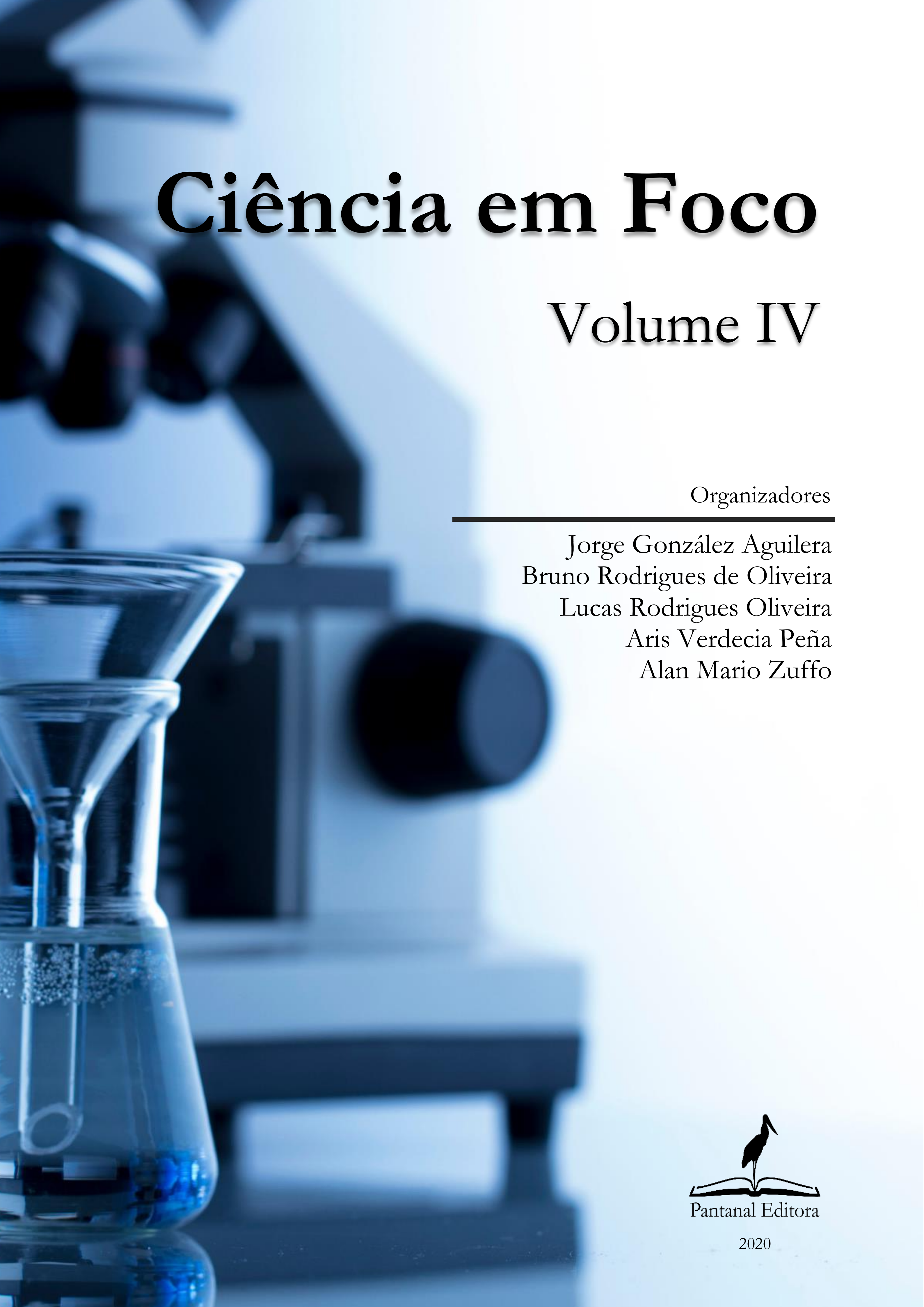

Ciência em Foco

Volume IV

Organizadores

Jorge González Aguilera
Bruno Rodrigues de Oliveira
Lucas Rodrigues Oliveira
Aris Verdecia Peña
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Pantanal Editora

2020

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APRESENTAÇÃO

Neste quarto volume da série "Ciência em Foco" ampliamos as áreas de abrangência das pesquisas relatadas nos 29 capítulos que contemplam esta obra, dentre elas a área de educação, agrárias e alimentos, tendo sempre como centro a divulgação das pesquisas científicas com qualidade e relevância associadas aos problemas atuais no cotidiano de nossos colaboradores.

Relatos na área de educação abordam temas como a inclusão de autistas, desafios do ensino com crianças cegas, tecnologias e métodos de ensino em tempos de pandemia COVID-19, entre outros temas.

A procura dos professionais por novas formas de aproveitar e disponibilizar alimentos a serem elaborados em forma de doces e iogurtes é abordado nesta obra, trazendo desafios e inovações que permitem aumentar ainda mais a disponibilidade de alimentos em regiões menos favorecidas do Brasil.

Temas associados ao manejo das culturas da cana-de-açúcar, cebola, melão, milho, mandioca e café em diferentes regiões do Brasil, são discutidos. A produção de mudas de espécies florestais do cerrado com fins de reflorestamento e seu impacto ambiental, aproveitamento de resíduos de lodos, manejo de sementes amazônicas e a recuperação de áreas degradadas é também elencado.

Todos estes trabalhos visam contribuir no aumento do conhecimento gerado por instituições públicas, melhorando assim, a capacidade de difusão e aplicação de novas ferramentas disponíveis a sociedade.

Aos autores dos diversos capítulos, pela dedicação e esforços sem limites, que viabilizaram esta obra que retrata os recentes avanços científicos e tecnológicos, os agradecimentos dos Organizadores e da Pantanal Editora.

Por fim, esperamos que este livro possa colaborar e estimular aos estudantes e pesquisadores que leem esta obra na constante procura por novas tecnologias e assim, garantir uma difusão de conhecimento simples e ágil para a sociedade.

Os organizadores

SUMÁRIO

Capítulo XXVII

Seed priming on germination and seedling growth of watermelon (*Citrullus Lanatus*)

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INTRODUCTION

Watermelon [*Citrullus lanatus* (Thunb.) Matsum and Nakai] is an annual vine of the cucurbit family (Cucurbitaceae). It is a native species from warm and dry regions of Africa, and now widely cultivated throughout the world for its edible fruits (Filgueira, 2012). Optimum seed germination and seedling emergence in watermelon occur at relatively high temperatures (25–28 °C). Poor seed germination is a common phenomenon at sub-optimal temperatures (Demir et al., 2004), which causes a great concern for growers that grow watermelon seedlings in late winter and early spring in the southern and southeastern regions of Brazil. Delayed and reduced seedling emergence cause non-uniform stand establishment, which result in yield reductions (Singh et al., 2001) and impairs the early watermelon markets in the cool regions of Brazil.

Many treatment techniques have been developed to improve the germination of watermelon seeds, especially under improper conditions. There is not a universal technique for improving seed germination. Among the methods used, pretreatment of seeds with plant growth regulators and salts are considered the most appropriate and promising because of ease of application, scale of economies, and labor-saving attributes compared with methods in which the environment must be controlled for prolonged periods of time (Demir et al., 2004; Nascimento, 2005; Ghassemi-Golezani et al., 2008a). Indeed, seed priming treatments using salts such as potassium nitrate (KNO_3) have been effective in improving seed germination under improper conditions (Demir et al., 2004; Nascimento, 2005; Steiner et al., 2018, Oliveira et al., 2019). Hydropriming treatment has also be successfully applied to improve germination performance of watermelon (Huang et al., 2002) and cucumber seeds (Gurgel-Júnior et al., 2009; Oliveira et al., 2017).

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However, few reports were documented on priming treatments using plant growth regulators (PGRs) such as gibberellin and cytokinin in watermelon seeds.

Cytokinin (CK) and gibberellin (GA) are key hormones controlling plant development. These plant hormones have an important role on several physiological and developmental processes, control of the cell cycle, apical dominance, including morphogenesis of shoots and roots, lateral root initiation, stem elongation, leaf and cotyledon expansion, and regulation of senescence (Al-Khassawneh et al., 2006; Taiz et al., 2017). Seed priming with optimal concentrations of CK and GA has been shown to have beneficial effects on germination, growth and yield of a wide range of plant species (Jamilet al., 2007; Alonso-Ramirez et al., 2009; Nasri et al., 2012; Kandil et al., 2014).

Gibberellin at 200 mg L^{-1} enhanced the seed germination and seedling growth of papaya (*Carica papaya* L.) (Lopes et al., 2008). Nasri et al. (2012) reported GA increased germination percentage of lettuce under salt stress conditions. Albuquerque et al. (2009) reported GA_3 increased the growth characteristic in sweet pepper. Batista et al. (2015) studied the effect of different priming techniques on germination and growth of pepper and reported that GA_3 at 200 mg L^{-1} enhanced the germination and seedling growth when compared to unprimed seeds. Iqbal et al. (2006) showed that application of CK at 100 or 200 mg L^{-1} increased the germination rate and initial growth of wheat seedlings when compared to the hydropriming. Cytokinins at 10 mg L^{-1} or 100 mg L^{-1} significantly increased the germination rate of pigeon pea seeds compared to unprimed seeds (Sneideris et al., 2015). However, seed priming with CK at 50 or 100 mg L^{-1} inhibited the primary root development of maize seedlings compared to control. These and other contradictory results seem to indicate an inherent differential response among different species or genotypes; therefore, justifying the need of conducting more research in order to investigate the effects of seed priming with CK on germination and early growth of watermelon.

This research was carried out to investigate the effects of different priming techniques on seed germination and initial growth of watermelon [*Citrullus lanatus* (Thunb.) Matsum and Nakai] seedlings.

MATERIAL AND METHODS

Seeds of watermelon [*Citrullus lanatus* (Thunb.) Matsum and Nakai, cv. Crimson Sweet] were surface sterilized with 1% (v/v) of sodium hypochlorite solution for 5 minutes and washed immediately with distilled water many times. The sterilized seeds were then subjected to priming by direct immersion in solutions of 0.2% gibberellin (50 mg L^{-1} gibberellic acid), 0.2% cytokinin (90 mg L^{-1} kinetin), 0.2% potassium nitrate (2 g L^{-1} KNO_3), and 0.2% calcium nitrate [2 g L^{-1} $Ca(NO_3)_2$] for 6 hours at 25 °C. A set of seeds subjected to direct immersion in distilled water was taken as control. After priming period, seeds were put to dry in plastic boxes (11.0 × 11.0 × 3.5 cm, type Gerbox) with germitest paper at room temperature (24–28 °C) for 48 hours (Eira et al., 1990).

Five replicates of 25 seeds were evenly distributed in plastic boxes with blotter paper, properly moistened with distilled water, in a volume equivalent to 2.5 times the mass of dry paper. The boxes were then closed with lids to prevent evaporation and maintain the relative humidity close to 100%. Germination was carried out in a germination chamber under 12/12 h photoperiod (light/darkness), light fluence of 40 μmol m^{-2} s^{-1} photosynthetic photon flux density (PPFD) and temperature of 26 °C (±2 °C) for 12 days.

First count and germination: The evaluations were performed at 5 (first count of germination test) and 12 days (total germination percentage) after starting the test, and the results were expressed as the mean percent of normal seedlings, according to the recommendations of Seed Analysis Rules - RAS (BRASIL, 2009). At 12 days were also measured the percentage of abnormal seedlings and dead seeds.

Shoot and radicle length: the shoot and radicle length were measured in 15 normal seedlings randomly obtained after count of the total germination (12 days) using meter scale. The results were expressed in centimeter (cm).

Shoot and root dry matter: all normal seedlings obtained at 12 days were separated into shoot and roots. The plant parts were removed carefully and dried in a forced air circulation oven for three days at 60 ºC, and then weighed. The results were expressed in mg $seedling^{-1}$.

The normality of data was previously tested by the Kolmogorov-Smirnov test and then data were submitted to analysis of variance (ANOVA), and means of five priming treatments were compared by the Tukey test at the 0.05 level of confidence. For statistical analysis, the data expressed in percentage were previously transformed into arc $\sin\sqrt{(x/100)}$. The analyses were performed using Sisvar version 5.3 software for Windows (Statistical Analysis Software, UFLA, Lavras, MG, BRA).

RESULTS AND DISCUSSION

The different priming treatments significantly affect the measurements of the germination process of watermelon seeds (Figure 1). The first count of germination test ranged from 0 to 97%, and was significantly greater under KNO_3, Ca $(NO_3)_2$ and GA priming, followed by hydropriming (control), and lower under CK priming (Figure 1A). The germination percentage values in the control treatment (Figure 1B) were higher than the standard values (i.e., 80%) for commercially of watermelon seeds in Brazil (BRASIL, 2012), indicating that the seeds used in this study had high physiological quality.

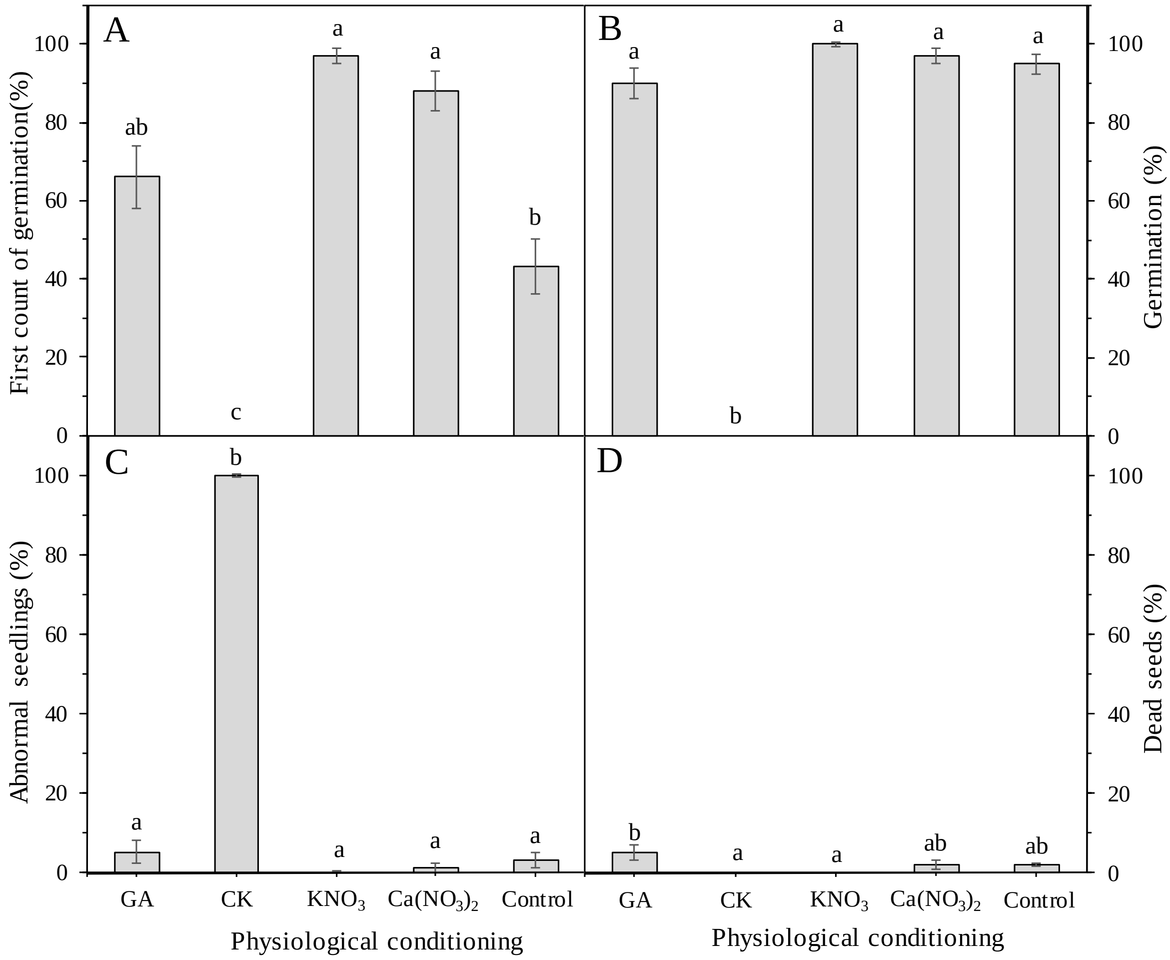

Figure 1. Effect of different priming treatments on the first count of germination test – 5 days (A) and germination percentage – 12 days (B), abnormal seedlings (C), and dead seeds (D) of watermelon seeds [*Citrullus lanatus* (Thunb.) Matsum and Nakai, cv. Crimson Sweet]. Bars followed by the same lower-case letters are not significantly different by Tukey test at the 0.05 level of confidence. Data refer to mean values (n = 4) ± standard error. Source: The authors.

The germination percentage of watermelon seeds ranged from 0 to 100%, and was significantly greater when seeds were subjected to priming with GA, KNO_3, $Ca(NO_3)_2$ and water (control), and lower under CK priming (Figure 1B). The high efficiency of seed priming with PGRs and salts in improving the germination and growth of the seedlings have been reported by other authors. Alonso-Ramirez et al. (2009) showed that GA have strong stimulatory effect on seed germination, and which their exogenous application was repeatedly found to promote germination Arabidopsis seeds even under unfavorable stress conditions. Seed priming with GA caused an increase in seed germination and seedling growth of sweet pepper (Albuquerque et al., 2009), lettuce (Nasri et al., 2012) and sugar beet (Jamil et al., 2007; Kandil et al., 2014). Batista et al. (2015) showed that all the priming methods tested (i.e., GA, KNO_3, $Ca(NO_3)_2$ and hydropriming) resulted in the improvement of germination rate of pepper seeds when compared to unprimed seeds (control). Huang et al. (2002) and Gurgel et al. (2009) reported that hydropriming treatment can be successfully applied on watermelon and cucumber seeds to improve germination performance, respectively.

The seed priming with 0.2% solution of CK resulted in 100% of abnormal seedlings (Figure 2), and was significantly greater than the other priming techniques used (Figure 1C). Although cytokinins are required for many growth and developmental processes in plants such as cell division, morphogenesis of shoots and roots, apical dominance, chloroplast maturation, leaf and cotyledon expansion, and seed germination (Hirose et al., 2008; Taiz et al., 2017), the exogenous application of supra-optimal cytokinin concentrations has remarkable effect on the inhibition of cell elongation process in both shoots and roots (Taiz et al., 2017). The inhibition of internode and root elongation induced by excess cytokinin is due to the production of ethylene triggered by the enzyme 1-Aminocyclopropane-1-carboxylic acid synthase (ACS) (Taiz et al., 2017). These results indicate that chances in endogenous CK concentration may negatively regulate elongation of shoots and roots (Figure 2). Aragão et al. (2001) studied the effect of seed priming with CK on germination and growth of maize and reported that benzyl aminopurine (BAP) at 50 or 100 mg L^{-1} inhibited the development of the primary root compared to control. However, seed priming with optimal concentrations of CK has been shown to have beneficial effects on germination and early growth of wheat (Iqbal et al., 2006) and pigeon pea (Sneideris et al., 2015).

Another factor that may be related to inhibiting the growth of watermelon seedlings is that the action of CK is light-dependent. Changes in fluence rate of white light were shown to have effect on the action of CK and therefore on elongation of the stem and root. Under conditions of low light fluence, as in this study (40 μmol m^{-2} s^{-1} PPFD), the cytokinin inhibits elongation of shoots and roots (Taiz et al., 2017).

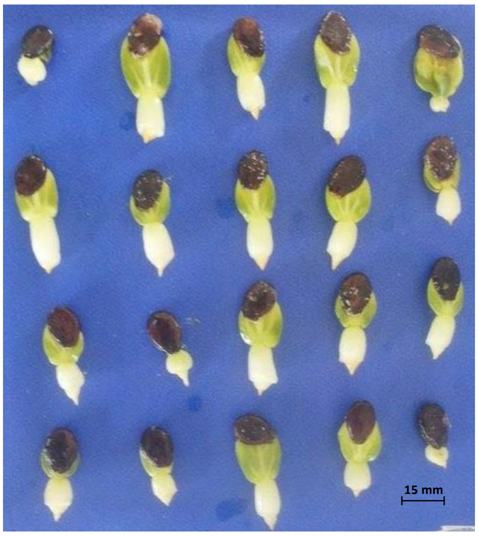

Figure 2. Abnormal seedlings proceeding from watermelon seeds of the cultivar Crimson Sweet subjected to priming by direct immersion in 0.2% cytokinin solution (90 mg L^{-1} of kinetin) at 12 days after sowing. The illustration shows seedlings with malformed roots, thickening of the hypocotyl, and without the formation of shoot. Source: The authors.

The percentage dead seed varied from 0 to 5%, and was significantly greater under GA priming, and lower under CK and KNO_3 priming (Figure 1D). The low percentage of dead seeds is indicative of the high initial viability of watermelon seeds used.

The growth of watermelon seedlings was significantly affected by different priming treatments (Figure 3). Seed priming with GA, KNO_3, Ca $(NO_3)_2$ and water (hydropriming) resulted in higher shoot length of watermelon seedlings (Figure 3A). These results indicate that the seed priming with gibberellic acid, salts or water were adequate to promote the shoot growth of watermelon. Batista et al. (2015) also reported the efficiency of GA, KNO_3, Ca $(NO_3)_2$ and water priming to enhance the shoot growth of pepper seedlings compared to unprimed seeds.

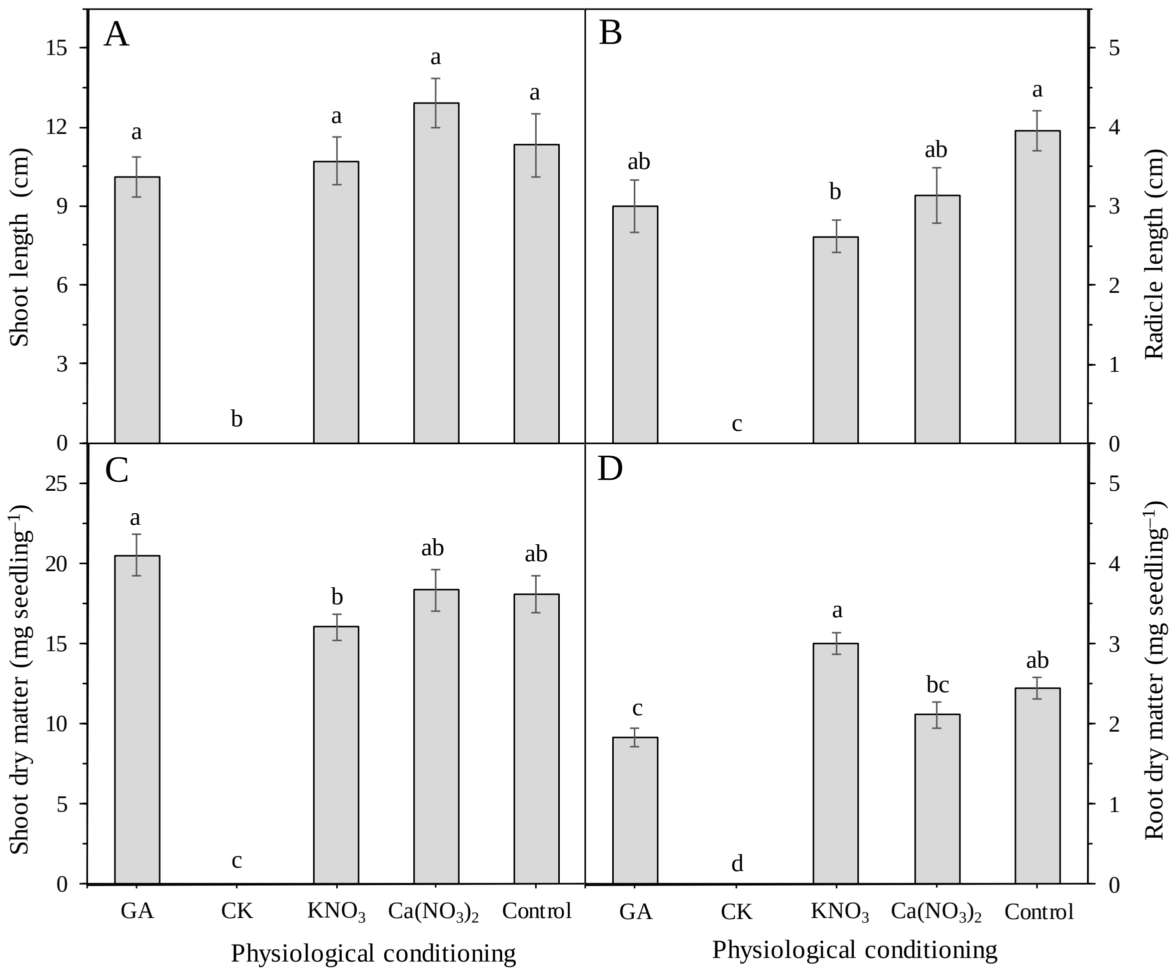

Figure 3. Effect of different priming treatments on shoot length (A), radicle length (B), shoot dry matter (C) and root dry matter (D) of watermelon seedlings [Citrullus lanatus (Thunb.) Matsum and Nakai, cv. Crimson Sweet]. Bars followed by the same lower-case letters are not significantly different by Tukey test at the 0.05 level of confidence. Data refer to mean values (n = 4) ± standard error. Source: The authors.

Radicle length of the watermelon seedlings was favored under hydropriming (3.95 cm), followed by Ca $(NO_3)_2$ and GA priming, whereas the KNO_3 priming had the lowest effect (2.62 cm) (Figure 3B). Shoot dry matter of watermelon seedlings was significantly higher under GA, Ca $(NO_3)_2$ and water priming (Figure 3C), whereas the higher dry matter of the roots was obtained with KNO_3 and water priming (Figure 3D). Demir et al. (2004) and Nascimento (2005) reported that seed priming with KNO_3 enhanced the seed germination and growth of watermelon under improper conditions. The high efficiency of hydropriming treatments in improving the early seedling growth was also reported previously in watermelon (Huang et al., 2002), lentil (Ghassemi-Golezani et al., 2008b) and cucumber (Gurgel et al., 2009). Seed priming with GA has been shown to have beneficial effects on germination and growth of a wide range of plant species (Jamil et al., 2007; Lopes et al., 2008; Albuquerque et al., 2009; Alonso-Ramirez et al., 2009; Nasri et al., 2012; Kandil et al., 2014).

In general, the results presented here indicate that seed priming with GA, KNO_3, Ca $(NO_3)_2$ and water (hydropriming) can be successfully applied to improve the germination and initial growth of watermelon seedlings. Germination and seedling emergence stages are critical for crop production; rapid and uniform field emergence is essential to achieve high yield and uniform plant stands, resulted in early maturity and reduced disease attack (Singh et al., 2001; Subedi et al., 2005).

FINAL CONSIDERATIONS

Seed priming with GA, KNO_3, Ca $(NO_3)_2$ and water (hydropriming) may can be successfully applied on watermelon seeds to improve germination performance and growth characteristics of seedlings. The seed priming with 0.2% solution of CK (90 mg L^{-1} kinetin) inhibited the germination and cell elongation process of the seedlings, and therefore should not be used by watermelon growers.

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Toda a nossa ciência, comparada com a realidade, é primitiva e infantil – e, no entanto, é a coisa mais preciosa que temos.

Albert Einstein

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