



Atmospheric DBD Plasma Improves Agronomic Traits in Brassica juncea

Jaydeb Kundul, Soumya Kanti Sarkar¹, Arunava Bhattacharya², Nadir Hossain³ and S Chandra^{4,5,*}

¹Dept. of Physics, Kaliyaganj College, Kaliyaganj, 733123, India ²Tata Consultancy Services, Kolkata, 700156, India

³ Dept. of Physics Raiganj Surendranath Mahavidyalaya, Raiganj, 733134, India

⁴ Gourmmeri General Degree College, Kushmandi, 733121, India

⁵ Institute of Natural Sciences and Applied Technology, Kolkata 700032, India

Abstract:

This study investigates the effects of atmospheric-pressure dielectric barrier discharge (DBD) plasma treatment on the agronomic performance of Brassica juncea (L.) Czern. (brown mustard). Seeds were exposed to DBD plasma for varying durations (1-10 min) and subsequently evaluated for germination kinetics, seedling growth parameters, disease resistance, and ultimate crop yield. Results demonstrated that plasma treatment significantly enhanced germination rates by up to 25% compared to untreated controls, with concomitant improvements in radicle elongation and seedling vigor. Treated plants exhibited increased resistance to *Alternaria brassicae* infection, correlated with elevated activity of defense-related enzymes (peroxidase, phenylalanine ammonia-lyase). Field trials revealed a 15-20% increase in harvestable yield for plasma-treated cohorts. Spectroscopic analysis confirmed the generation of reactive nitrogen species during treatment, suggesting their role in eliciting plant defense mechanisms. Notably, DBD plasma application effectively reduced seed-borne pathogen load without chemical fungicides, indicating its potential as a sustainable pre-sowing treatment. These findings establish DBD plasma as a viable physical seed enhancement technology for improving productivity and disease management in B. juncea cultivation.

Keywords: Cold plasma, Brassica juncea, seed priming, plant immunity, non-thermal plasma, seed-borne pathogens, sustainable crop protection.

1. BASICS:

1.1 INTRODUCTION TO COLD ATMOSPHERIC DBD PLASMA IN AGRICULTURE :

Dielectric barrier discharge

(DBD) plasma is a type of non-

thermal plasma that operates at atmospheric pressure,

generating a cocktail of reactive oxygen, nitrogen species (RONS). These species have antimicrobial and bioactive effects and can alter seed surface chemistry, influence metabolic

pathways, and activate plant defense mechanisms. When applied to seeds, DBD plasma modifies germination behavior, early growth kinetics, and immunity responses—all without the need for synthetic chemicals.

The demand for sustainable pre-sowing technologies is growing, especially in the context of food security and climate-resilient farming. Plasma-based seed treatments offer a residue-free, energy-efficient method for improving productivity and reducing crop losses due to pathogens. This study focuses on *Brassica juncea*, a widely cultivated oilseed crop in South Asia.

1.2 Objective of the Study

The aim of this study was to examine the agronomic effects of DBD plasma treatment on *Brassica juncea* seeds. The treatment durations (1-10 minutes) were tested to determine optimal exposure for maximum benefits. Parameters assessed included germination efficiency, seedling vigor, disease resistance against *Alternaria brassicae*, and overall yield improvement under field conditions. Biochemical analysis was also conducted to understand the mechanism behind disease tolerance and growth enhancement.

2. EXPERIMENT

2.1 Materials and Plasma Exposure

Certified *Brassica juncea* seeds were selected and divided into control and treatment groups. Atmospheric DBD plasma was generated using a custom-built electrode system powdered under ambient air. Seed batches were exposed to plasma for varying durations (1, 3, 5, 7, and 10 minutes). The treatment was performed under room temperature without damaging the seed coat integrity.

Post-treatment, the seeds were sown in controlled greenhouse trays for germination trials and in open field plots for agronomic evaluation. Soil conditions, temperature, and irrigation were kept uniform across all experimental replicates.

2.2 Growth and Disease Resistance Assessment

Parameters studied included germination percentage, mean germination time (MGT), seedling length, and fresh biomass. Disease resistance was evaluated using inoculation with *Alternaria brassicae* spores under controlled infection. The degree of infection and lesion formation were recorded, along with enzymatic assays to quantify peroxidase and phenylalanine ammonia-lyase (PAL) activity, two biomarkers of plant defense.

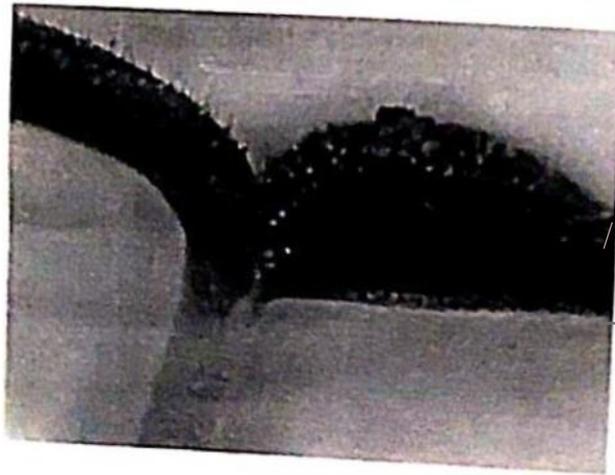
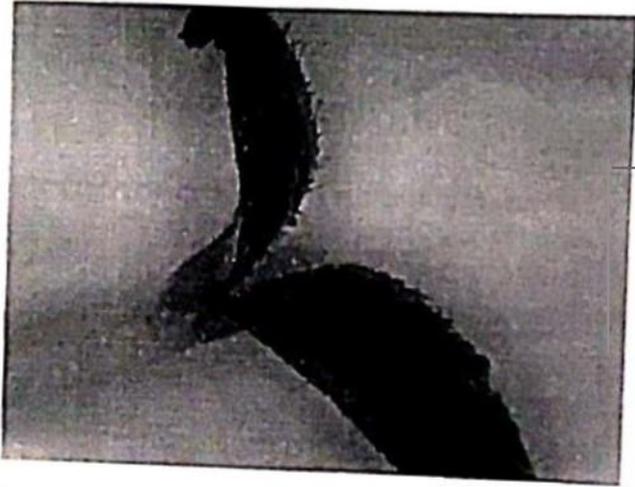
Yield was measured at maturity in terms of seed weight per plant and overall plot yield. Microbial analysis was conducted to evaluate seed-borne pathogen suppression due to plasma exposure.

3. FINDINGS + IMAGES

Enhanced Germination and Seedling Vigor

Seeds treated with 3-5 minutes of plasma showed significantly enhanced germination (up to 25% over *control*) and more rapid radicle emergence. The seedlings displayed greater length and mass,

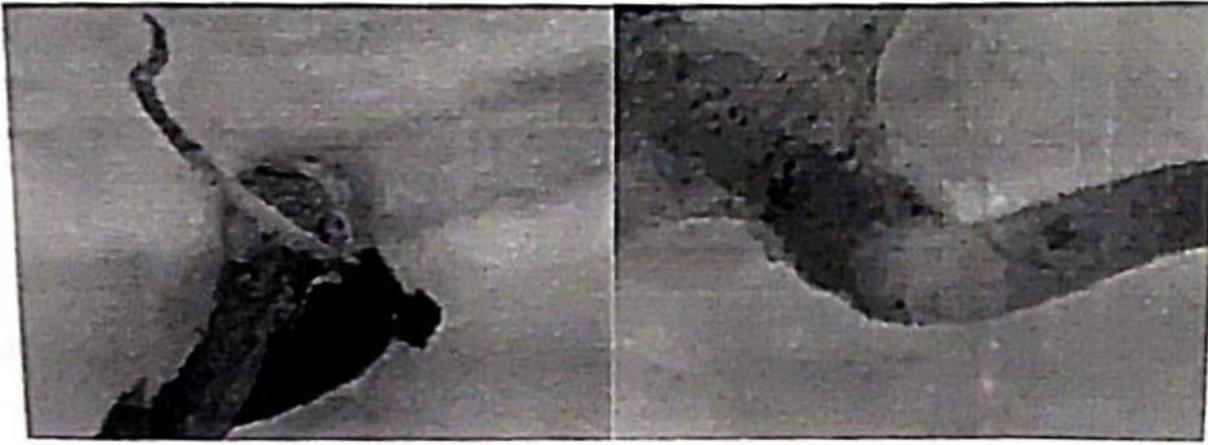
indicating accelerated early growth. Prolonged exposure beyond 7 minutes began to show reduced benefit or mild oxidative stress symptoms.



The seeds treated with PAW for 10 minutes and the sprouts after 5th day. Leaf follicles are clearly visible.

improved Disease Resistance and Yield: *plasma*-treated plants were more resilient to *Altemaria Brassicae* infection, with reduced lesion formation and faster recovery. This resistance correlated with increased enzymatic defense markers—peroxidase and PAL levels were elevated by 30-40% over control groups.

Field Yield data revealed a 15-20% increase in harvestable seed mass for plasma-treated plots, validating the effectiveness of DBD treatment in real-world agronomic settings.



The roots on left rots early than that below (PAW treated)



The plasma treated seeds show rapid growth of secondary root system.

4. CONCLUSION

4.1 1 Summary of Results

Atmospheric DBD plasma treatment serves as an efficient pre-sowing tool for improving both germination and field productivity of *Brassica juncea*. Moderate treatment durations (3-5 min) led to enhanced seedling growth and increased resistance to fungal infections. The stimulation of plant defense enzymes and the presence of reactive species during plasma exposure contribute to these beneficial effects.

This technology offers a clean, scalable solution for improving crop performance without the use of chemical pesticides or fertilizers. It aligns well with the goals of sustainable agriculture and eco-friendly farming.

4.2 Future Scope

Further optimization is needed to tailor plasma dose and exposure for different crops. Integration with automated seed priming systems and multi-season field trials will help validate long-term benefits. Research into plasma-induced epigenetic or metabolic changes in plants can deepen our understanding of this promising agro-technology.

5. References

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