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RF AND MICROVAWE PLASMA APPLICATION FOR PRE-SOWING CARYOPSIS TREATMENTS

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Abstract. Application of radio frequency and microwave air plasma for pre-sowing seeds treatment with the purpose of enhancement of their germination parameters and productivity is described.

1. INTRODUCTION

In the present work the response of seed germination characteristics of some important agricultural plants to low-temperature high frequency plasma has been studied. We have considered the plasma irradiation not only as germination improvement factor but also as a stressful factor influencing seed germination and seedling at early and later growth stages. The response of the root and shoot morphometric parameters to stressful factors caused by plasma treatment was examined in germinating wheat and oat seeds. The goal of these investigations was to determine if an alternate seed pre-sowing treatment approach based on plasma methods would offer a more effective and environmentally sound alternative over traditional seed processing technologies.

2. EXPERIMENTAL CONDITIONS AND MATERIAL

Wheat and oat seeds were exposed to rf and microwave air plasmas using two experimental plasma plants.

The commercial computer-controlled plasma system Plasonic AR-550-M was equipped by the downstream 2.45 GHz microwave power-source Plasonic MAL 1200 with a magnetron input of 500 W (Šerý et al. 2000). A Petri dish with tested seeds (150 caryopsis) was placed into a cylinder-form vacuum chamber (volume of approximately 10 litres) and exposed to the after-glow air plasma. The flow rate of the working gas through the reactor chamber was 3.3 ml/s, working pressure – 140 Pa. Seven caryopsis samples were prepared for tested plant species: one for control, another for vacuum treatment and the others five for plasma treatment with expositions 3, 5, 10, 20, and 40 min.

The radio frequency plasma pre-treatments were performed in the rf plasma plant based on the 5.28 MHz HFR-62-5-IG-101 alternating current generator (Azharonok et al. 2009). A capacitively coupled rf discharge was operated between two parallel round copper electrodes with diameter 120 mm. The distance between electrodes was 20 mm. A Petri dish with caryopsis (about 200 pieces) was placed on the grounded electrode and exposed to air plasma at pressure 40 – 100 Pa during 3.5, 5 and 10 min.

Treated and control (untreated) seeds were germinated in rolled filter paper moistened with a deionized water. Roots and shoots were measured and dried in laboratory condition and then weighed.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

The effectiveness of pre-sowing rf and microwave plasma treatments of wheat and oat caryopses in dependence on the exposure duration is demonstrated in Figs. 1, 2 and 3.

It is shown, that the germination ability and germination energy of rf plasma treated wheat seeds at optimal exposure conditions (t= 7 min) was higher by 2%, the weight of 100 shoots – by 3% compared with untreated ones (Fig. 1). The root/shoot ratio of seedling at the early growth stage 1.3 times increased after microwave plasma treatment during 5 min – for wheat (Fig. 2) and 40 min – for oat seeds (Fig. 3). We consider this phenomenon as a positive factor for plant adaptation to an environmental stress at later growth stages.

In spite of a negligible seeds germination enhancement after plasma treatment it is observed considerable (up to 30%) increase of the weight of 100 shoots for all experimental conditions. Strength and weight forcing of shoots will provide good conditions for plants grow.

It was shown also that plasma treatment stimulates strength and branching of sprouts and roots especially on the 7^{th} – 10th days of ontogenesis. So, the positive effect of plasma pre-treatment on seed germination parameters becomes apparent

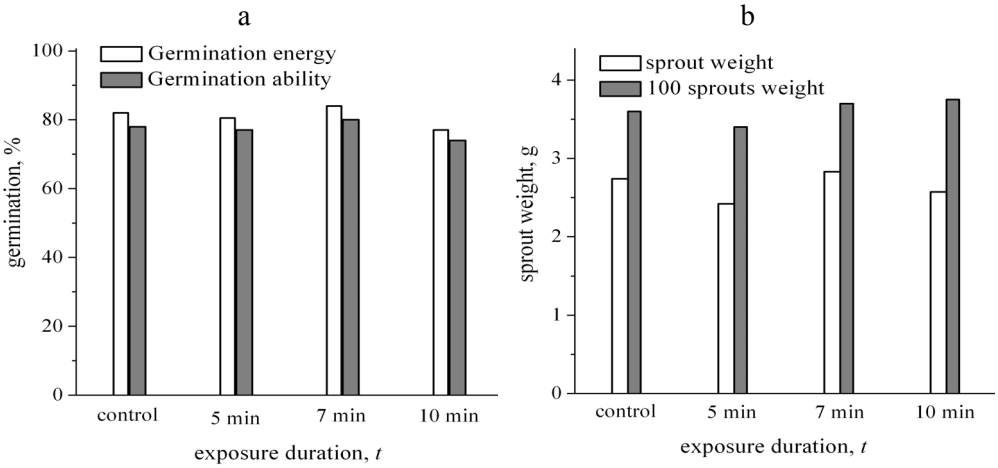

Figure 1: Germination (a) and sprout weight (b) of control wheat seeds and rf plasma treated ones in dependence on exposure duration. Germination energy was checked on the 4th day of ontogenesis, germination ability – on the 7th, sprout weight– on the 10th day.

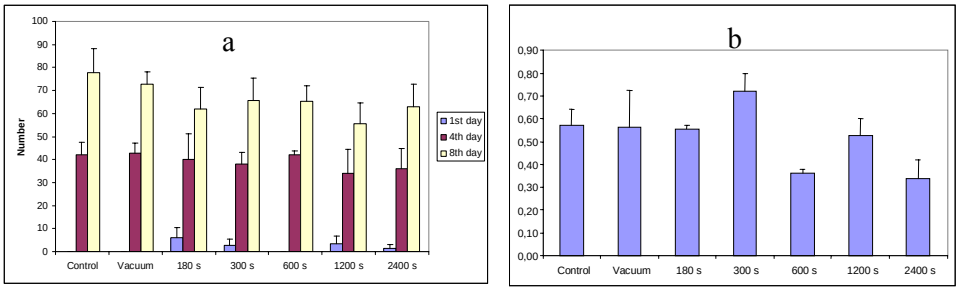

Figure 2: Germination (a) and root/shoot ratio (b) of control wheat seeds and microwave plasma treated ones in dependence on exposure duration.

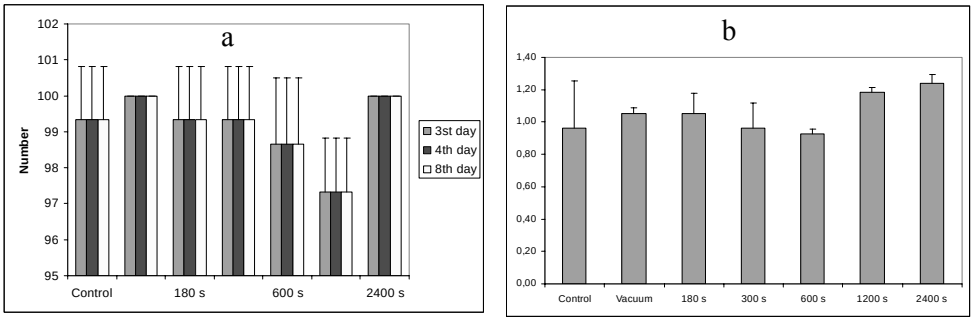

Figure 3: Germination (a) and root/shoot ratio (b) of control oat seeds and microwave plasma treated ones in dependence on exposure duration.

not on the first days of ontogenesis but with some lateness. We suppose that during the adaptation as a result of plasma treatment seed accrues the peculiar biolog-

ic safety properties that become apparent on the late phases of ontogenesis (Filatova et al. 2009). It is probably associated with better stress tolerance ability of plasma treated seeds.

Changes in seed coat surface as a result of plasma treatment are shown in Fig. 4. We observed that treated caryopses of wheat had darker coat shade than the

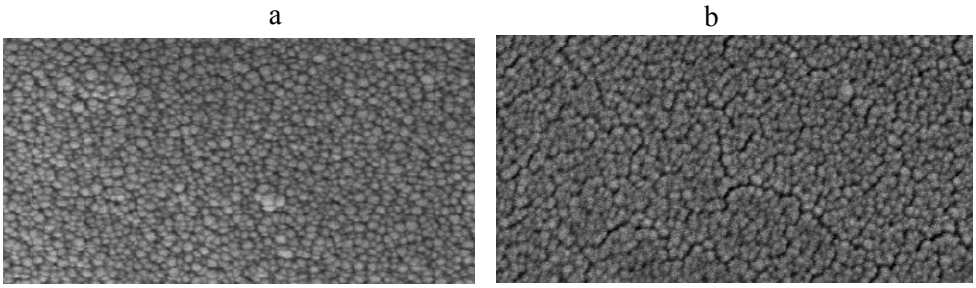

Figure 4: SEM image of wheat seed coat surface. Normal sufrace of non-treated wteat caryopses (a) and the surface treated by plasma (b). Magnification of 30000 times was used.

control samples. Treated seeds got wet faster in water than the non-treated ones, too. Deep longitudinal cracks on wheat seed coat surface treated by plasma are obvious in comparison with the control. This "eroded" surface caused by plasma treatment can lead to higher number of germinated seeds, faster germination and rootage improving due to increase of total surface energy and its hydrophylic property.

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