Technology Networks

How Does Cold Plasma Enhance Seed Germination and Plant Growth?

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Feeding the world

When we think about the greatest threat facing humanity, we tend to picture climate change and antibiotic resistance, not what we are going to have for dinner. But the truth is, our need for food poses one of the biggest challenges to the planet.

According to an estimate by the Food and Agricultural Organization of the United Nations (FAO), by 2050 the world's population will reach 9.1 billion – almost all of this increase will occur in developing countries (1). To feed that many people, world food production will need to increase vastly, and food production in the developing world will need to *double*. By 2050 we will need to feed two billion more people. Is there a way to do that?

To respond to the growing need for food worldwide, farmers will need new technologies to produce more food from less land. It is therefore necessary to improve crop production techniques and enhance the germination of seeds.

Limitations of conventional methods are creating a large demand for new technologies. One method recently tested by researchers for its potential to improve germination is cold plasma technology – a non-thermal and environmentally friendly method which offers unique advantages over traditional processing technologies.

What exactly is cold plasma?

For those unfamiliar with plasma, the simplest way to think of it is as one of the four states of matter observable in everyday life, with the other three being solid, liquid, and gas. Most people interact with plasmas on a daily basis - examples include our TVs, neon lights, and plasma balls – those clear glass balls with bolts of electricity, which draw a colorful strand of light to your finger when you touch it.

Plasma can be observed in lightning, the aurora borealis, and the Sun – in fact, it is estimated that 99.9 % of the Universe is in a plasma state, however, very few natural plasmas are generated here on Earth (2). Based on the relative temperatures of electrons, ions, and neutral particles, plasmas are classified as

“thermal” (hot) and “non-thermal” (cold). The latter has been investigated recently for applications in food processing, as it operates at low temperatures, which helps in retaining the quality of food products (3).

In laboratory conditions, cold plasmas are artificially generated from neutral gases, creating a cocktail of different chemical species such as positive ions, negative electrons, excited atoms, UV photons, radicals and reactive neutral species such as reactive oxygen (ROS) and nitrogen species (RNS) (4).

Tests are showing promising results

Cold plasma technology can be applied during different stages of agricultural food production, including treatment of seeds for the promotion of germination rates and plant growth, which can increase crop yields and shorten harvest time. How effective the treatment is going to be depends on the type of seed, as well as environmental factors, such as climate, water availability, and soil conditions. Therefore, the time of plasma treatment has to be optimized for each type of seed individually (5).

Several publications and patents since the 1990s have shown enhancements of seed germination and the research is still ongoing (6). Improvement of germination, longer shoots and roots of the seedlings, and higher yields of plasma-treated seeds have been reported by several authors using various seeds, including wheat (7–10), maize (11), soybeans (12), and tomato (13).

Another interesting approach is using water exposed to plasma, that is “plasma-activated water” (PAW), for watering the seeds – this type of solution may work effectively as a fertilizer. Chiara Lo Porto from the University of Bari, a lead researcher of a study demonstrating increased rates of germination and plant growth of soybeans (14), explains: “Thanks to the plasma treatment, PAW is

enriched with a cocktail of chemical active species called RONS (Reactive Oxygen and Nitrogen Species). Among these species, nitrates and hydrogen peroxide have a fertilizing effect on the growth of the plants."

"Moreover, they stimulate a chemical and hormonal response in the seed that breaks its dormancy by weakening the endosperm (i.e. the coat of the seed) and moving the stocked-up resources of the seed to a ready-to-use location. This allows the seedling to erupt easily from the seed and to grow faster and healthier." – she adds.

How exactly does this purple gas boost plant growth?

Although many studies investigated the effects of plasma on seeds, the mechanisms resulting in germination enhancement and promotion of plant growth are not entirely clear – the overall result can be a combination of various factors:

- Changes in seed surface wettability resulting in increases in water absorption (15,16) - less irrigation water would be needed for plant growth, which would be particularly important in countries in which water resources are limited.

- Breaking the seed dormancy – reactive species, formed during plasma discharge, such as nitric oxide, can break the seed dormancy and lead to faster germination (17).

- Seed coat erosion - some seeds require scratching or nicking of the hard seed coat to allow moisture to enter the seed to begin the germination process – it was observed that as a result of plasma treatment seeds often have a slightly damaged surface (18,19).

- Removal of microorganisms (18,20) - cold plasma treatment inactivates bacteria and fungi present on the seeds, which means that plasma-treated seeds would be less likely to pose health risks related to microbial contamination and cause economic losses.

Other applications and the future of cold plasma for food processing

Plasma technologies have demonstrated their potential for seed processing in many different aspects -Aside from microbial decontamination and germination improvement, cold plasma is also a promising technology for insect control in stored grains (21), degradation of pesticides (22) and the removal of mycotoxins (23,24).

Overall, the economical and environmentally friendly nature of cold plasma offers unique advantages over traditional seed processing techniques. According to Keener & Misra (25), the future looks very promising for the use of this technology in the food industry and the opportunities are only limited by the creativity of the inventor. They report that cold plasma research on food has grown exponentially with more than 100 papers published every year.

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