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# Germination improvement of fenugreek (*Trigonella foenum-graecum*) seeds with cold plasma: Exploring long-lasting effects of surface modification

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Pre-sowing cold plasma (CP) treatment of seeds is a well-established method for enhancing seed germination and plant growth[1]. This paper investigates the long-term effects of CP treatment on fenugreek (*Trigonella foenum-graecum*) seeds to understand the fundamental mechanisms of plasma action and to lay the groundwork for future field experiments. Seeds were treated briefly (10 and 20 seconds) with the kINPen 11 plasma jet and stored for three months before sowing. Post-storage, the treated seeds demonstrated higher germination rates, with seedlings growing longer and more vigorously than untreated ones. The most significant improvement in germination was observed with a 20-second treatment. Despite age-related hydrophobic recovery, plasma-treated seeds consistently showed better wettability than the control group, although no direct link between wettability and germination improvement was found. Scanning electron microscopy (SEM) showed increased surface roughness and micro structuring of the seed coat's outer layers following plasma treatment, while X-ray photoelectron spectroscopy (XPS) indicated a rise in the O/C ratio and the presence of calcium and potassium. These results suggest that argon plasma etches the seed coat's outermost layer, leading to structural changes.

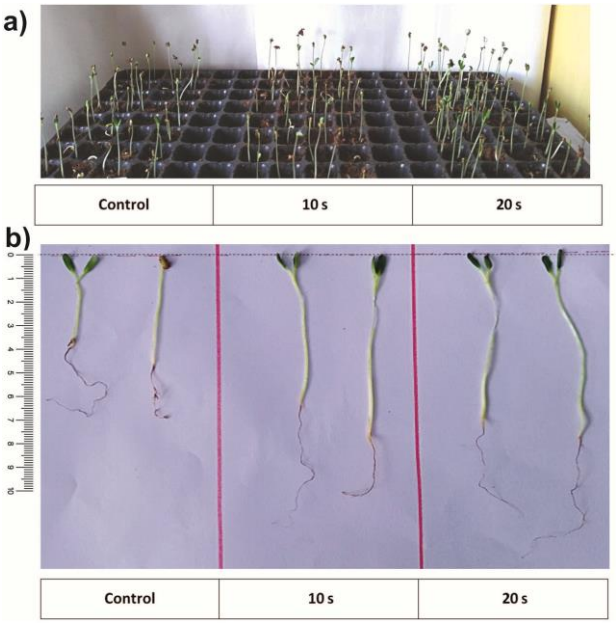


Figure 1: Photograph of fenugreek seeds sown and germinated in a tray filled with cocopeat.

It is believed that these lasting changes in the seed coat structure, which may disrupt its tissues and allow easier access to the seed's interior, contribute to the observed faster germination and growth of plasma-treated seeds[2,3]. This mechanism can be described as plasma scarification of the seed. This study demonstrates the potential of cold plasma technology as an effective and straightforward method for enhancing seed germination and plant growth over the long term, with significant implications for agriculture.

References

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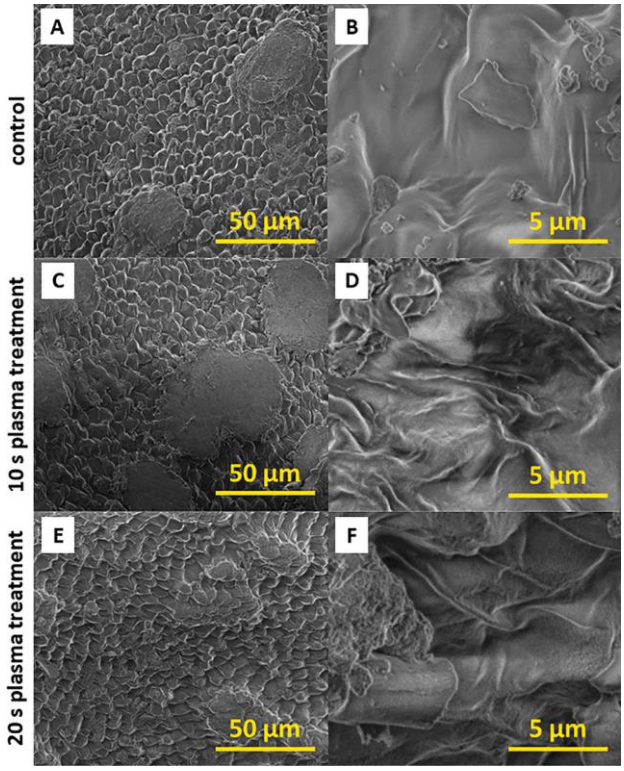


Figure 2: SEM images of the surface of fenugreek seeds