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Plasma treatment on maize seeding for enhance seed performance and resistance

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Introduction:

Plasma treatment is an innovative technique used to enhance seed performance and resistance in agriculture. In maize cultivation, plasma treatment of seeds has shown promising results in improving germination rates, resistance to diseases, and overall seed vigour. Plasma treatment involves exposing seeds to a low-temperature plasma, which is an ionized gas consisting of ions, electrons, and neutral particles. This process is usually carried out in a controlled environment using a plasma generator. The treatment modifies the seed surface properties without significantly altering the internal structure of the seed. Plasma is a partially or fully ionized gas that can be ignited at low atmospheric conditions and consists of charged species (electrons and negative and positive ions), neutral species (atomic and/or molecular radicals and non-radicals), electric fields, and photons. One of the earliest applications of plasma for treatment of seeds was studied in early 1960s, when the effects of glow discharge on cotton, wheat, alfalfa, red clover, sweet clover, beans, and several varieties of grass seeds were investigated.

It was shown that the plasma treatment influences seed germination, moisture adsorption, and apparently reduces hard-seed content in legumes. Plasma treatment can increase the rate and uniformity of seed germination by improving water absorption and breaking seed dormancy. Plasma treatment can effectively reduce seed-borne pathogens, such as fungi and bacteria, by disrupting their cellular structures. It can also induce systemic resistance in seeds, making the resulting plants more resistant to diseases. Treated seeds often show improved seedling vigour, which can lead to stronger and more resilient plants. Plasma treatment can modify the seed coat, enhancing its permeability to water and nutrients, which facilitates better seedling growth. This method is environmentally friendly as it reduces the need for chemical seed treatments, which can have adverse effects on the environment and human health.

Plasma Treatment has both physical as well as chemical effects on seeds. Physically, the plasma treatment causes etching and ablation of the seed coat, which increases its surface roughness and improves water uptake.

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Whereas, chemically reactive species generated during plasma treatment, such as reactive oxygen species (ROS) and reactive nitrogen species (RNS), can interact with seed surface molecules, enhancing seed metabolism and defence mechanisms. The biological avenues of plasma treatment have shown that the reactive species can also inactivate pathogens present on the seed surface, reducing the incidence of seed-borne diseases.

Certain cautions are required for Plasma Treatment as specialized plasma generators are required to produce the necessary plasma conditions for seed treatment. These generators can vary in design, including dielectric barrier discharge (DBD) and radio-frequency (RF) plasma systems. Key parameters such as treatment time, plasma power, and gas composition (e.g., air, oxygen, nitrogen) need to be optimized for effective treatment without damaging the seeds. Seeds must be handled carefully during treatment to ensure uniform exposure to plasma and prevent physical damage. Studies have shown that plasma-treated maize seeds exhibit higher germination rates and more robust seedling growth compared to untreated seeds. Research has indicated a significant reduction in seed-borne pathogens and enhanced resistance to soil-borne diseases in plasma-treated seeds. Field trials have reported increased maize yields from plasma-treated seeds due to improved plant health and vigor. Plasma treatment is a promising technology for enhancing maize seeding resistance and overall performance. It offers multiples benefits, including improved germination, increased disease resistance, and better seedling vigor, all while being environmentally friendly. With continued research and development, plasma treatment could become a standard practice in maize cultivation, contributing to sustainable agricultural practices and higher crop productivity.