Impact of Different Seed Priming Techniques on Germination and Seedling Performance of Common Bean Under Water Deficit Conditions

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Introduction

Unfavorable moisture in seedbeds is a frequent cause of poor and unsynchronized seedling emergence (Angadi and Entz, 2002). On the other hand, achieving rapid and uniform seedling emergence is a key point for crop performance since slow germination rates frequently expose plantlets to adverse environmental conditions and soil-borne diseases (Osburn and Schroth 1989). Several authors (Patanè et al. 2009; Ton et al., 2009; Paparella et al., 2015; Bosco de Oliveira and Gomes-Filho, 2016) have reported that seed priming treatments (pre-treatments) could accelerate germination and seed emergence, produce more vigorous plants, particularly under abiotic stress.

Common bean (*Phaseolus vulgaris* L.) is one of the most important grain legumes for direct human consumption (Broughton et al., 2003), and although it is known to be susceptible to drought stress, common bean is frequently produced under water limiting conditions (Leport et al., 2006).

Croatia has long tradition of common bean production which is based on landraces and usually takes place under rain fed conditions on small-scale farms (Carović-Stanko et al., 2017). Morphological and physiological traits, such as reduction of the leaf area, gas exchange adjustments, the distribution and conductance of stomata on the leaves, root system architecture, osmotic adjustment, and different phenology represent adaptation mechanisms to drought stress in common bean (Beebe et al., 2007; Beebe et al., 2010; Rosales et al. 2012; Lanna et al. 2016; Polanía et al. 2016). However, there is no single morphological or physiological trait which could be addressed to drought tolerance (Aruda et al., 2018).

Aim

The aim of this study was to investigate mitigating potential of hydro- and osmopriming to water deficit stress in seedlings of main Croatian common bean landraces.

Table 1. Seed priming treatments

Priming treatment	Duration	References
d H_2O	4 h	This study
1.5% KNO_3	12 h	Ghassemi-Golezani et al., 2008
15 mM $CaCl_2$	3 h	Mohajer et al., 2017
2% H_2O_2	4 h	Abass and Mohamed, 2011
-0.8 MPa PEG-6000	12 h	Ghassemi-Golezani et al., 2008

Figure 1. Growth chamber experiment – common bean in pouches

Figure 2. Root morphology of common bean seedling

Materials and methods

- Used common bean landraces: 'Biser', 'Zelenčec', 'Trešnjevac' and 'Zlatni trešnjevac'
- Description of seed priming treatments is given in Table 1.
- After priming treatments, seeds were grown for 15 days in growth chamber, in pouches (Figure 1) dipped in 'Magnavaca' nutrient solution (Magnavaca et al., 1987).
- Conditions were: 75% air humidity of 25/20 °C day/night temperature, and 18/6 h day/dark photoperiod (300 µmol m^2 s^{-1} PAR)).
- Seed germination and subsequent seedling growth was performed under control conditions (0 MPa) and water deficit conditions (-0.3 MPa) applied by adding PEG 6000 to the nutrient solution.

Measurements

- Germination - number of germinated seeds was counted 9th day of the experiment (ISTA 1995).
- root morphological traits (root length (RL), depth (RD), width (RW), surface area (RSA), volume (RV), average diameter (RAD), number of tips (RNT), number of forks (RNF)).
- leaf chlorophyll content index (CCI).
- gas exchange parameters (net photosynthesis rate (A), stomatal conductance (g_s), transpiration rate (E), mesophyll CO_2 concentration (Ci), water use efficiency (WUE))
- chlorophyll fluorescence (Fv/Fm and Fv/Fo).
- root fresh weight (RFW), shoot fresh weight (SFW), root dry weight (RDW) and shoot dry weight (SDW).
- Data were analysed using mixed model ANOVA. By combining water deficit treatments and priming treatments different groups were created and discriminant analysis (PROC DISCRIM) was performed to evaluate how valid the groups are, and which variables distinguish the best among them.

Results

Figure 3. Effect of seed priming treatments on Fv/Fm, of common bean plants grown in control and water deficit conditions

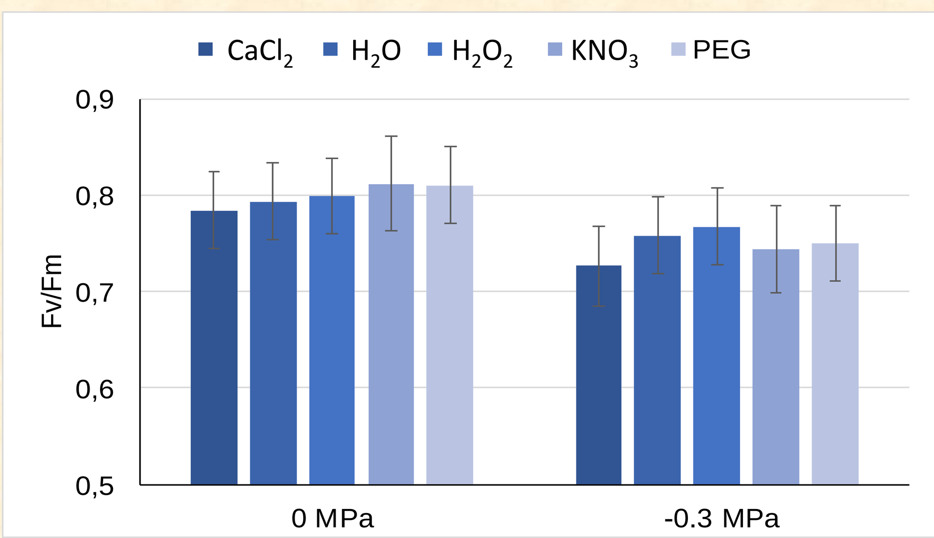


Figure 5.Effect of seed priming treatments on A, of common bean plants grown in control and water deficit conditions

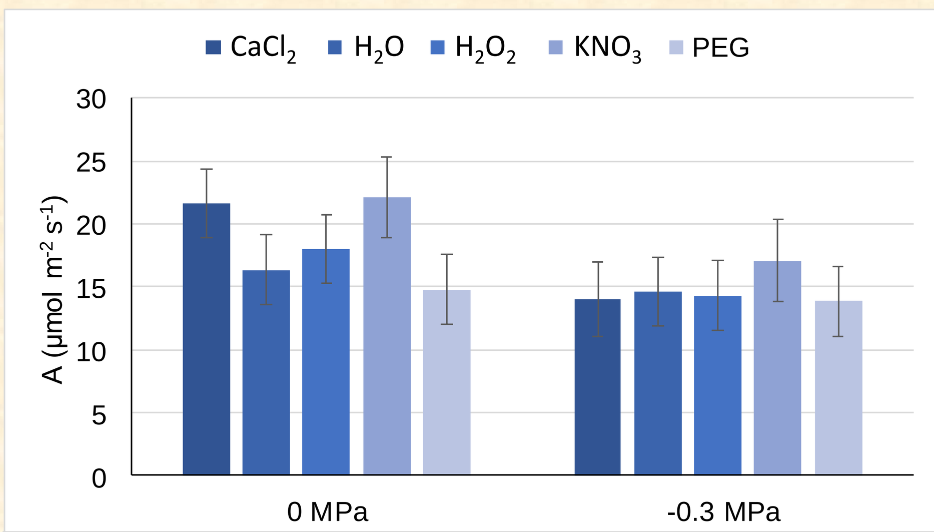


Figure 4. Effect of seed priming treatments on CCI, of common bean plants grown in control and water deficit conditions

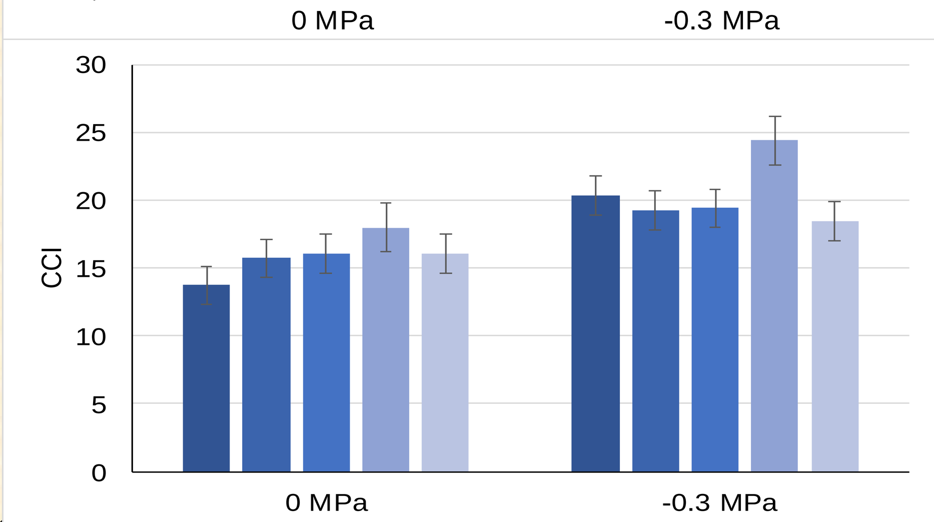


Figure 6. Effect of seed priming treatments on RL, of common bean plants grown in control and water deficit conditions

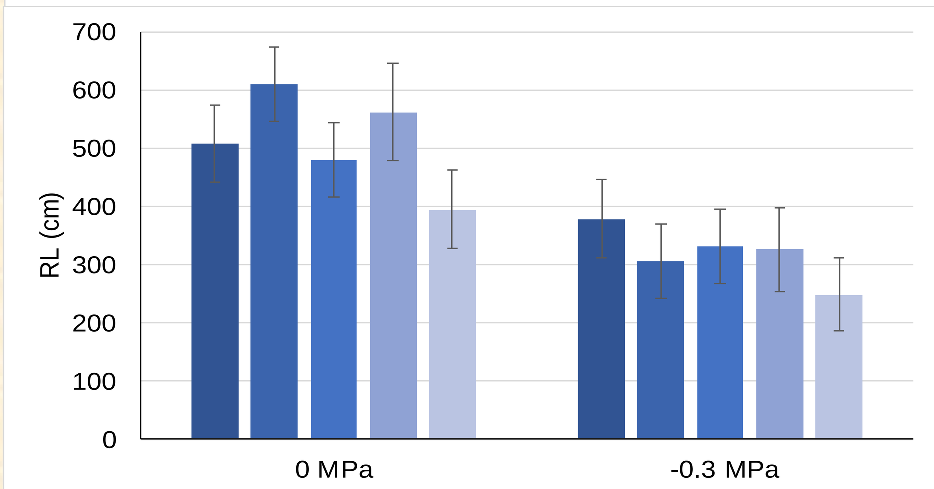
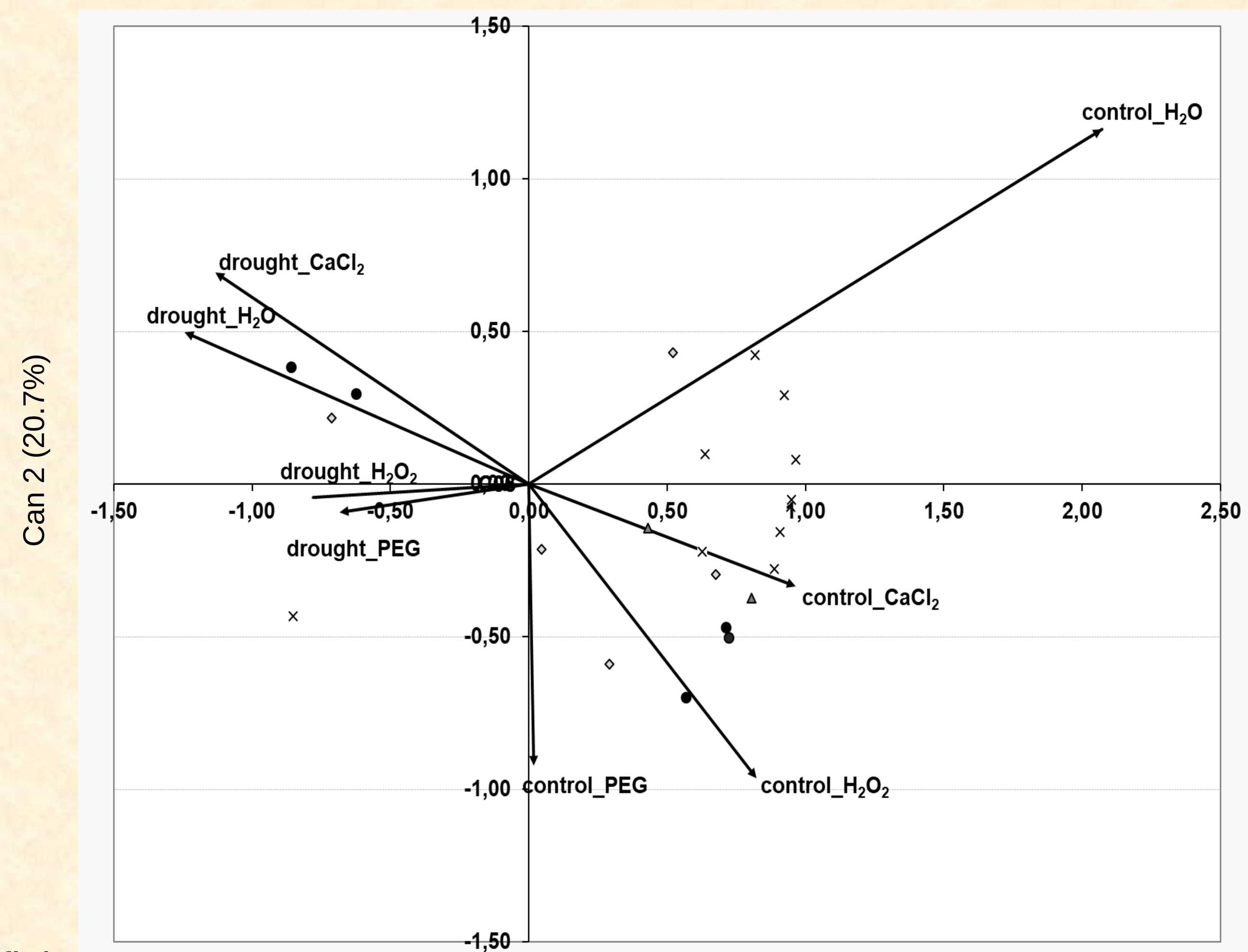


Figure 7. Biplot of the discriminant analysis of combined groups (water deficit x seed primng treatment) based on the photosynthesis related traits (◊); chlorophyll related traits (●); and root related traits (x)



- Reduced chlorophyll fluorescence (both Fv/Fm and Fv/Fo) indicate stress among plants grown under water deficit.
- Water deficit decreased all measured root traits except average root diameter which increased.
- Water deficit increased average CCI, probably due to reduced SFW and SDW, but decreased average A, and g_s values.
- Irrespectively to water deficit treatments, priming affected CCI (highest found in KNO_3 primed plants), and root traits (smallest values, except RAD, were found in PEG primed plants and the highest in $CaCl_2$ primed plants).
- The first axis of canonical correspondence analysis explains more than 50% of the total variation and differentiates among drought treatment and control treatment groups.
- First axis is positively correlated to root traits (except the RAD which is negatively correlated) and negatively to CCI.
- Second canonical component explains more than 20% of the total variation and differentiate among: drought_H_2O, drought_$CaCl_2$ and control_H_2O from other groups and is more correlated to gas exchange parameters.

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