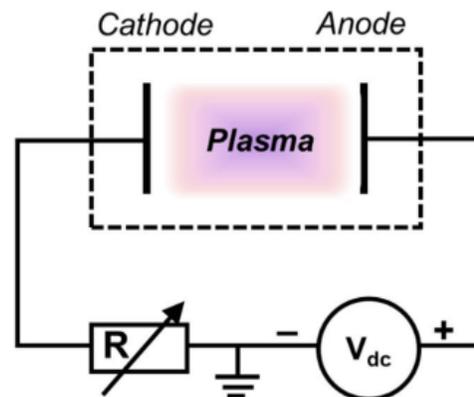
States of the matter



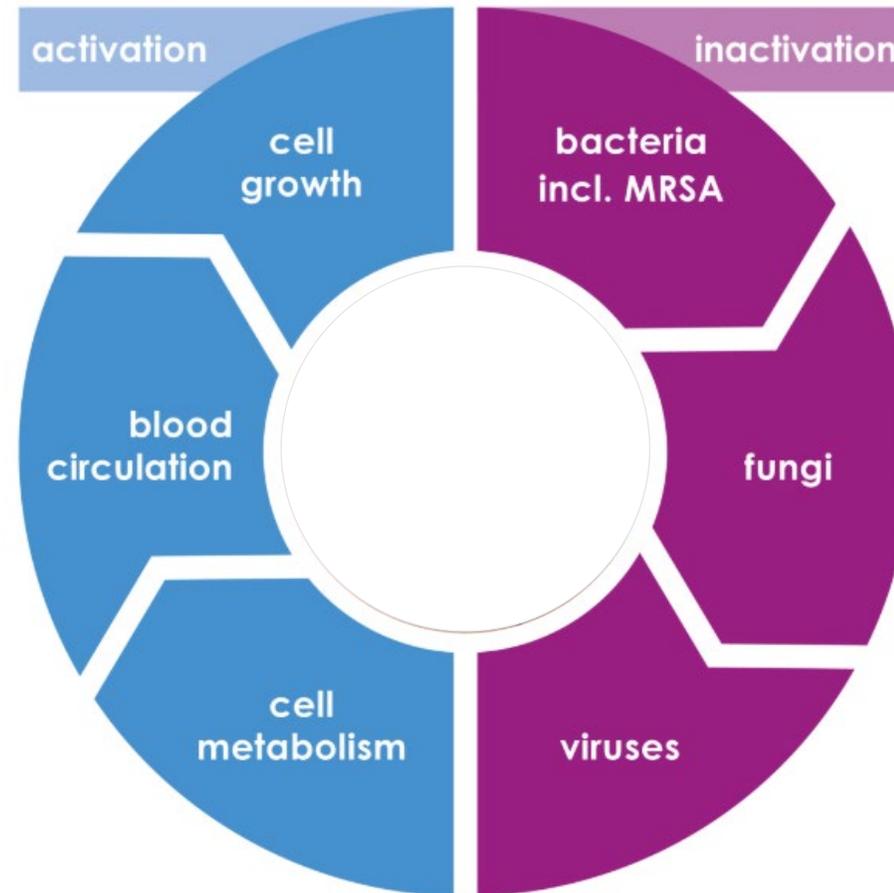
Electron configuration of Argon



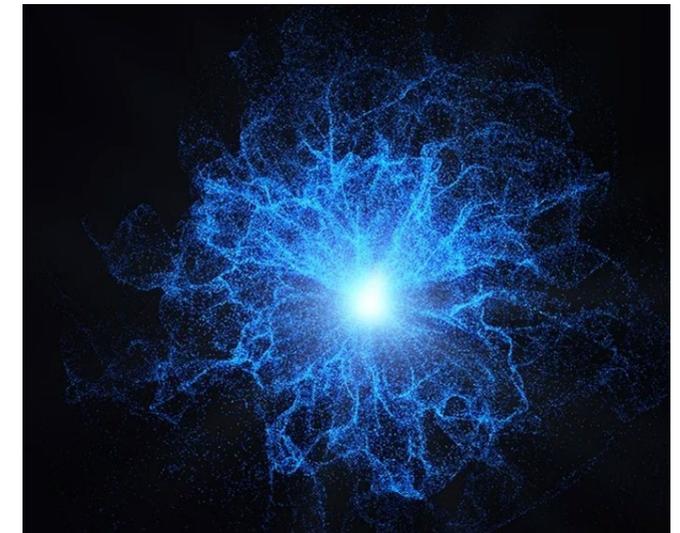
Argon contains 18 electron, 18 protons and 22 neutrons; after adding energy Such as heat, an electron leaves an atom to form positive charges ions.



Plasma treatment



A plasma consists of **positive ions**, **negative electrons**, neutral molecules, **UV light** and excited molecules, which can possess a massive amount of internal energy.

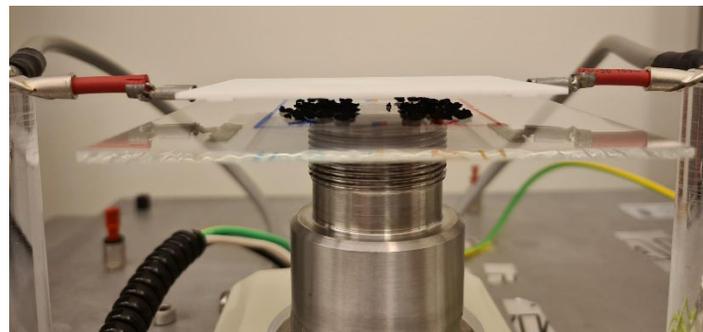
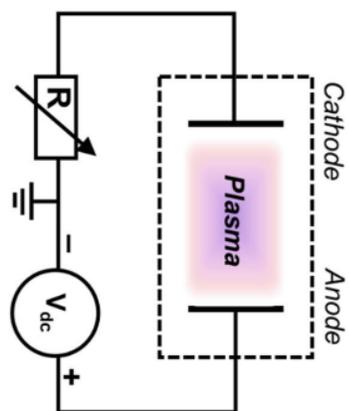


Plasma technology is commonly used in many industries, including in the automotive, microelectronics, packaging and medical device industries.

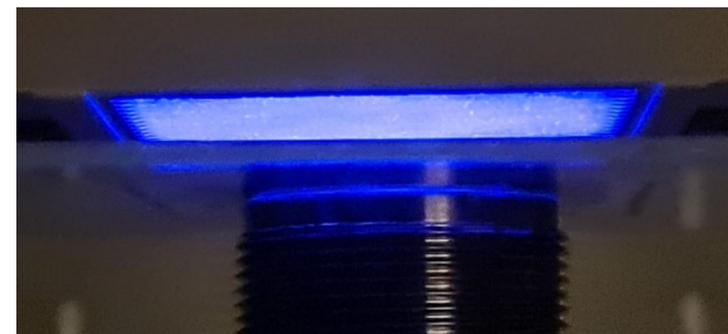


Prof. Eugen Stamate,
ORBIT, DTU

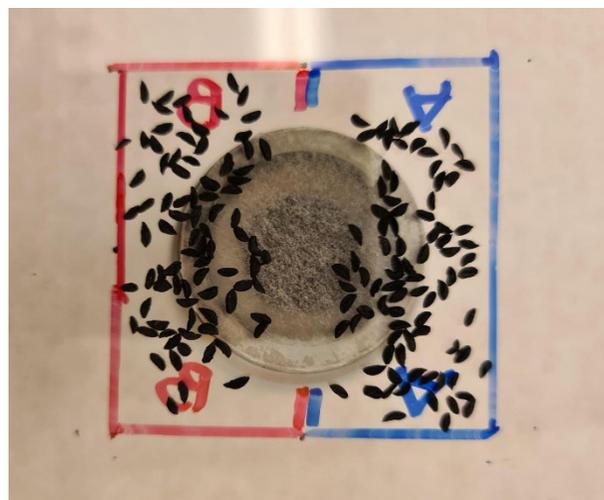
Plasma treatment set-up



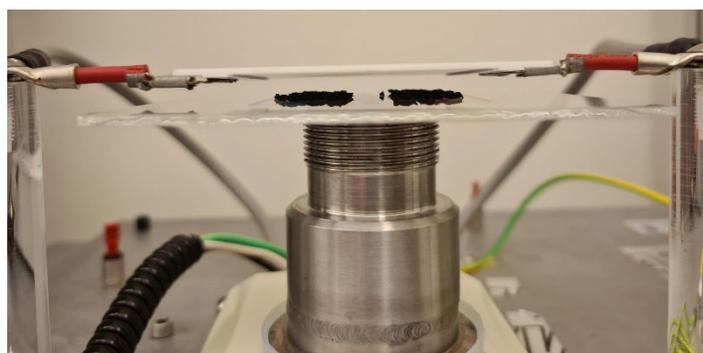
A and B seeds on glass placed below the plasma source



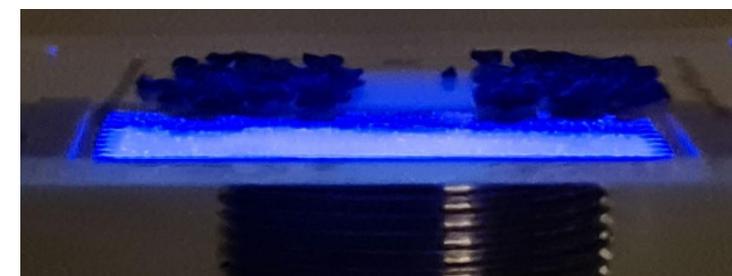
Plasma on, active area view (plasma on top of seeds)



A and B seeds placed on glass
Total treatment area 50 x 50 mm²

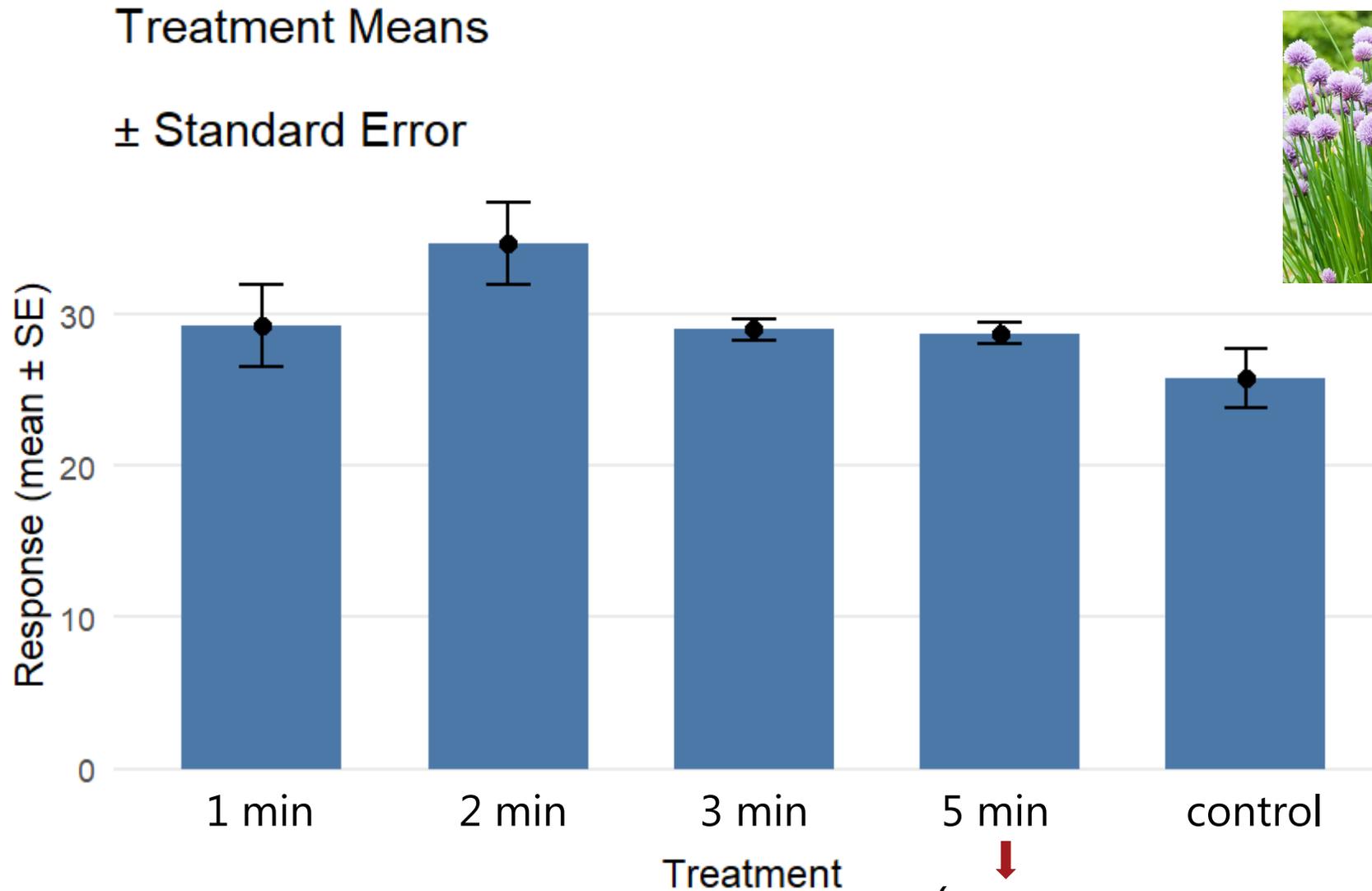


Visualization of the plasma source to glass surface: 5 mm



Seeds on glass during plasma on (the discharge is reflected on glass)

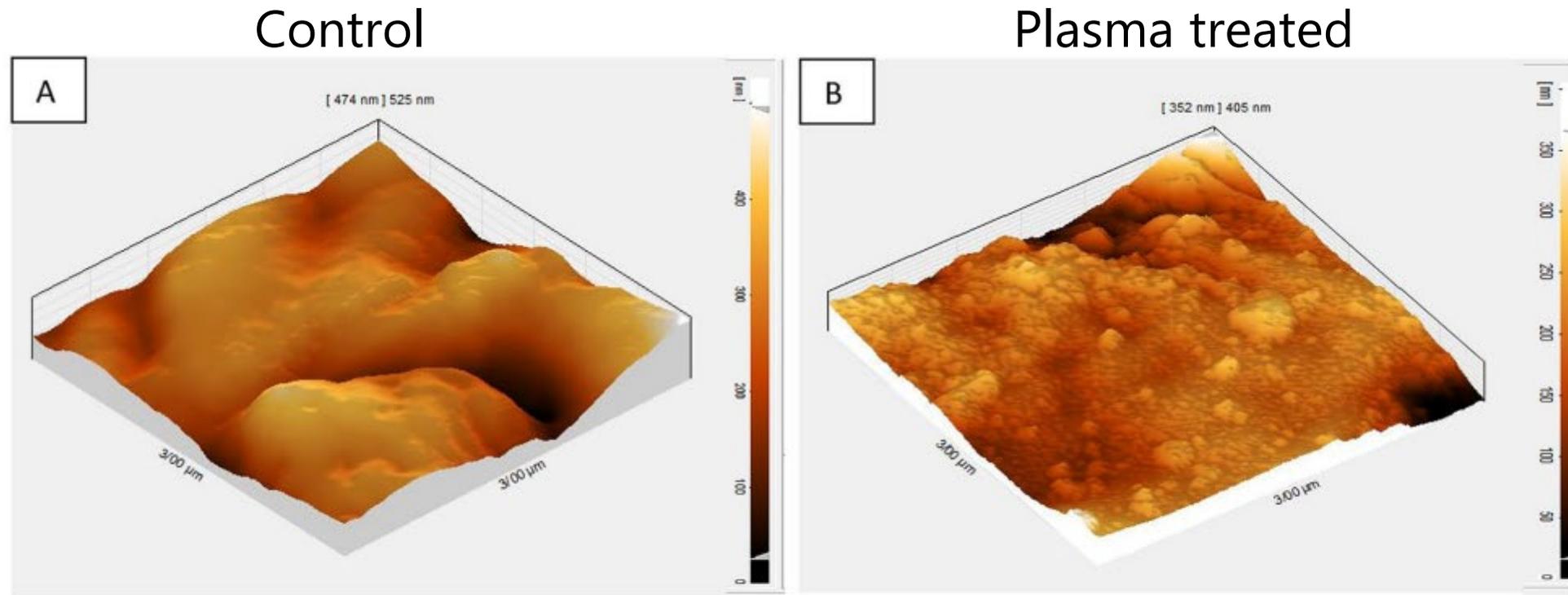
Plasma treatment with a coplanar barrier discharge (CBD)



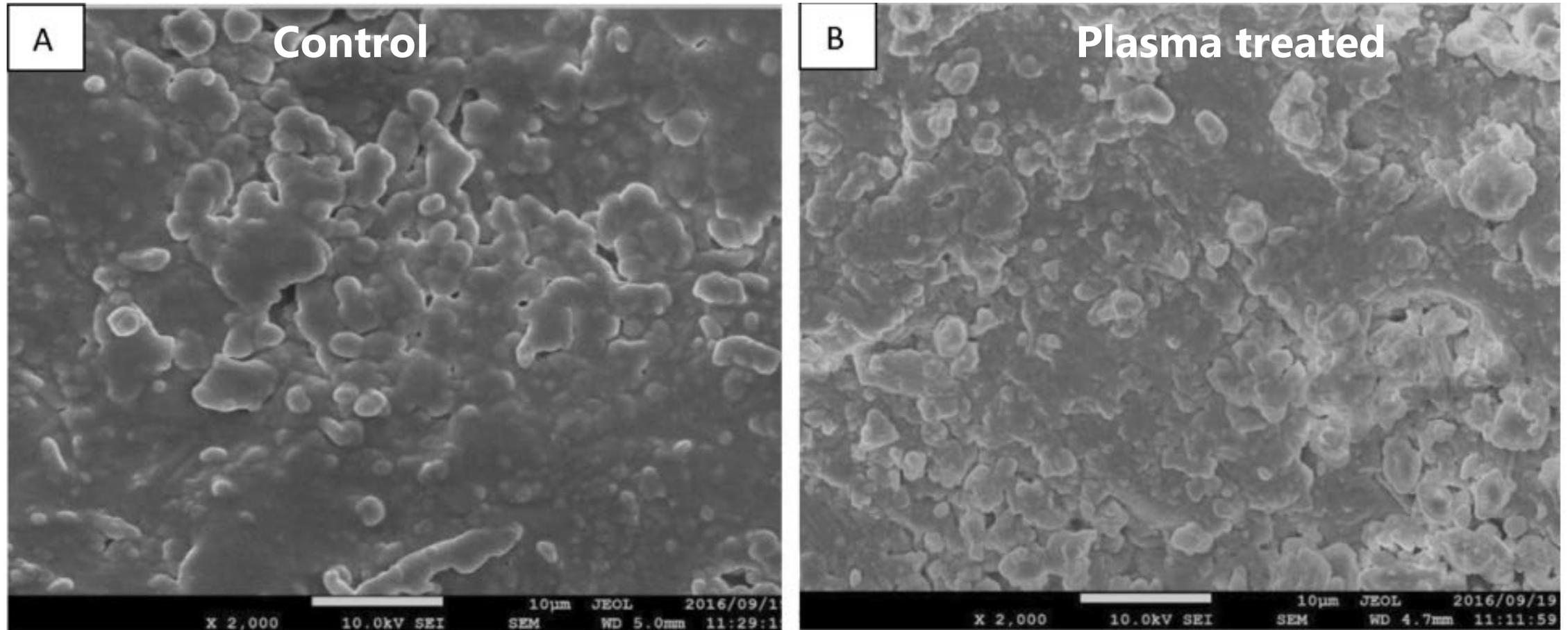
Chive seeds
from



Surface of wheat kernel (A) without and (B) with plasma treatment

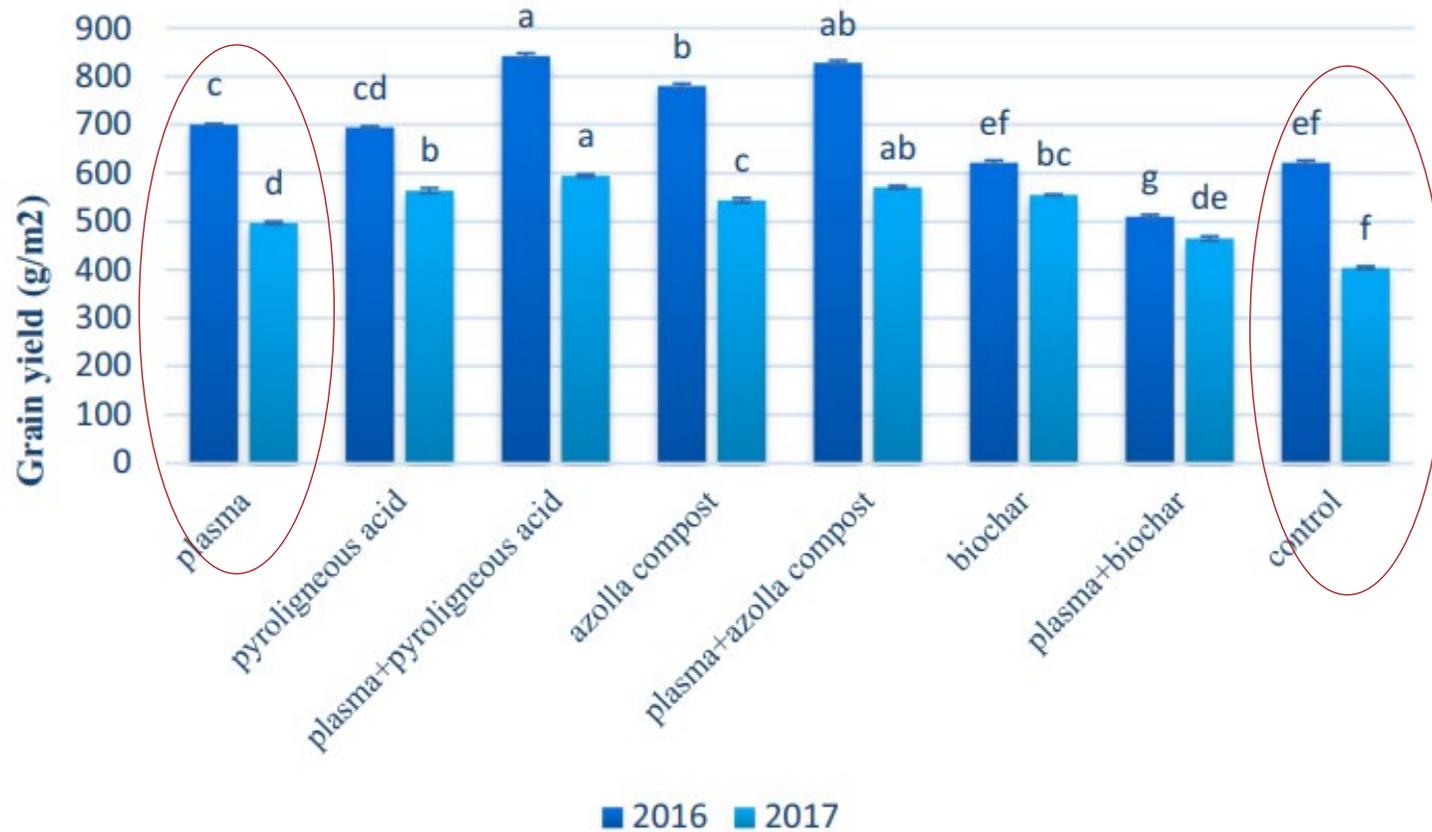


Atomic force microscope (AFM) image of wheat seed surface at 10 µm. **(A)** control Without plasma and **(B)** Seed surface after receiving 180 s, 50 W plasma treatment. Images were taken from identical locations on the dorsal side of the wheat kernels.



Scanning electron microscopy (SEM) image of seed surface of wheat seed surface at 10 µm. **(A)** control without plasma and **(B)** Seed surface after receiving 180 s, 50 W plasma treatment. Images were taken from identical locations on the dorsal side of the wheat kernels.

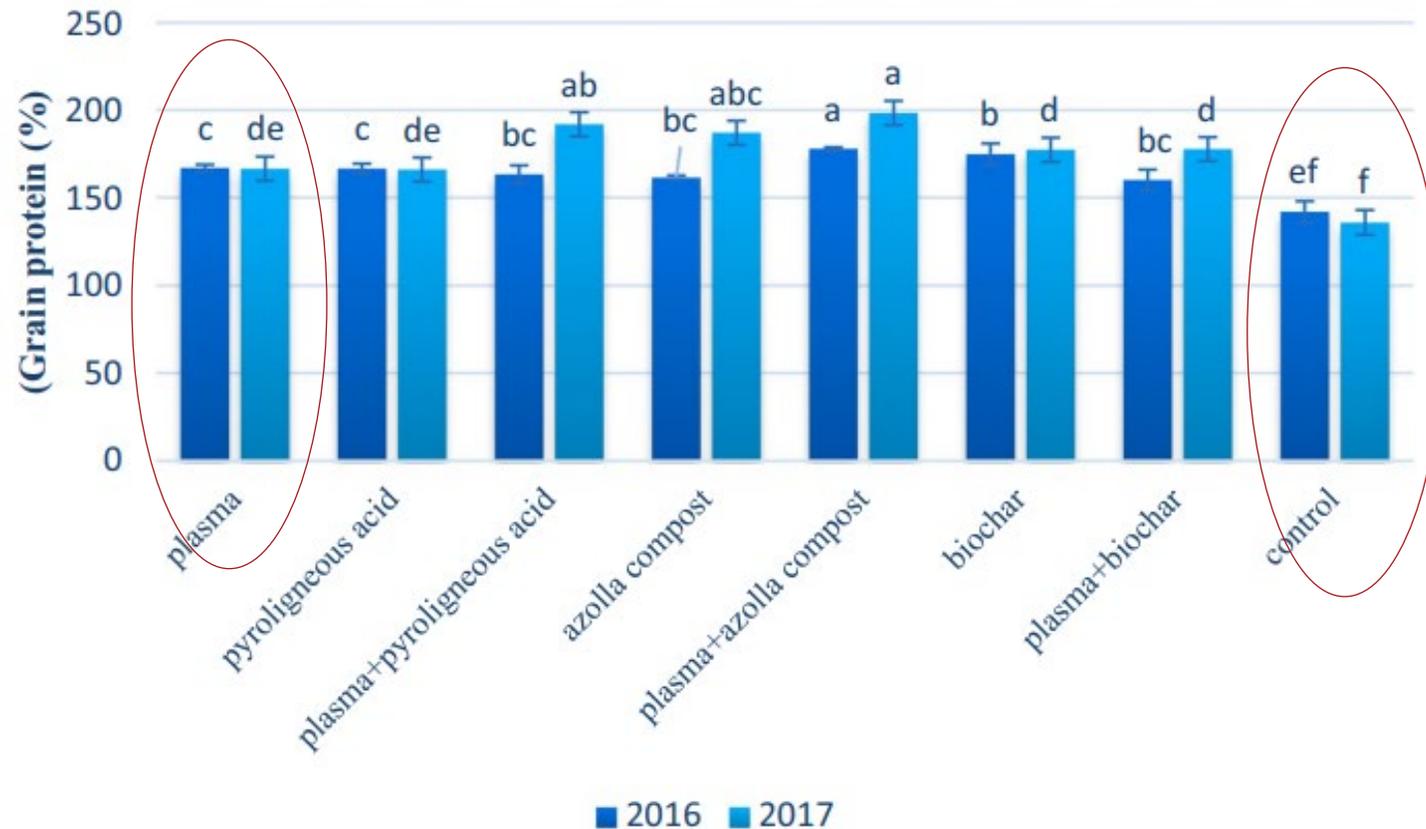
Grain yield



Mean comparison of effect of application of plasma, pyroligneous acid, azolla compost and biochar on grain protein of wheat

(From Saberi, M., Ghomi, H., Andreasen C., 2022)

Content of grain protein



Mean comparison of effect of application of plasma, pyroligneous acid, azolla compost and biochar on grain protein of wheat (Saber, M., Ghomi, H., Andreasen C., 2022).

Using low-pressure plasma for *Carthamus tinctorium* L. seed surface modification

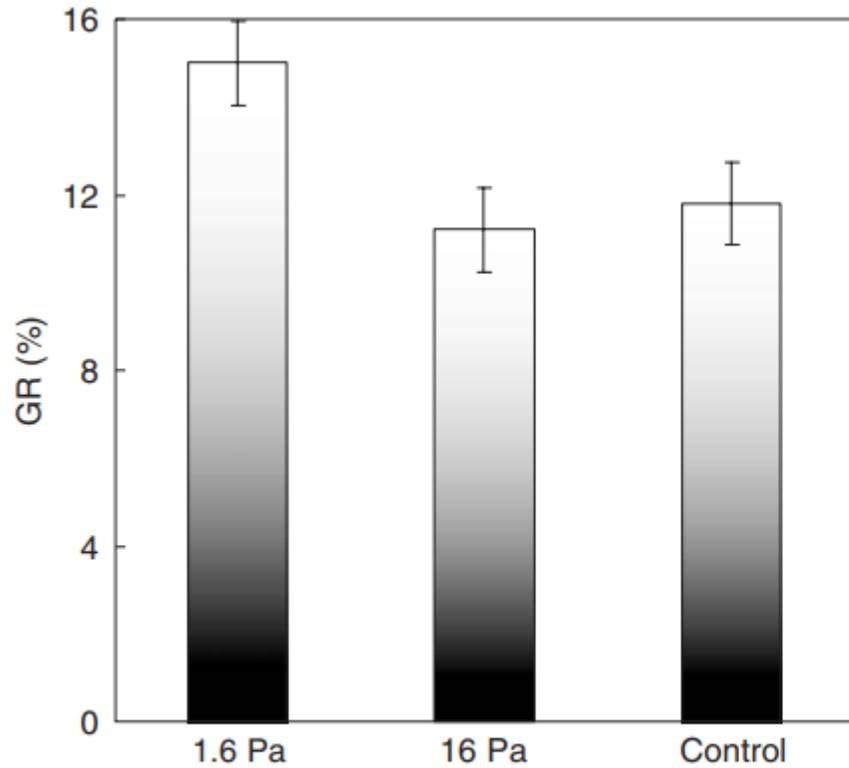


Fig. 3. Percentage of germination rate plotted for control and plasma-modified *C. tinctorium* L. *semen* at two different pressures at constant 20 W RF power and 30 min treatment time. Germination rate (GR).

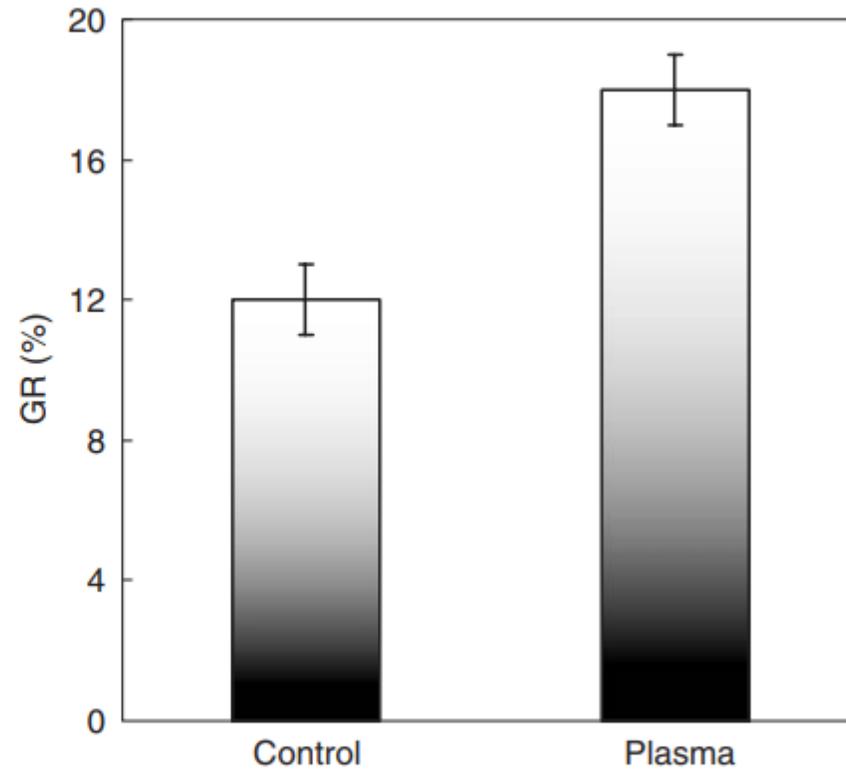


Fig. 4. Percentage of germination rate plotted for control and plasma-treated *C. tinctorium* L. *semen* at 16 Pa pressure, 20 W RF power and 130 min treatment time. Germination rate (GR).



Safflower

Conclusion

- There are some promising examples showing that laser beams and plasma treatment can improve seed germination
- The effect depends on the laser used (e.g., wavelength, energy) and the plant species
- The effect is mainly on the seed surface
- However, there is also a risk that the wrong dose can harm the seeds
- Much more research is needed to study and optimize the methods