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ORIGINAL SCIENTIFIC PAPER

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QUALITY OF GARDEN PEA (*Pisum sativum* L.) PRIMED SEED

ABSTRACT: The objective of this study was to examine the effects of different priming treatments on seed quality and initial growth and development of garden pea. For this purpose, three garden pea cultivars, developed at the Institute of Field and Vegetable crops, Novi Sad were examined. The laboratory experiment was conducted under optimal conditions. Seeds were primed in water (hydropriming), 0.5% KNO_3 solution, and -0.49 MPa PEG solution for 24 hours; non-primed seeds were controls. The results showed that the percentage of germination, shoot and root length, and mean germination rate significantly increased after the tested priming treatments, while the percentage of abnormal seedlings and mean germination time were significantly decreased after the priming treatments compared to the control. The increase of fresh and dry seedling biomass was significant only in cv.1 and cv.2. Despite the genetic diversity of pea cultivars, the results indicated that the examined seed priming treatments enhanced seed quality and vigour of garden pea cultivars.

KEYWORDS: garden pea cultivar, seedling growth and biomass, seed priming, seed quality

INTRODUCTION

Garden pea (*Pisum sativum* L.) is an important legume, rich in proteins, dietary fibres, starch, carbohydrates and micronutrients, including vitamins and

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minerals. With up to 35% of proteins and essential amino acids, such as lysine and tryptophan (Elzebroek and Wind, 2008), the garden pea is an important legume in human nutrition. According to Petrović et al. (2016), together with other legumes, it provides one-third of the required amount of protein in human consumption. The annual global production of green pea seeds is approximately 21.7 million tons (FAOSTAT, 2021), while Serbian production amounts to approximately 38,000 tons and has a rising trend.

Seed germination is the most critical stage in plant growth and development, ultimately determining the success of crop production (Kathare and Hug, 2021; Almansouri et al., 2001). Rapid and uniform seedling emergence is the key factor of crop performance, because slow germination exposes plants to adverse environmental conditions, strong weed competition and soil-borne diseases (Paparella et al., 2015; Vidak et al., 2022). Seed quality has become a priority, while seed priming has proven to be a well-established treatment for seed quality enhancement (Adhikari et al., 2021; Cokkizgin, 2013; Paparella et al., 2015). Seed priming is a water-based technique that allows controlled seed rehydration and triggers metabolic processes normally activated during pre-germinative metabolism, while preventing seed transition towards full germination.

Beneficial effects on seed germination of various seed priming techniques, such as hydropriming and osmopriming, have been reported in many crops. However, information on the effects of these seed pre-treatments on the seed quality of the domestic garden pea is lacking. In this context, the aim of the research was to evaluate the effects of hydropriming and osmopriming on garden pea seed quality and initial development.

MATERIALS AND METHODS

Experimental (Plant) materials

The seeds of three garden pea cultivars were obtained from the Institute of Field and Vegetable Crops, the National Institute of the Republic of Serbia, Novi Sad.

Priming treatments

Before priming, garden pea seeds were disinfected with 5% (w/v) sodium hypochlorite for 5 min and then rinsed thoroughly with distilled water thrice. Seeds were immersed keeping the ratio of seed weight and solution volume 1:5 (w/v) in a 0.5% KNO_3 solution, a polyethylene glycol PEG-6000 solution (-0.49 MPa) and water at 25 °C for 24 h in dark. Thereafter, treated seeds were rinsed with distilled water thrice and dried back near to their original moisture content at room temperature.

The germination test

Working samples consisted of 3 x 100 seeds. Primed and non-primed seeds were placed in plastic boxes 240 x 150 mm with double-layer filter paper moistened with distilled water. The samples were incubated for 8 days in a germination chamber at 20 °C. Germination, abnormal seedlings, as well as shoot and root length, and fresh seedling weight of ten seedlings were determined eight days after seed placement in the germination chamber. To obtain the dry seedling weight, pea seedlings were oven-dried at 80 °C for 24 h. Mean germination time was calculated using the equation of Ellis and Roberts (1981): $MGT = \Sigma Dn / \Sigma n$, where n is the number of germinated seeds on day D and D is the number of days. The mean germination rate was calculated as the reciprocal value of the mean germination time (Ranal et al., 2009).

Statistical analysis

The data were subjected to analysis of variance using Statistica 10 (StatSoft, Inc., 2007) software package. Mean values followed by standard deviation were separated using Duncan's multiple range test at probability level $p<0.05$.

RESULTS AND DISCUSSION

Analysis of variance showed that the germination percentage of cv.1 was significantly influenced by all the tested seed priming treatments (Figure 1). However, other tested pea cultivars responded differently to priming treatments. Germination of pea cultivar cv.2 was significantly increased by priming with KNO_3 and PEG solution up to 7.28% and 4.41%, respectively. In cv.3, a beneficial effect on germination percentage was observed after hydropriming (74.6%) and priming with PEG solution (88.0%) compared to the control (72.3%). Garden pea cultivars also responded differently to priming treatments in terms of abnormal seedling percentage. In cv.1, no significant difference in the percentage of abnormal seedlings was observed between primed seeds and control. Hydropriming significantly increased the percentage of abnormal seedlings (4.7%) of cv.2 compared to control, while all the tested treatments led to a significant decrease of abnormal seedlings in cv.3 compared to control. The results are in agreement with the findings of Yanglem et al. (2016) and Kuar et al. (2015). Sachan et al. (2016) also found that hydropriming significantly increases pea seed germination. However, a higher percentage of abnormal seedlings in cv.2 after hydropriming could be due to a higher rate of radical protrusion and imbibitional injury, and a rapid inflow of water into the fast-absorbing legume seed embryonic cells, which led to physical disruption of the cell membrane (Powell and Matthews, 1977; Sachan et al., 2016). Moreover, similar increases in the germination of alfalfa (Mouradi et al., 2016a), soybean (Miladinov et al., 2018), wheat (Baque et al., 2016), and rice (Ruttanaruangboworn

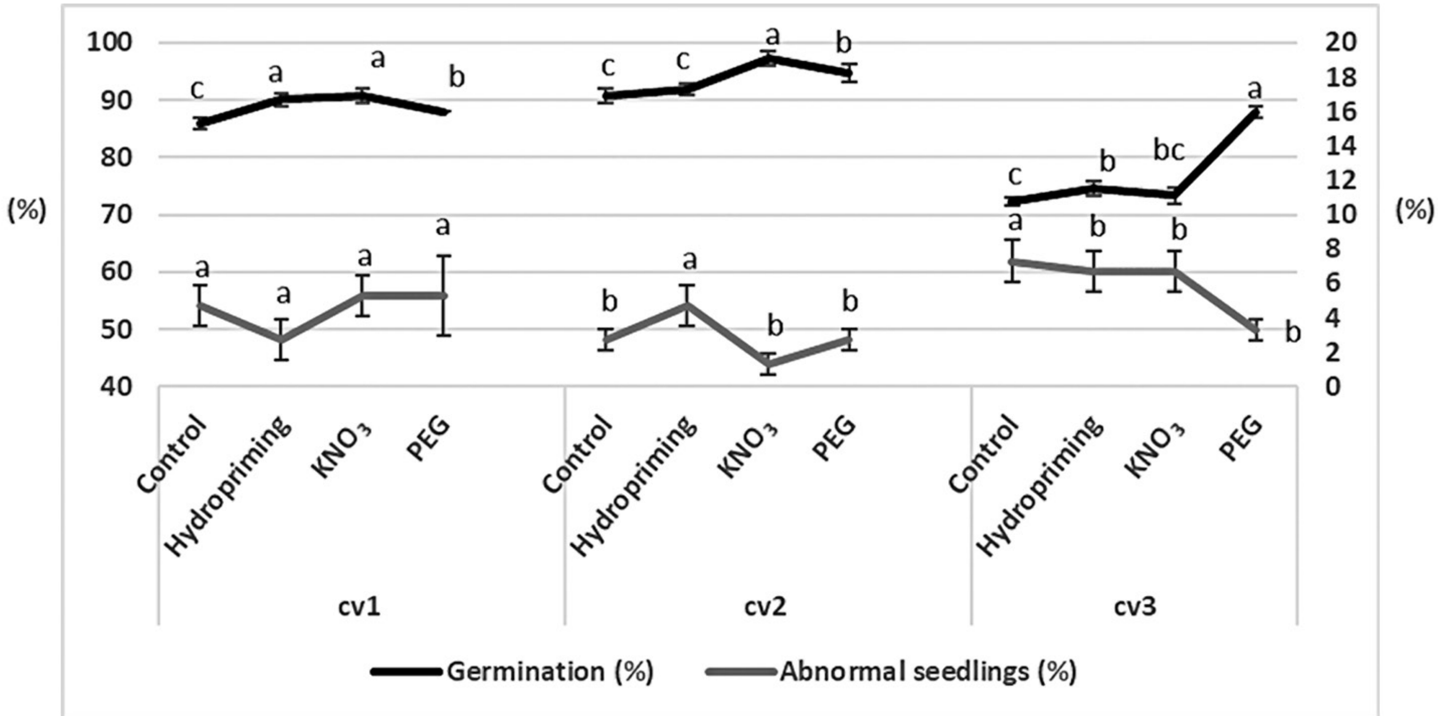

Figure 1. The effects of seed priming with water, KNO_3 solution and PEG solution on germination percentage (%) and abnormal seedlings (%) of garden pea cultivars. Mean values with the same letter within pea cultivar are not statistically different at $p \leq 0.05$.

et al., 2017) through priming with water, KNO_3 and PEG were reported in previous research. Seed priming most likely contributes to the repair of membrane damage caused by deterioration, which results in better germination and higher vigour level compared to non-primed seed (Jisha et al., 2013).

The shoot length of pea seedlings varied among the pea cultivars, ranging between 25.9 mm and 29.5 mm in control (Figure 2). However, the shoot length of pea cultivars was significantly affected by all the tested seed priming treatments. The results revealed the maximum shoot length (41.6 mm) in pea cultivar cv.1 primed with water (hydropriming). Pea cultivars cv.2 and cv.1 had a similar performance after the seed priming treatments, while the shoot length of cv.3 was increased up to 16.3% by priming with PEG. Beneficial effects of hydropriming and PEG priming on shoot length were also reported by Cokkizgin (2013) and Yanglem et al. (2016) on pea, and Baque et al. (2016) on wheat. Furthermore, the root length of cv.1 and cv.2 was significantly improved after all the tested seed priming treatments compared to the control, while cv.3 responded positively only to priming with KNO_3. According to Yanglem et al. (2016), a significant improvement in shoot and root length in primed seeds might be due to the involvement of priming agents in cell elongation or cell division and meristem growth.

However, pea cultivars responded differently to priming treatments in terms of fresh and dry biomass accumulation (Figure 3). All the tested pea cultivars had similar fresh and dry seedling weights in control. A significant increase in fresh and dry seedling weight was recorded in cv.1 after all the seed priming treatments, and in cv.2 after hydropriming, while no significant differences were observed in cv.3 compared to the control. Maximum values of the fresh and dry weight of seedlings were observed in cv.1 primed with KNO_3. The results are in accordance with the findings of Ali et al. (2021), who confirmed KNO_3 effectiveness in improving the fresh and dry weight of seedlings. Furthermore, a positive effect of hydropriming on fresh and dry seedling biomass was also observed in chickpea (Sarwar et al., 2006), sunflower (Catiempo et al., 2021) and other plant species. Contrary to our results obtained in cv.3, where the increase in fresh and dry seedling weight was not statistically significant compared to the control, Barique et al. (2016) reported that the maximum dry weight of seedlings was recorded in seeds primed with PEG solution. These results are in accordance with the results of Mouradi et al. (2016b), obtained on alfalfa under optimum conditions.

Analysis of variance showed that MGT and MGR were significantly affected by the seed priming treatments (Figure 4). In general, all the seed priming treatments significantly decreased MGT and increased MGR in all the tested pea cultivars compared to the control. The reduction in MGT ranged between 19.4% (cv.3 primed with PEG) and 46.7% (cv.3 primed with KNO_3) depending on the pea genotype and the seed priming treatment. A similar pattern of increase in MGR following a priming treatment was observed. Osmopriming also caused MGT reduction in soybean (Sadeghi et al., 2011), wheat (Abnavi and Ghobadi, 2012), sugar beet (Hosseini and Koocheki, 2007), and maize (Ahammad et al., 2014). Seed priming with KNO_3 and PEG has

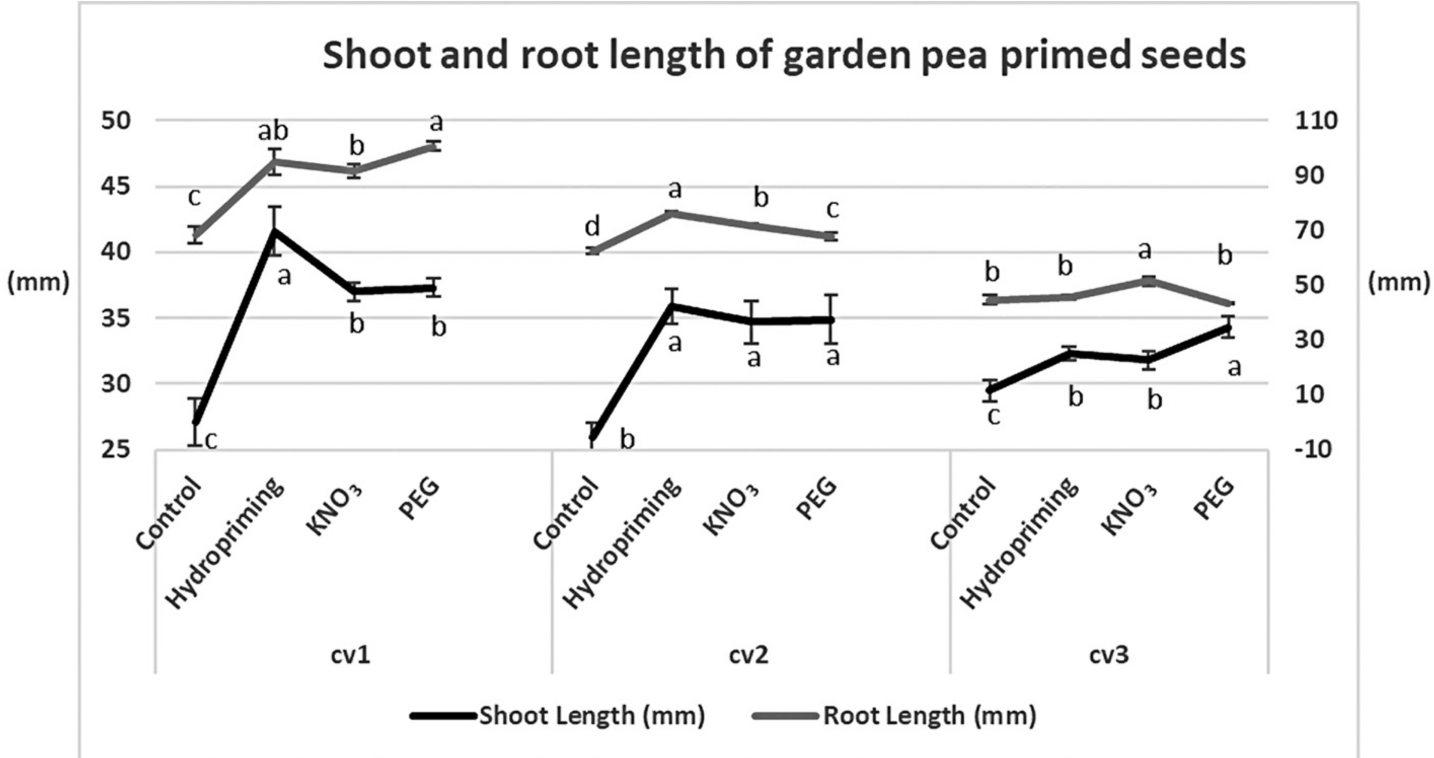

Figure 2. The effects of seed priming with water, KNO_3 solution and PEG solution on a shoot (mm) and root length (mm) of garden pea cultivars. Mean values with the same letter within the pea cultivar are not statistically different at $p \leq 0.05$

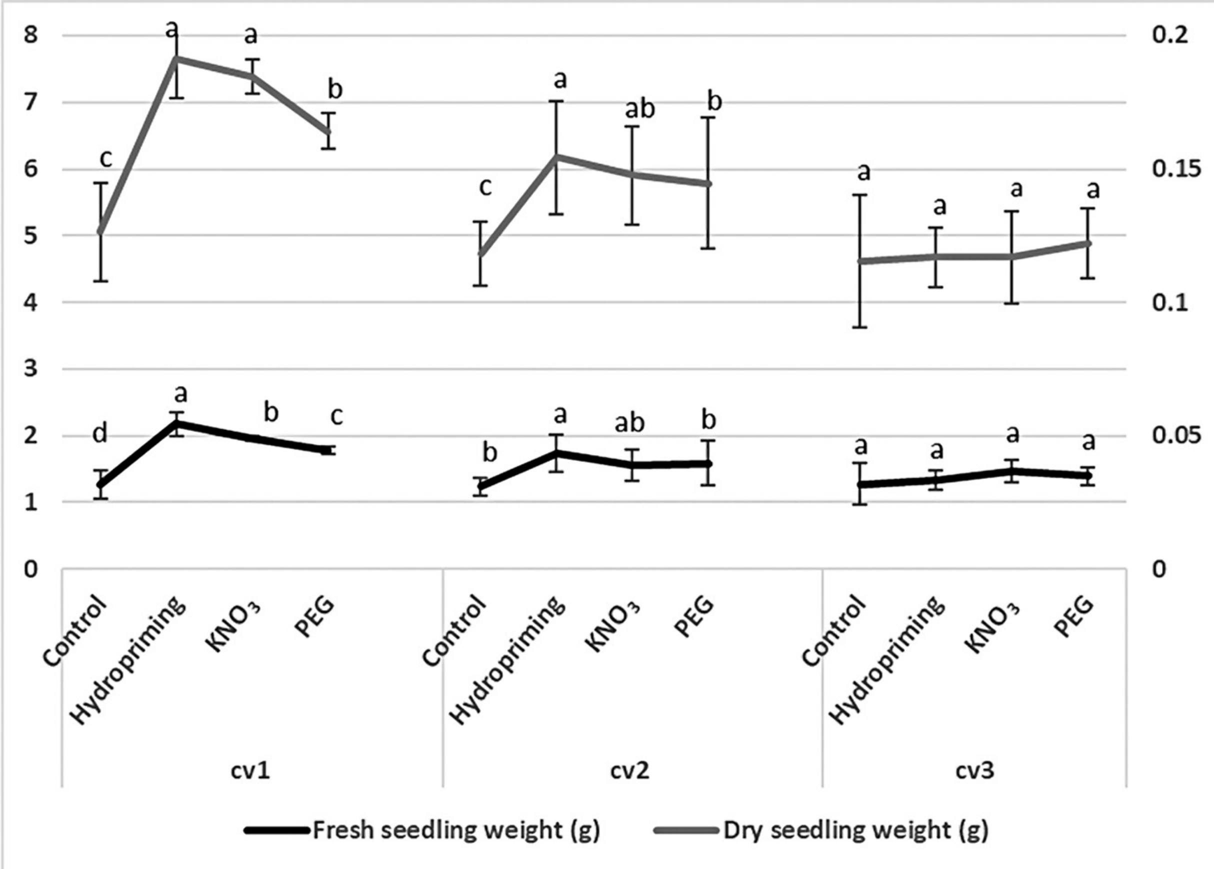

Figure 3. The effects of seed priming with water, KNO_3 solution and PEG solution on fresh (g) and dry seedling weight (g) of garden pea cultivars. Mean values with the same letter within the pea cultivar are not statistically different at $p \leq 0.05$

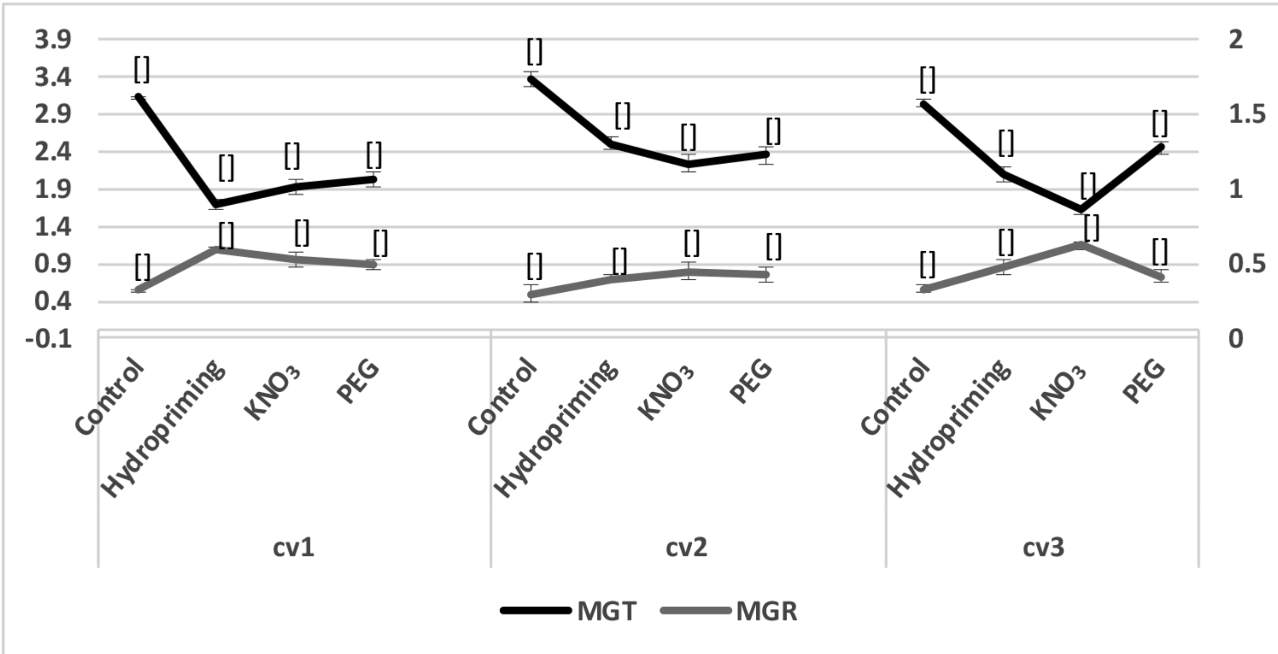

Figure 4. The effects of seed priming with water, KNO_3 solution and PEG solution on mean germination time (MGT) and mean germination rate(MGR) of garden pea cultivars. Mean values with the same letter within the pea cultivar are not statistically different at $p \leq 0.05$

beneficial effects on germination speed and uniformity (Ruttanaruangboworn et al., 2017), as well as supporting the early stages of the germination process by the mediation of cell division in germinating seeds (Nasri et al., 2011), which in turn results in positive effects on MGT and MGR. Moreover, seed priming changes the activity of enzyme α-amylase (Farooq et al., 2006) and other hydrolytic enzymes (Szopińska and Politycka, 2016) in primed seeds, which leads to better germination and seedling growth.

CONCLUSION

The obtained results confirmed the positive effects of the tested seed priming treatments on seed germination and initial growth of garden pea cultivars. The positive effect of the tested seed priming treatments on biomass accumulation was less pronounced in cultivar 3 compared to the other garden pea cultivars. The findings indicate that priming seeds with a solution of KNO_3 and PEG could efficiently improve the quality of garden pea seeds and initial plant development.

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REFERENCES

Abnavi MS, Ghobadi M (2012): The effects of source of priming and post-priming storage duration on seed germination and seedling growth characteristics in wheat (*Triticum aestivum* L.). *J. Agric. Sci.* 4: 256–268.

Adhikari B, Dhital PR, Ranabhat S, Poudel H (2021): Effect of seed hydro-priming durations on germination and seedling growth of bitter gourd (*Momordica charantia*). *PLoS One*. 16: e0255258.

Ahammad KU, Rahman MM, Ahmed M (2014): Effect of osmopriming on the maize (*Zea mays* L.) seedling. *Bangladesh J. Agril. Res.* 39: 427–435.

Ali LG, Nulit R, Ibrahim MH, Yien CYS (2021): Efficacy of KNO3, SiO2 and SA priming for improving emergence, seedling growth and antioxidant enzymes of rice (*Oryza sativa*) under drought. *Sci. Rep.* 11: 3864.

Almansouri M, Kinet JM, Lutts S (2001): Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). *Plant Soil* 231: 243–254.

Baque A, Nahar M, Yeasmin M, Quamruzzaman M, Rahman A, Azad MJ, Biswas PK (2016): Germination behaviour of wheat (*Triticum aestivum* L.) as influenced by polyethylene glycol (PEG). *Universal J. Agril. Res.* 4: 86–91.

Catiempo RL, Photchanachail S, Bayogan ERV, Wongs-Aree C (2021): Impact of hydropriming on germination and seedling establishment of sunflower seeds at elevated temperature. *Plant Soil Environ*. 9: 491–498.

Cokkizgin A (2013): Effects of hydropriming and osmo-priming on seed vigor of pea (*Pisum sativum* L.). *Agric. For. Fish*. 2: 225–228.

Ellis RA, Roberts EH (1981): The quantification of ageing and survival in orthodox seeds. *Seed Sci. Technol.* 9: 373–409.

Elzebroek ATG, Wind K (2008): *Guide to cultivated plants*. Wallingford, UK: CAB International, pp. 540.

FAOSTAT (2021). Available to: http://www.fao.org/faostat/en/#data/QC

Farooq M, Basra SMA, Tabassum R, Afzal I (2006): Enhancing the performance of direct seeded fine rice by seed priming. *Plant Prod. Sci*. 9: 446–456.

Hosseini A, Koocheki A (2007): The effect of different priming treatments on germination percent and mean germination time of four varieties of sugar beet. *J. Agron. Res*. 5: 69–76.

Jisha KC, Vijayakumari K, Puthur JT (2013): Seed priming for abiotic stress tolerance: an overview. *Acta. Physiol. Plant*. 35: 1381–1396.

Kathare PK, Hug E (2021): Signals | Light signalling in plants. In: *Encyclopedia of Biological Chemistry* III (Third Edition). Jez J (ed.)., Elsevier, volume 6, 78–89.

Kuar H, Chawla N, Bassi G, Pathak M (2015): Effect of different seed priming treatments on germination of Okra (*Abelmoschus esculentus* L.). *Int. J. Curr. Sci*. 15: 51–58.

Miladinov Z, Balešević-Tubić S, Đukić V, Ilić A, Čobanović L, Dozet G, Merkulov-Popadić L (2018): Effect of priming on soybean seed germination parameters. *Acta Agric. Ser.* 45: 15–26.

Mouradi M, Bouizgaren A, Farissi M, Makoudi B, Kabbadj A, Very AA, Sentenac H, Qaddoury A, Ghoulam C (2016a): Osmopriming improves seeds germination, growth, antioxidant responses and membrane stability during early stage of Moroccan alfalfa populations under water deficit. *Chilean J. Agric. Res*. 76: 265–271.

Mouradi M, Bouizgaren A, Farissi M, Latrach L, Qaddoury A, Ghoulam C (2016b): Seed osmopriming improves plant growth, nodulation, chlorophyll fluorescence and nutrient uptake in alfalfa (*Medicago sativa* L.) – rhizobia symbiosis under drought stress. *Sci. Hort.* 213: 232–242.

Nasri N, Kaddour R, Mahmoudi H, Baatour O, Bouraoui N, Lachaâl M (2011): The effect of osmopriming on germination, seedling growth and phosphatase activities of lettuce under saline condition. *Afr. J. Biotechnol*. 10: 14366–14372.

Paparella S, Araújo SS, Rossi G, Wijayasinghe M, Carbonera D, Balestrazzi A (2015): Seed priming: state of the art and new perspectives. *Plant Cell Rep*. 34: 1281–1293.

Petrović G, Jovičić D, Nikolić Z, Tamindžić G, Ignjatov M, Milošević D, Milošević B (2016): Comparative study of drought and salt stress effects on germination and seedling growth of pea. *Genetika* 48: 373–381.

Powell AA, Matthews S (1977): Deteriorative changes in pea seeds stored in humid and dry conditions. *J. Exp. Bot.* 28: 255–234.

Ranal MA, Santana DG, Ferreira WR, Mendes-Rodrigues C (2009): Calculating germination measurements and organizing spreadsheets. *Revista Brasil. Bot*. 32: 849–855.

Ruttanaruangboworn A, Chanprasert W, Tobunluepop P, Onwimol D (2017): Effect of seed priming with different concentrations of potassium nitrate on the pattern of seed imbibition and germination of rice (*Oryza sativa* L.). *J. Int. Agric.* 16: 605–613.

Sachan VK, Kumar R, Nautiyal P (2016): Impact of hydropriming treatments on seed invigoration in vegetable pea (*Pisum sativum* L.). *Veg. Sci.* 43: 70–72.

Sadeghi H, Khazaei F, Yari L, Sheidaei S (2011): Effect of seed osmopriming on seed germination behaviour and vigor of soybean (*Glycine max* L.). *ARPN J. Agric. Biol. Sci*. 6: 39–43.

Sarwar N, Yousaf S, Jamil F (2006): Induction of salt tolerance in chickpea by using sample and safe chemicals. *Pak. J. Bot*. 38: 325–329.

Szopińska D, Politycka B (2016): The effects of hydro- and osmopriming on the germination, vigour and hydrolytic enzymes activity of common zinnia (*Zinnia elegans* Jacq.) seeds. *Folia Hort*. 28: 3–11.

Vidak M, Lazarević B, Javornik T, Šatović Z, Carović-Stanko K (2022): Seed water absorption, germination, emergence and seedling phenotypic characterization of the common bean landraces differing in seed size and color. *Seeds* 1: 324–339.

Yanglem SD, Ram V, Rangapps K, Devi MH, Singh NJ, Singh AK (2016): Effect of seed priming on germination and initial seedling growth of pea (*Pisum sativum* L.) cultivars. *Bioscan*. 11: 2625–2630.

ОРИГИНАЛНИ НАУЧНИ РАД

КВАЛИТЕТ СЕМЕНА ПОВРТАРСКОГ ГРАШКА (*Pisum sativum* L.) НАКОН ПРАЈМИНГА

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РЕЗИМЕ: Циљ овог истраживања био је да се испитају ефекти различитих третмана прајминга на квалитет семена и почетни раст и развој повртарског грашка. У ту сврху испитане су три сорте повртарског грашка створене у Институту за ратарство и повртарство у Новом Саду. Лабораторијски оглед је изведен у оптималним условима. Семе је потапано у воду (хидропрајминг), 0,5% раствор KNO_3 и -0,49 MPa раствор PEG током 24 сата; нетретирано семе је било контрола. Резултати су показали да су се проценат клијања, дужина надземног дела и корена изданака, као и средња стопа клијања значајно повећали у испитиваним третманима прајминга, док су се проценат атипичних изданака и средње време клијања значајно смањили у третманима прајминга у поређењу са контролом.

Повећање свеже и суве биомасе изданака било је значајно само код сорти cv.1 и cv.2. Упркос генетској разноликости сорти грашка, ови резултати су показали да су испитивани третмани прајминга семена ефикасне методе у смислу повећања квалитета и вигора семена сорти повртарског грашка.

КЉУЧНЕ РЕЧИ: сорте повртарског грашка, раст и биомаса биљака, прајминг семена, квалитет семена