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The effects of different gas phase composition low-pressure plasma treatment of red clover (*Trifolium pratense*) seeds on seed germination and morphological parameters of seedlings

Z. Naučienė[1], G. Petrauskas[2], E. Norkeviciene[2], L. Degutytė-Fomins[1], Mildažienė[1], R. Žūkienė[1], K. Koga[3], M. Shiratani[3]

[1] Faculty of Natural Sciences, Vytautas Magnus University, Lithuania; [2] Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, Lithuania;

[3] Department of Electronics, Faculty of Information Science and Electrical Engineering, Kyushu University, Japan

Institute e-mail (presenter): zita.nauciene@vdu.lt

New environmentally friendly technologies that enhance the natural adaptability of plants in agricultural production are essential for reducing the unsustainable use of water, nutrients, and agricultural chemicals. Non-equilibrium low-temperature, or cold plasma (CP), applications in agriculture are gaining wide attention. The complex interaction of CP and seeds is influenced by reactive particle content, which depends on the gaseous phase composition. In this study, we evaluated seed treatment effects of low-pressure plasma discharge using different compositions of gaseous phase and treatment duration on red clover *(Trifolium pratense, cv* 'VB Vytis') germination and morphological parameters of seedlings. Dry seeds were treated with a vacuum for 7 min (V7, additional control). CP for 5 and 7 min in air (CP5 and CP7), for 5 and 7 min in argon (CP5(Ar) and CP7(Ar)), and 7 min in nitrogen and nitrogen-oxygen 20:80 gas, respectively (CP7(N_2) and CP7(N_2/O_2)). The seeds were germinated *in vitro* and sown in the soil 4 days after seed treatment. All treatments had no significant effect on maximal seed germination and germination rate *in vitro*. After 4 weeks, part of the plants were harvested for plant weight determination, the rest were analyzed using 3D multispectral plant phenotyping sensor, PlantEye. The greatest effect of seed treatment was observed in the CP7 group: the average fresh plant weight was the highest (53% higher compared to the control) and the height was twice the high of the control. The plant height in CP7 was about 2-fold higher compared to CP7(Ar), CP7(N_2) and CP7(N_2/O_2) (increased oxygen content compared to air) (Fig. 1A, 1B). Leaf area in the V7, Cp5(Ar), CP7, and CP7(N2) groups were 68, 67, 77 and 95% higher than in the control group, respectively, showing the trend of a positive effect on leaf area in lower oxygen content groups (Fig. 1C). The obtained results confirm that pre-sowing treatment of seeds with CP changes the growth parameters of the plant even if there is no effect on seed germination. The greatest effect on plant mass and height was obtained by treating red clover seeds with CP for 7 min in low-pressure atmospheric gas, but the greatest positive effect on leaf area was obtained by treating seeds with CP using gases with lower oxygen content.

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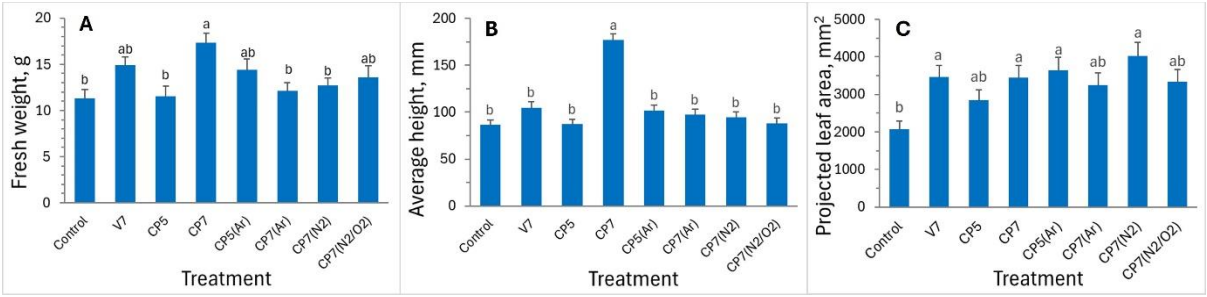

Figure 1. Effect of seed treatment with CP on plant morphological parameters: fresh plant weight (A), average plant height (B), and average leaf area (C). *The average values± standard error are presented. Different lowercase letters indicate significant differences ($p < 0.05$).*