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Original Article

Physiological quality of soybean seed cultivars by osmoconditioning

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Abstract

Soybean cultivars present seeds of different physiological quality and they lose vigor and germinative potential during their permanence in the field after maturity. Therefore, this study was settled to evaluate the response ability to osmotic conditioning of seeds of six soybean cultivars – Confiança, UFV-16, Splendor, Garantia, UFVS 2005 and UFV-18 – harvested at the R8 stage and 15 and 30 days later. The cultivars were multiplied in the field, in a randomized complete-block design, with four replications. The osmotic conditioning of the seeds were carried out with a polyethylene glycol solution (PEG 6000), at -0,8 MPa, with 0.2% of Captan fungicide, at 20 °C, during 96 hours. Non conditioned seeds were used as control. The following characteristics were evaluated: first and final counting on germination test; seedling emergence rate and emergence speed index in the field; and electric conductivity. Harvest delay decreases seed germination and vigor, with different intensity, depending on the cultivar. The osmoconditioning reduces the leaching of solutes by the seed and positively affects the seed germination and vigor of all cultivar studied, more pronouncedly when seeds are much more weathered.

Key words: *Glycine max*, seed germination, osmotic conditioning, seed vigor

Qualidade fisiológica de sementes de cultivares de soja por meio do condicionamento osmótico

Resumo

Os cultivares de soja apresentam sementes de diferentes qualidades fisiológicas, as quais perdem vigor e capacidade de germinação durante a permanência no campo após a maturação. Portanto, objetivou-se avaliar a melhoria, quando submetidas ao osmocondicionamento, da qualidade das sementes de seis cultivares de soja – Confiança, UFV-16, Splendor, Garantia, UFVS 2005 e UFV-18 – colhidas no estádio R8 e aos 15 e 30 dias após esse estádio. O plantio dos cultivares foi realizado no campo, em delineamento experimental de blocos completos casualizados, com quatro repetições. O condicionamento osmótico das sementes foi realizado em solução de polietileno glicol (PEG 6000) a -0,8 Mpa, com 0,2 % do fungicida Captan, a 20 °C, por 96 horas. Sementes não condicionadas foram utilizadas como testemunhas. As seguintes características foram avaliadas: contagem inicial e final no teste de germinação; emergência e índice de velocidade de emergência das plântulas no campo; e condutividade elétrica. O retardamento da colheita reduz a germinação e vigor das sementes, com diferente intensidade, dependendo do cultivar. O condicionamento osmótico reduz a lixiviação de solutos pelas sementes e afeta positivamente a germinação e o vigor das sementes de todos os cultivares estudados, especialmente das sementes mais intemperizadas.

Palavras-chave: *Glycine max*, germinação, osmocodicionamento, vigor

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Introduction

The quality of the seeds depends on all genetic, physical, physiological, and sanitary attributes (Popinigis, 1985). The quality is subjected to degenerative changes of physical, biochemical and physiological nature after maturation. These changes may reduce the physiological quality of seeds and they depend on environmental conditions of the period before the harvest, as well as harvesting processes, drying, processing and storage (McDonald Jr., 1975). Soybean should be harvested as soon as possible after physiological maturity, but it is not always possible, due to the high humidity of the seeds itself or caused by rain during the harvest period. This delay causes damage to seed quality. The deterioration tolerance level in the field differs among cultivars and weather conditions have much more influence on seed quality than the time of permanence of seeds in the field after physiological maturity (Sediyama et al., 1972, 1981).

Seed vigor is a major physiological quality attribute to be considered in the implementation of a crop. Techniques to improve the vigor and seed germination performance in the field aim to establish rapid and uniform germination. Priming is the most common technique used for seed vigor improvement. It is the presoaking of seeds before the sowing, in a solution with negative osmotic potential, obtained with substances such as polyethylene glycol (PEG 6000). The osmoconditioning consists of a controlled hydration of the seeds that activates the pre-germinative metabolic processes (Nascimento & West, 2000), but these are ceased just before the radicle protrusion (Bradford, 1986). This process not only improves germination and seed vigor, but also allows a faster and more uniform seedling emergence (Braccini et al., 1997; Del Giúdice et al., 1999; Nunes et al., 2004a; Nascimento, 2005) with effects upon crop productivity (Nunes et al., 2003).

The objective of this study was to evaluate the physiological response of seeds of different soybean cultivars to seed priming for different times of harvest.

Materials and Methods

This work was carried out in Experimental Field and in the Laboratory of Soybean Breeding and Seed Research of Plant Sciences Department of the Federal University of Viçosa. Seeds of six soybean cultivars, from different maturity groups, Confiança (semi-early), UFV-16 (medium), Splendor (medium), Garantia (semi-late), UFVS 2005 (late) and UFV-18 (late) were produced in the agricultural year of 2005/2006, in the field, in a randomized complete block experimental design, with six treatments in the plots and four replications. Each plot had a 10 meter long row spaced at 50 cm. The soil was prepared with one plowing and two disking (conventional soil preparation system). Fertilization, cultural techniques and phytosanitary control were performed according to the recommendations for the soybean culture (Embrapa Soja, 2004).

The harvest of the plants of each cultivar was carried out at three stages: the R8 stage (95 % of the pods reached their mature color) and 15 and 30 days after the R8 stage, to obtain different vigor levels. Four rows per plot were randomly harvested in the first stage (R8 stage), and three rows at each harvest at 15 and 30 days after the R8 stage.

The plants were threshed in a stationary threshing machine as they were harvested and the seeds were dried out to 11 to 12% humidity (wet basis) under sunlight. The seeds were packed in cotton fabric bags after being cleaned and uniformed according to size with sieve # 13 and kept in a chamber set at 10 °C and 70 % of relative humidity.

The daily climatic data of rain precipitation and minimum, average and maximum temperatures were registered during the period of seed production (Figure 1).

Osmotic conditioning: Samples of 100 seeds per cultivar, harvest period and replication in the field were placed into plastic containers of *gerbox* kind, with four sheets of paper towels (*germitest*), soaked with 30 mL of -0.8 MPa in PEG 6000 solution in the presence of 0.2% of the Captan fungicide. The *gerbox* boxes were placed in a B.O.D. incubator at 20 °C ± 1°C for 96 hours (Braccini et al., 1997; Del Giúdice et al., 1999). The PEG 6000 concentration used to achieve the desired osmotic potential (-0.8 MPa) at the temperature of 20 °C was 251.028g.L^{-1} of demineralized water, according to the equation of Michel & Kaufmann (1973): $\Psi_{os\ (atm)}=(1.18 \times 10^{-2}) C - (1.18 \times 10^{-4})C^2 + (2.67 \times 10^{-4})CT + (8.39 \times 10^{7}) C^2T$, in which: $\Psi_{os\ (atm)}$=osmotic potential; C= concentration (g/L); T= temperature (°C); and 1MPa= 10 atm.

The seeds were superficially washed after the osmoconditioning with flowing water to eliminate the excess of PEG and, afterwards, they were superficially dried, with dry *germitest* paper. Non-conditioned seeds were used as control.

The physiological quality evaluation of the seeds was carried out through the germination and vigor tests:

Germination test: germination tests were performed with four 50 seed sample replications from each treatment, in rolled paper towel previously moisturized with 2.5 times the paper weight. Germination proceeded in a germinator at 25 °C and counts were made five and eight days after seeding (ISTA, 1996, Brasil, 2009).

Seedling emergence test (SE): this evaluation was carried out in Prof. Diogo Alves de Mello Experimental Field - 50 seed samples of each treatment were manually distributed in 1.0 m long row and 0.25 m apart rows at 2-3 cm depth. Emerged seedling evaluation was daily made until 14 days after sowing (Nakagawa, 1999). The

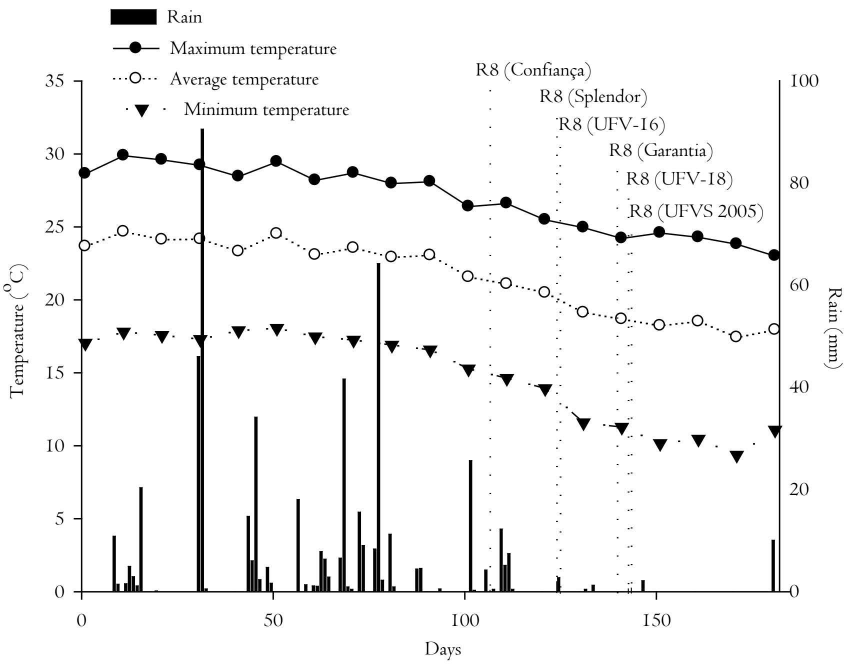

Figure 1. Rain (mm), maximum, average and minimum air temperatures (°C) during the period of seed multiplication in the field recorded from the sowing day, and the R8 stages of the six soybean cultivars.

percentage of emerged seedlings was evaluated and the seedling emergence rate (SER) in the field was calculated according to the formula of Maguire (1962). The minimum and maximum temperatures during the test were, respectively, 11.9 and 24.3 °C.

Electrical conductivity test (EC): four 50 seed sample replications of each treatment were weighed to the nearest 0.01 g and immersed in 75 mL of deionized water within 200 mL plastic vials. Seed hydration occurred into a germinator at 25 °C during 24 hours. After this period, EC was determined in the imbibition solution with a Digimed CD-21 constant electrode-1 conductivimeter, and results were expressed as µS $cm^{-1}g^{-1}$ (Hampton & Tekrony, 1995; Vieira & Krzyzanowski, 1999).

Statistical analysis was performed according to the split-split plot design in randomized complete blocks with four replications. The cultivars formed the plots,the time of harvest the subplots and priming the sub-subplots. As for the analysis of variance, the effects were tested by F test ($P \leq 0.05$) and, when significant, means were compared by the Tukey´s test ($P \leq 0.05$). The percentages of the counts were previously submitted to angular transformation for the better approximation to normal distribution and homogeneity of variances (Ryan, 2007). Data processing was performed with SAS software (Delwiche & Slaughter, 2003).

Results e Discussion

According to the analysis of variance, cultivar, priming and harvest time significantly affected all the evaluated traits and in most cases interactions were observed. Thus, the Figures 2-4 show the behavior of seeds of each cultivar under harvest delay and priming with PEG 6000. The data of temperature and rainfall (Figure 1) showed that soybean seed harvest has begun in a period in which cooler temperatures and low frequency and intensity of rainfalls are observed, what promoted high quality of seeds harvested at the R8 stage. The loss of seed quality was more evident at 30 days after the first harvest (Figures 2 to 4). The intensity of loss of seed quality, with a late harvest, differed from cultivar to cultivar, being lower for Confiança; higher for Garantia, UFV-18 and UFV-16; and intermediate for Splendor and UFVS 2005. Moreover, osmoconditioning treatment significantly improved all the indicators of physiological seed quality. The recovery of soybean seed quality by osmoconditioning was more evident when the seed deteriorated for longer stays on the field after the R8 maturity stage.

The best physiological quality of seeds was obtained when the seeds were harvested at the R8 stage, because after the physiological maturity the process of seed deterioration started, and the harvest delay negatively influenced the quality of the seeds (Sediyama et al., 1972). The best time to harvest the soybean seeds depends on the cultivar and seed moisture content at harvest time (Silva et al., 1979; Braccini et al., 2000). Reinvigoration of deteriorated seeds by osmoconditioning has been observed in other species (Santos, 2005).

The recovery of the physiological quality of seeds with the use of osmoconditioning can be explained by the reduced leaching of solutes, indicated by the results of electrical conductivity, including those seeds harvested at the R8 (Figures 2 to 4). The osmoconditioning caused a reduction of electrical conductivity, meaning that there was increased resistance to electrical current in the soaking solution due to the lower concentration of ions in the soaking solution. The osmoconditioning promotes the slow absorption of water by the seed and prevents possible injuries caused by the rapid absorption of water. This may preserve the solutes available for the membranes of embryonic tissues, and the metabolites may remain more available for use during the process of the germination and seedling emergence.

The higher amount of electrolytes released indicates a decrease in the seed physiological quality and seed germination (Marcos Filho et al., 1990). The osmotic agent reduces the rate and volume of absorbed water that slowly penetrates the seed and allows the tissues to develop in a more orderly manner (Del Giúdice et al., 1998, 1999; Braccini et al., 1999; Nunes et al., 2001, 2004b). Depending on the level of deterioration, especially for those with lower quality, priming has different effects on germination (Lanteri et al., 1996). Seeds with different physiological qualities respond differently to osmoconditioning

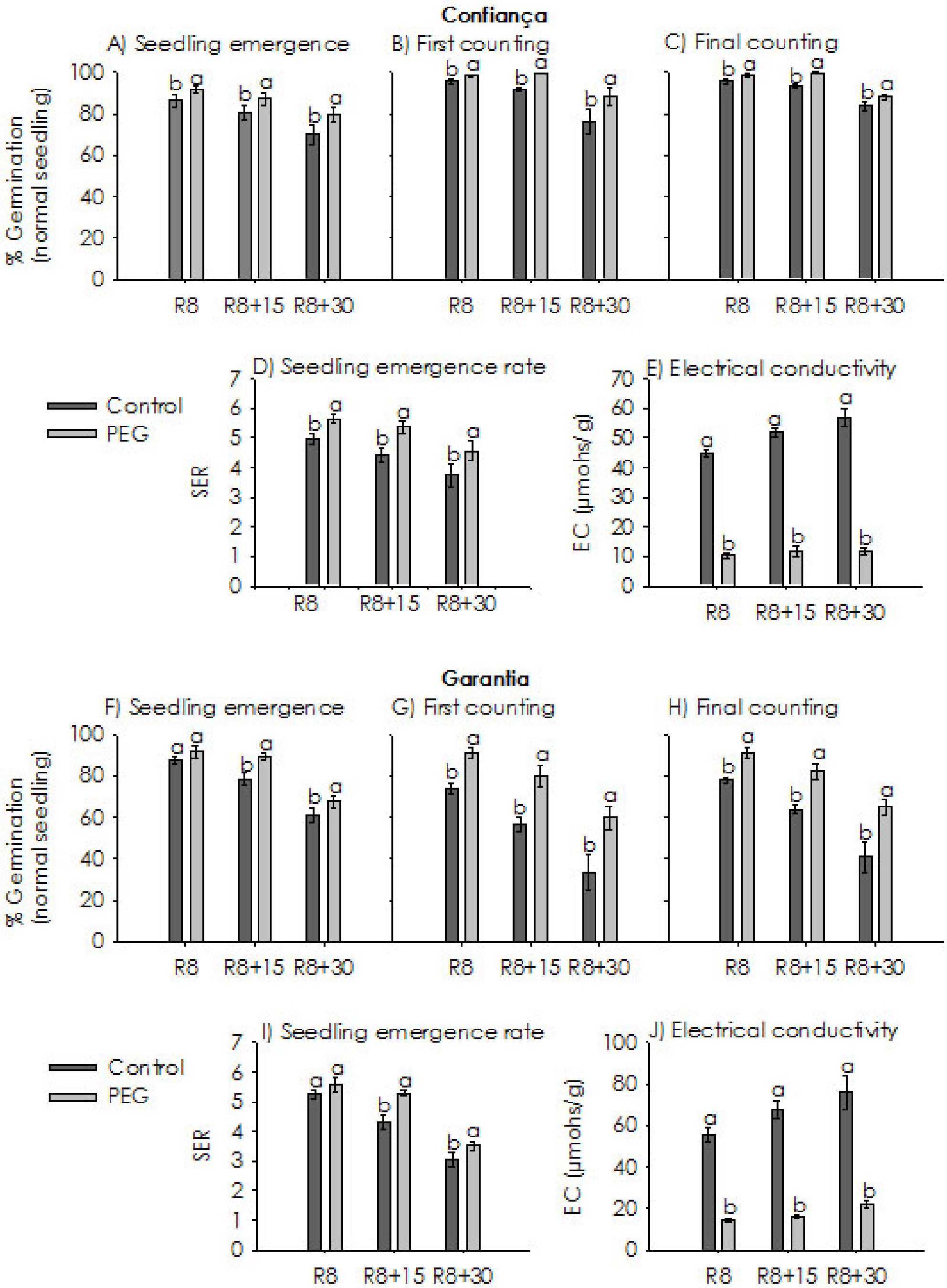

Figure 2. Estimated means of the seedling emergence in the field (A and F), first counting by germination test (B and G), final counting by germination test (C and H), seedling emergence rate in the field - SER (D and I), electrical conductivity - EC (E and J) of the seeds of soybean cultivars Confiança and Garantia harvested at three different times (R8, R8+15 days, R8+30 days), osmoconditioned with PEG 6000.

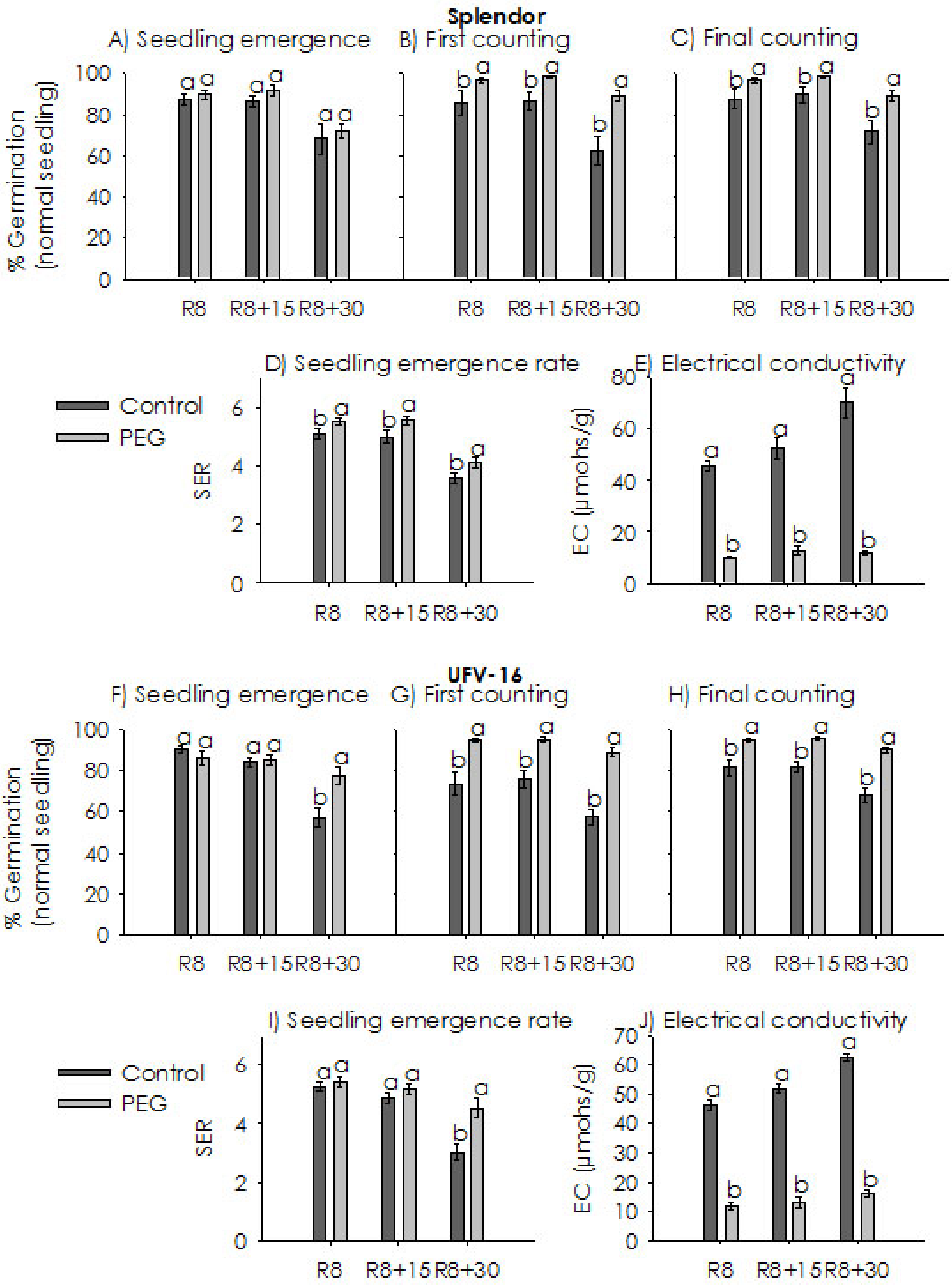

Figure 3. Estimated means of the seedling emergence in the field (A and F), first counting by germination test (B and G), final counting by germination test (C and H), seedling emergence rate in the field - SER (D and I), electrical conductivity - EC (E and J) of the seeds of soybean cultivars Splendor and UFV-16 harvested at three different times (R8, R8+15 days, R8+30 days), osmoconditioned with PEG 6000.

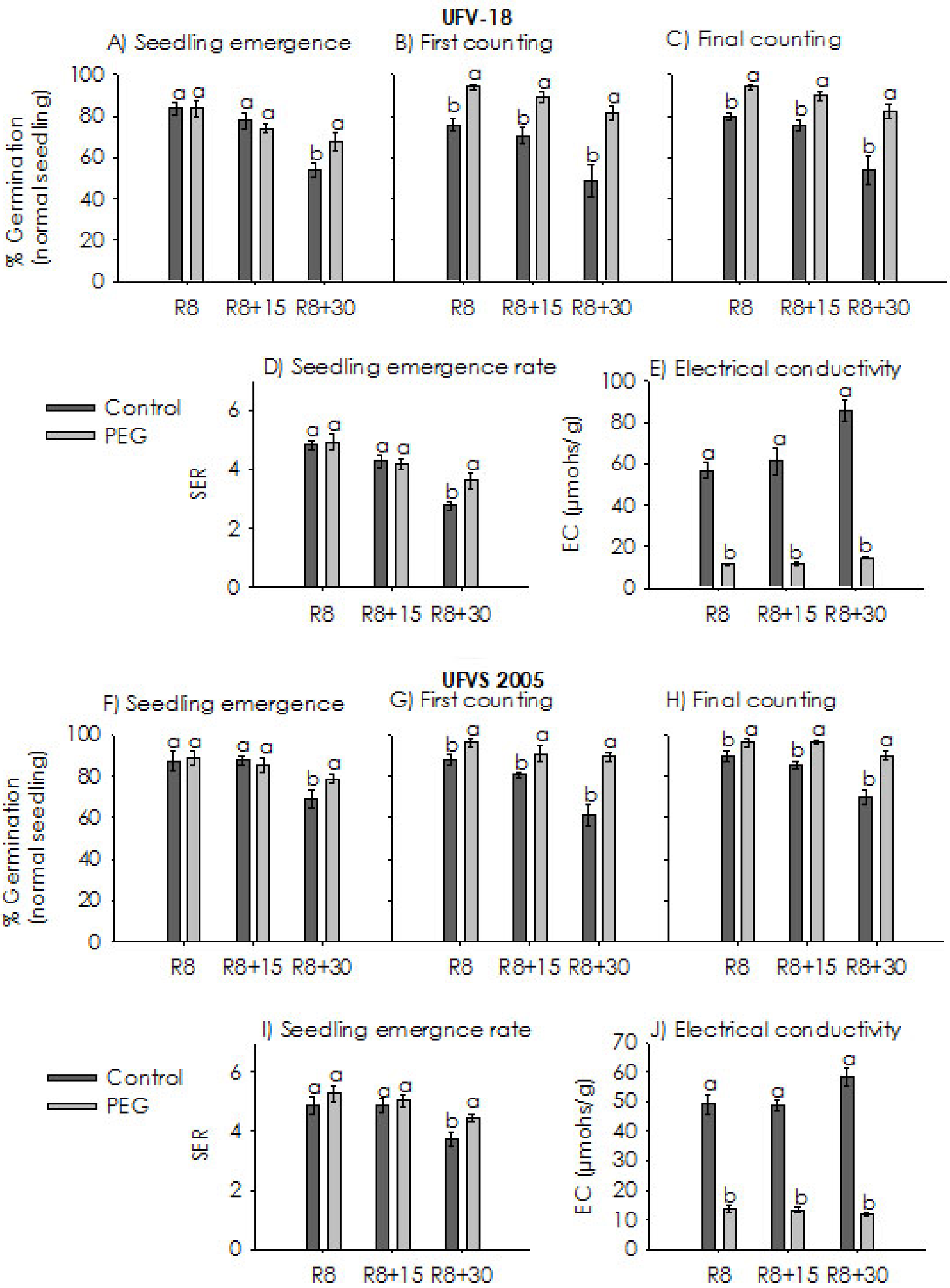

Figure 4. Estimated means of the seedling emergence in the field (A and F), first counting by germination test (B and G), final counting by germination test (C and H), seedling emergence rate in the field - SER (D and I), electrical conductivity - EC (E and J) of the seeds of soybean cultivars UFV-18 and UFVS 2005 harvested at three different times (R8, R8+15 days, R8+30 days), osmoconditioned with PEG 6000.

(Oliveira & Gomes-Filho, 2010), but in the present study the osmoconditioning was beneficial to the physiological quality of seeds.

Conclusions

The harvest delay decreases seed germination and vigor, with different intensity, depending on the cultivar. Confiança has produced seed of lower quality; Garantia, UFV-18 and UFV-16 have produced seeds of higher quality, and Splendor and UFVS 2005 have produced seeds of intermediate quality. Osmoconditioning reduces the leaching of solutes by the seed and positively affects the seed germination and vigor of all cultivars studied, and this effect is more pronounced when the seeds are much more weathered.

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