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Plasma-Assisted Nitrogen Fixation for the Elevation of Seed Germination and Plant Growth

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Abstract : Plasma-assisted nitrogen fixation is a process by which atomic nitrogen generated by plasma is converted into ammonia (NH_3) or related nitrogenous compounds. Nitrogen fixation is essential to plant because fixed inorganic nitrogen compounds are required to them for the biosynthesis of all nitrogen-containing organic compounds, such as amino acids and proteins, nucleoside triphosphates and nucleic acid. Most of our atmosphere is composed of nitrogen; however, the plant cannot absorb it directly from the air ambient. As a portion of the nitrogen cycle, nitrogen fixation fundamental for agriculture and the manufacture of fertilizer. In this study, plasma-assisted nitrogen fixation was performed by exposing a non-thermal atmospheric pressure nitrogen plasma generated a sinusoidal power supply (with an applied voltage of 10 kV and frequency of 33 kHz) on a water surface. Besides this, UV excitation of water molecules at the water interface was also done in order to disassociate water. Hydrogen and hydroxyl radical obtained from this UV photolysis electrochemically combine with nitrogen atom obtained from plasma. As a result of this, nitrogen fixation on plasma-activated water (PAW) significantly enhanced. The amount of nitrogen-based products like NO_x and ammonia (NH_3) synthesized by this combined process of UV and plasma are 1.4 and 2.8 times higher than those obtained by plasma alone. In every 48 hours, 20 ml of plasma-activated water (pH≈3.15) for 10 minutes with moderate concentrations of NO_x, NH_3 and hydrogen peroxide (H_2O_2) was irrigated on each corn plant (Zea Mays). It was found that the PAW has shown a significant impact on seeds germination rate and improved seedling growth. The result obtained from this experiment suggested that crop yield could increase in a short duration. In the future, this experiment could open boundless opportunities in plasma agriculture to mobilize nitrogen because nitrite, nitrate, and ammonia are more suitable for plant uptake.

Keywords : plasma-assisted nitrogen fixation, nitrogen plasma, UV excitation of water, ammonia synthesis
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