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ALLEVIATION OF SALINITY STRESS IN GARDEN PEA USING HYDRO- AND OSMOPRIMING

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SUMMARY

Salinity is one of the greatest challenges of successful agricultural production worldwide. However, seed priming might be efficient practice for enhancing seed germination and initial plant growth and development. This experiment was undertaken with the aim of assessing the impact of different priming methods on seed quality parameters and early growth of garden pea (Pisum sativum L.) cultivars under salinity stress. Pea seeds of three different cultivars were primed with water (hydropriming), KNO_3 solution (0.5%), and PEG 6000 solution (-0.5 MPa) for 24h in the dark. Unprimed and primed seeds were germinated between filter papers saturated with 120 mM NaCl using the germination test. The results clearly showed that the examined parameters of primed pea seeds were substantially greater than the parameters of unprimed seeds under saline stress. Moreover, seed priming with KNO_3 and PEG solutions were more effective in improving seed quality and initial growth in garden peas than hydropriming.

Key words:
salinity, Pisum sativum L., seed priming, seed germination, seedling growth

Abbreviations:
PEG - polyethylene glycol PEG 6000

INTRODUCTION

Salinity stress is one of the major menaces that impedes the thriving of plants and crop management worldwide. It has been estimated that in the next 25 years there will be a loss of about 30% of farmland due to expanded salinization of arable land (Wang et al., 2003). The growth and development of plants is disturbed by salinity, causing osmotic stress on plants. Soil salinity affects the reduction of water and nutrient intake, oxidative damage, ionic imbalance, seed germination dynamics with ionic toxicity Na^+ and Cl^-, low protein and photosynthesis, etc. (Khajeh-Hosseini et al., 2003; Sharma et al., 2012; Liang et al., 2018; Van Zelm et al., 2020). According to FAO Soils Portal (2023a), the land area of over 424 million hectares of topsoil and 833 million hectares of subsoil is salt-impeded either by containing excessive soluble salts or exchangeable sodium.

To overcome abiotic stresses such as salinity, various seed priming techniques are used nowadays. Seed priming is a technique of controlled seed hydration which encourages pre-germination metabolism, but germination does not occur (Farooq et al., 2009). Numerous studies have indicated that seed priming is the most pragmatic approach to battle against environmental stresses (Kaya et al., 2006; Farooq et al., 2010; Jafar et al., 2012). Beneficial effects of priming are manifested in synchronized germination by reducing absorption delay time and creating metabolites to improve germination and osmotic regulation (Farooq et al., 2013).

Pea (*Pisum sativum* L.) is one of the most significant grain legumes due to its crucial amount of proteins, fibre, carbohydrates, vitamins, and minerals, very important components of human nutrition (Nikolopoulou et al., 2007).

Alongside other legumes, they provide one-third of the total proteins required in the human diet (Petrović et al., 2016). Furthermore, after soybean, garden pea cultivars are the primary legumes in the world (Pawar et al., 2017). In 2021, garden pea was grown on over 2.5 million hectares with an average grain yield of 7.92 t ha^{-1} and total grain production of 20.5 million tonnes worldwide, while in Serbia, the garden pea was grown on over 5,700 hectares annually with an average yield of 4.1 t ha^{-1} (FAO, 2023b). The pea is a cool-season pulse grown in mild climate regions. Its tolerance to soil salinity differs among cultivars (Duzdemir et al., 2009).
Genetic diversity in terms of resistance to salt stress was reported in wheat (Jafar et al., 2012), maize (Akhtar et al., 2003), pea (Duzdemir et al., 2009), and sunflower (Hussain et al., 2012). Also, in wheat (Jafar et al., 2012) and lettuce (Nasri et al., 2011), a favorable influence of osmopriming on germination and initial plant growth under saline conditions was observed. However, in Serbia, information on the resistance of the garden pea cultivars to salinity stress is lacking, as well as information on the impact of hydropriming and osmopriming on the quality and initial growth of pea plants under salinity stress. Therefore, the present study was accomplished to evaluate the impact of hydropriming and osmopriming on seed quality and the initial growth of garden peas grown under salinity stress.

MATERIAL AND METHODS

Experimental (Plant) material

The used garden pea seeds were collected from three different cultivars (coded as C1, C2, and C3) developed at the Institute of Field and Vegetable Crops, the National Institute of the Republic of Serbia, Novi Sad (IFVCNS). The selected pea cultivars differ in their main characteristics. The pea cultivar coded as C1 is a very early cultivar which ripens after 55 days. It is defined by light green grains with high sugar content. The pods of cv. C1 are 6-7 cm long with 6-8 formed grains, while the 1000-grain weight is around 320 g. Pea cultivar C2 is a very early cultivar that ripens after 52-60 days. It is characterized by excellent grain quality suitable for green markets and industrial processes. The 1,000 grain weight of the cv. C2 is 400 g. The C3 pea cultivar is an early cultivar that takes 65–70 days to reach technical maturity. Technologically ripe grain of the cv. C3 is medium size, green in color, and 1,000 grain weight is about 350 g. The average length of the pods is about 7.5 cm, with 6-7 grains.
Seeds of the selected pea cultivars were produced on a chernozem soil in 2020 at the experimental field of IFVCNS (N 45°19`, E 19°50`) Vojvodina Province, Serbia.

Priming treatments

Seeds of the selected garden pea cultivars were sterilized using 5% (w/v) NaOCl for 5 min and then thoroughly washed three times with distilled water. For seed priming, seeds were completely submerged while maintaining a seed weight to solution volume ratio 1:5 w/v (Ghezal et al., 2016; Farooq et al., 2006) in distilled water (hydropriming), -0.5 MPa PEG 6000 solution, and 0.5% KNO_3 solution for 24 hours at 25 °C in dark conditions (Cokkizgin, 2013). Seeds were then rinsed intensively with distilled water, air-dried at room temperature close to their initial weight, and used at once for the germination test. Non-primed seeds were taken as control.

The germination test

To observe the impact of various priming treatments on garden pea seed quality and initial plant development under saline stress conditions, a laboratory study was carried out at the Laboratory for Seed Testing, IFVCNS, Novi Sad. Primed and non-primed seeds of garden pea cultivars were germinated in Petri dishes between double-layer Whatman paper at 20 °C and 50% of relative humidity in a germination chamber for 8 days (ISTA, 2022). The filter paper was moistened with 10 ml of 120 mM NaCl solution, which is considered to be the concentration that results in 50% inhibition of pea shoot and root length (Ghezal et al., 2016). A total of 100 seeds per replica were placed in each Petri dish. The experiment was arranged in a completely randomized design (CRD), with three replications. Germination energy was determined on the fifth day after sowing, while germination percentage and abnormal seedling percentage were determined on the eighth day after sowing. A radicle length of 10 mm was the criterion by which the seed was considered germinating. Seedlings that do not have well-developed essential structures such as the primary root, shoot axis, and cotyledons, seedlings with a deficiency of any of the basic structures or that are severely and irreparably damaged so that uniform development cannot be expected were considered abnormal seedlings (ISTA, 2022).
To obtain the shoot and root length, 25 seeds per pea cultivar and treatment were germinated in rolled filter paper pre-moistened with 120 mM NaCl. The rolled filter papers were set up in plastic bags and placed at 20 °C in the germination chamber for 8 days. Each treatment contained three replications. Shoot and root length of 10 randomly selected normal seedlings and fresh shoot and root weight of pea seedlings were determined 8 days after placing the

seeds on filter paper (at the end of the experiment). To obtain the dry shoot and root weight, 10 pea seedlings were dried at 80 °C for 24 hours. The seedling vigor index was determined using the formula by Abdul-Baki & Anderson (1973):

$$SVI = SL \times SG$$

whereas:
SVI – Seedling Vigor Index,
SL – Seedling length (cm),
SG – Seed germination (%).

Statistical analysis

The required statistical analysis of data which was based on a CRD design was conducted using Statistica 10 (StatSoft, Inc., 2007). All reported results were analyzed using two-way analysis of variance (ANOVA) and treatments means were compared using Duncan's multiple range test ($p < 0.5$).

RESULTS

The effects of cultivar, seed priming treatment and their interaction on germination energy, seed germination and abnormal seedlings are presented in Table 1, Table 2, and Table 3. Seed priming treatments had a considerable impact on pea parameter values. Additionally, each parameter under germination test was strongly impacted by the cultivar, while cultivar × treatment interaction significantly altered all tested pea parameters (Tab. 1-3).

The effect of seed priming treatments on germination energy, seed germination, and occurrence of abnormal seedlings of pea cultivars in germination test is presented in Table 1. With the exception of priming with KNO_3 in the case of the cv. C1 and hydropriming in the case of the cv. C2 and cv. C3, the significant and favorable effects of seed priming treatments were observed in comparison to the control for the evaluated germination parameters. Additionally, a preporedance of seed priming with KNO_3 and/or PEG over hydropriming was noticeable in germination parameters of cv. C2 and cv. C3. Furthermore, only hydropriming led to a significant decrease in germination parameters of cv. C3 under salinity stress.

Under salinity stress, only the germination energy of cv. C1 was increased by 5.8% after hydropriming, while in cv. C3 it was significantly reduced by 16.1% compared to the control. Similar results were found for seed germination, where hydropriming increased cv. C1's germination percentage by 4.7% and decreased cv. C3's germination percentage by 15.8%. Additionally, priming with KNO_3 decreased abnormal seedlings percentage of cv. C1, cv. C2, and cv. C3 by 11.3%, 86.8%, and 62.5%, respectively, while priming with PEG decreased occurrence of abnormal seedlings of cv. C1 and cv. C3 by 94.3% and 33.1%, respectively.

Table 1. Effect of priming with water (hydropriming), KNO_3 solution, and PEG solution on germination energy, seed germination, and abnormal seedlings of garden pea cultivars under salinity stress

Garden pea cultivar	Treatment	Germination energy (%)	Seed germination (%)	Abnormal Seedlings (%)
C1	Control	79.0 ± 1.0 b	82.0 ± 1.0 b	5.3 ± 0.6 a
	Hydropriming	83.6 ± 0.6 a	86.0 ± 1.0 a	2.0 ± 1.0 b
	KNO_3	79.3 ± 1.2 b	82.0 ± 1.0 b	4.7 ± 0.6 a
	PEG	83.3 ± 1.2 a	86.0 ± 1.7 a	0.3 ± 0.6 c
	p value	0.0005	0.0036	0.0001
C2	Control	66.7 ± 2.1 c	70.3 ± 2.1 c	5.3 ± 1.5 a
	Hydropriming	67.7 ± 0.6 c	69.3 ± 1.2 c	3.3 ± 1.2 a
	KNO_3	82.3 ± 0.6 b	84.7 ± 1.2 b	0.7 ± 0.6 b
	PEG	86.3 ± 0.6 a	88.7 ± 1.5 a	5.3 ± 0.6 a
	p value	0.0000	0.0000	0.0017
C3	Control	62.0 ± 1.0 c	63.3 ± 1.5 c	16.0 ± 1.0 b
	Hydropriming	52.0 ± 0.0 d	53.3 ± 1.2 d	26.7 ± 1.2 a
	KNO_3	81.3 ± 1.2 a	82.7 ± 1.2 a	6.0 ± 1.0 d
	PEG	72.3 ± 0.6 b	73.3 ± 1.2 b	10.7 ± 0.6
	p value	0.0000	0.0000	0.0000
F test	Cultivar (C)	634.1***	426.9***	631.4***
	Treatment (T)	459.6***	250.6***	106.8***

	C × T	173.2***	92.9***	107.3***

Legend: * - data presented in the table are mean ± SD; Different letters indicate significant difference between the control and priming treatments at $p < 0.05$; level of significance - * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, ns-not significant

In the present study, Table 2 shows the impact of priming treatments on shoot and root length and fresh weight of different pea cultivars. The cultivar average revealed positive and significant effects of priming treatments in relation to their controls in saline condition, with the exception of hydropriming in cv. C3.

In addition, significant differences between individual treatments were noted, except for shoot length (hydropriming vs. KNO_3 vs. PEG) of cv. C1; shoot length (KNO_3 vs. PEG) of cv. C2; root length (hydropriming vs. KNO_3) of cv. C1 and cv. C2; root length (KNO_3 vs. PEG) of cv. C3; fresh shoot and root weight (hydropriming vs. KNO_3) of cv. C1; and fresh root weight (KNO_3 vs. PEG) of cv. C1 and cv. C2. The highest increase in shoot length of cv. C1 and cv. C2 (46.15% and 42.3%, respectively), as compared to the control, was observed after priming with KNO_3, whereas cv. C3 had the greatest shoot length (21.9%) after priming with PEG.

Regarding root length, no such pattern was observed (Tab. 2). In other words, even though all treatments increased root length, with the exception of cv. C3 after hydropriming, the highest increase in root length was observed after priming with PEG (72.3, 61.9%, and 35.2%, respectively). Moreover, priming with KNO_3 also showed a significant and favorable impact on root length (38.8%, 26.2%, and 27.8%, respectively) but to a lesser extent compared to priming with PEG. In addition, hydropriming led to a significant increase in the root length of cv. C1 and cv. C2 (42.5% and 28.5%) compared to the control, while no significant differences were observed in cv. C3.

As for the fresh shoot and root weight, consistent improvements in these parameters were found in seeds of all tested garden pea cultivars primed with KNO_3 and PEG (Tab. 2). However, significant differences between these treatments were noted as follows: KNO_3 vs. PEG for fresh shoot weight (all tested cultivars) and fresh root weight (cv. C1) under salinity stress. The greatest enhancements in fresh shoot weight (62.5% and 59.3%) of cv. C2 and cv. C3, as well as fresh root weight (47.4% and 23.4%), compared to the control, were observed after priming with KNO_3. These parameters of cv. C1 and cv. C2 were significantly improved by hydropriming compared to the control, while no difference was observed for the cv. C3.

Table 2. Effect of priming with water (hydropriming), KNO_3 solution, and PEG solution on shoot and root length, and fresh shoot and root weight of garden pea cultivars under salinity stress

Garden pea cultivar	Treatment	Shoot length (mm)	Root length (mm)	Fresh shoot weight (g)	Fresh root weight (g)
C1	Control	13.0 ± 0.7 b	37.9 ± 1.3 c	0.2541 ± 0.008 c	0.2779 ± 0.005 c
	Hydropriming	18.8 ± 1.3 a	54.0 ± 0.3 b	0.4287 ± 0.008 b	0.4460 ± 0.021 b
	KNO_3	19.0 ± 0.5 a	52.6 ± 2.8 b	0.4202 ± 0.013 b	0.4563 ± 0.027 b
	PEG	18.5 ± 0.8 a	65.3 ± 1.5 a	0.4975 ± 0.018 a	0.5571 ± 0.013 a
	p value	0.0001	0.0000	0.0000	0.0000
C2	Control	9.7 ± 1.1 b	30.2 ± 1.2 c	0.2021 ± 0.011 d	0.2115 ± 0.015 c
	Hydropriming	10.5 ± 1.2 b	38.8 ± 0.8 b	0.2360 ± 0.015 c	0.2606 ± 0.024 b
	KNO_3	13.8 ± 0.7 a	38.1 ± 0.7 b	0.3284 ± 0.015 a	0.3117 ± 0.010 a
	PEG	13.3 ± 1.0 a	48.9 ± 1.4 a	0.2761 ± 0.002 b	0.3254 ± 0.019 a
	p value	0.0018	0.0000	0.0000	0.0002
C3	Control	11.4 ± 6.3 b	23.0 ± 1.3 b	0.1866 ± 0.005 c	0.2566 ± 0.005 b
	Hydropriming	12.7 ± 0.8 ab	22.7 ± 0.4 b	0.1891 ± 0.011 c	0.1933 ± 0.017 c
	KNO_3	12.1 ± 1.0 b	29.4 ± 1.7 a	0.2973 ± 0.013 a	0.3167 ± 0.019 a
	PEG	13.9 ± 0.5 a	31.1 ± 1.4 a	0.2769 ± 0.006 b	0.3145 ± 0.006 a
	p value	0.0147	0.0001	0.0000	0.0000
F test	Cultivar (C)	146.9***	1030.2***	709.2***	376.1***
	Treatment (T)	38.0***	252.5***	286.1***	144.77***
	C × T	8.7***	30.4***	51.7***	34.13***

Legend: * Data presented in the table are mean ± SD. Different letters indicate significant difference between the control and priming treatments at $p < 0.05$; level of significance - * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, ns—not significant

The analysis of average pea parameters, such as dry shoot and root weight and seedling vigor index, across garden pea cultivars revealed significant and positive effects of seed priming treatments with KNO_3 and PEG (Tab. 3). Regarding shoot and root dry weight, similar patterns were observed as for fresh weight. The greatest improvements in dry shoot weight (46.9% and 81.7%) of cv. C2 and cv. C3 were observed in priming with KNO_3, while priming with PEG was the best treatment in case of dry shoot weight (59.1%) of cv. C1, as compared to the control.

Hydropriming increased dry shoot weight (34.3% and 27.7%) of cv. C1 and cv. C2, in relation to the control, but to a lesser extent than other treatments.

As for the dry root weight, all treatments significantly improved this parameter, with exception of hydropriming in cv. C3. The highest increase, compared to the control, in root dry weight (78.8% and 45.2%) of cv. C1 and cv. C2 was obtained in priming treatment with PEG, as well as in root dry weight (22.1%) of cv. C3 in priming treatment with KNO_3. However, contrary to this, decrease in dry root weight (-7.1%) in comparison to the control was obtained from hydropriming.

Furthermore, the results disclosed that the seedling vigor index varied among pea cultivars under salinity stress (Tab. 3). The obtained results revealed that the tested garden pea cultivar responded positively to priming with KNO_3 and PEG. The greatest improvements in seedling vigor index (72.5% and 96.4%) of cv. C1 and cv. C2 were observed in priming with PEG, while priming with KNO_3 was the best treatment in case of seedling vigor index (57.7%) of cv. C3, as compared to the control. Although hydropriming enhanced the seedling vigor index of cv. C1 and cv. C2 by 50.0% and 21.7%, respectively, it caused a decrease in seedling vigor index of cv. C3 (-27.0%).

Table 3. Effect of priming with water (hydropriming), KNO_3 solution, and PEG solution on dry shoot weight, dry root weight, and seedling vigor index of garden pea cultivars under salinity stress

Garden pea cultivar	Treatment	Dry shoot weight (g)	Dry root weight (g)	Seedling vigor index
C1	Control	0.0391 ± 0.005 c	0.0316 ± 0.001 c	417.7 ± 13 c
	Hydropriming	0.0525 ± 0.002 b	0.0454 ± 0.001 b	626.2 ± 21 b
	KNO_3	0.0536 ± 0.001 b	0.0476 ± 0.002 b	587.3 ± 32 b
	PEG	0.0622 ± 0.001 a	0.0565 ± 0.002 a	720.5 ± 10 a
	p value	0.0000	0.0000	0.0000
C2	Control	0.0256 ± 0.001 c	0.0232 ± 0.001 c	280.8 ± 7 d
	Hydropriming	0.0327 ± 0.001 b	0.0293 ± 0.001 b	341.6 ± 14 c
	KNO_3	0.0376 ± 0.002 a	0.0335 ± 0.002 a	439.4 ± 7 b
	PEG	0.0338 ± 0.001 b	0.0337 ± 0.002 a	551.4 ± 20 a
	p value	0.0000	0.0000	0.0000
C3	Control	0.0251 ± 0.001 c	0.0281 ± 0.001 c	217.6 ± 2 b
	Hydropriming	0.0275 ± 0.002 c	0.0261 ± 0.001 d	188.8 ± 4 c
	KNO3	0.0456 ± 0.001 a	0.0343 ± 0.001 a	343.2 ± 12 a
	PEG	0.0329 ± 0.002 b	0.0320 ± 0.001 b	329.8 ± 13 a
	p value	0.0000	0.0000	0.0000
F test	Cultivar (C)	813.5***	589.5***	1334.7***
	Treatment (T)	236.6***	191.6***	374.8***
	C × T	46.56***	40.9***	48.9***

Legend: * Data presented in the table are mean ± SD. Different letters indicate significant difference between the control and priming treatments at $p < 0.05$; level of significance - * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, ns—not significant

DISCUSSION

Seed priming with KNO_3 and PEG solution remarkably enhanced the resistance in garden pea cultivars by increasing germination percentage, initial plant growth, and biomass accumulation. However, garden pea cultivars responded differently to all examined seed priming treatments. The greatest increase in germination percentage was noticed in two pea cultivars (C1, C2) primed with PEG solution, while pea cultivar C3 had the highest germination percentage under salinity stress when primed with KNO_3. Also, our results indicated that hydropriming reduced the inhibiting effects of salinity stress on pea seed germination but to a lesser extent than other priming treatments (Tab. 1). Similar positive effects of priming with KNO_3 and PEG solution on germination were also observed on lettuce (Nasri et al., 2011), alfalfa (Mouradi et al., 2016), wheat (Steiner et al., 2018), sorghum (Chen et al., 2021). According to Ghezal et al. (2016), NaCl stress (salinity stress induced by NaCl content in medium) prevents water absorption by seeds, leading to a significant reduction in germination. These authors also stated that the beneficial effect of seed priming under salinity stress is associated with efficient mobilization and usage of seed reserves. Moreover, primed seeds improved genetic repair, prior and rapid DNA, RNA, and protein synthesis as well as metabolic repair during imbibition (Srivastava, 2002; Ghezal et al., 2016). Nasri et al. (2011) declared that KNO_3 stimulates seed germination by acting as an osmoticum, thereby increasing water uptake. Also, several studies have noted that seed priming with PEG advances germination under salinity stress (Naglreiter et al., 2005; Zhang et al., 2009). Additionally, Nejatzadeh-Barandozi (2018) stated that seed priming with PEG was more effective in enhancing germination than priming with KNO_3, which is consistent with the results obtained in this study. Regarding the effect

of seed priming on the initial plant growth, our results showed that shoot and root length of pea seedlings were improved in seed priming with KNO_3 and PEG in the presence of NaCl. The fresh and dry shoot and root weight of pea seedlings was also improved by priming with KNO_3 and PEG compared to control. The favorable effect of priming with KNO_3 on seedling growth under salinity was also observed on lettuce (Nasri et al., 2011), melon (Farooq et al., 2007), chickpea (Sarwar et al., 2006). Likewise, Aydinoğlu et al. (2019) stated that seed priming with PEG mitigated the adverse effects of salinity stress on initial seedling growth in common vetch. This can be justified by the fact that during osmopriming, when seeds transit from dry to germinating state, the antioxidant pathway involving ascorbate peroxidase (APX) is stimulated and the pathway involving catalase (CAT) and superoxide dismutase (SOD) enzymes are suppressed; thus, the antioxidant system is strengthened and the germination potential is improved due to osmopriming, resulting in greater seed tolerance to stress (Chen & Arora, 2011).

Furthermore, the beneficial effect of hydropriming on the initial growth and biomass accumulation has also been established in all pea cultivars, but to a lesser extent compared to other priming treatments. These results are consistent with Dai et al. (2017), who reported that soybean seedlings from comprehensively primed seeds showed better growth status compared to hydropriming. Related results were also achieved in maize (Akter et al., 2018) and sunflower (Matias et al., 2018). The reduction of fresh and dry root weight was observed in pea cultivar C3 after hydropriming, contrary to the findings of Sarwar et al. (2006). This can be explained by the fact that an unequal degree of seed hydration, which can occur when applying this technique, can also lead to a lack of simultaneous metabolic activation within seeds (McDonald, 2000).

Murungu (2011) stated that hydropriming might result in the retention of excess water in the seed, which might lead to physiological seed damage. Another reason might be salt deposition in the root growing medium, as the main reason for physiological drought, which leads to reduction in cell division and cell enlargement in the root growing region, and ultimately reduction in root growth and biomass accumulation (Godfrey et al., 2004).

As stated by Ghezal et al. (2016), the higher shoot and root length than control is an indicator of improved seedling vigor which is in accordance with the result of this study. Seed priming treatments markedly enhanced the seedling vigor index in the tested garden pea cultivars, except in the pea cultivar C3 after hydropriming, which is probably due to the inhibited initial seedling growth caused by salinity. In their findings, Oliviera et al. (2019) also reported favorable impacts of hydropriming and KNO_3 priming on seedling vigor index of melon under salinity stress. Additionally, Chen et al. (2021) stated that priming treatments mitigate damage caused by salinity stress and that their effects were greater on germination index and vigor index than on final germination rate, indicating that priming predominantly enhanced seed vigor under salinity stress.

CONCLUSION

Based on our results, the studied parameters showed positive effects of the tested treatments on seed germination and plant development of the garden pea cultivars under saline stress, albeit to a lesser extent after hydropriming than after priming with KNO_3 and PEG. The findings suggest that application of KNO_3 priming and PEG priming could be considered as effective approaches in improving garden pea seed germination and initial development under saline stress conditions. However, garden pea cultivars differed in their response to different priming treatments. Further research on the physiological and biochemical mechanisms of plant response to seed priming under saline stress should be conducted, and extensive field trials would be necessary to evaluate the effects of priming treatments on yield and yield quality.

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