Turkish Journal of Food and Agriculture Sciences

T U R J F A S

5(1): 26-38 (2023)

Research Article

DOI: https://doi.org/10.53663/turjfas.1275739

COMPARATIVE ANALYSIS OF SEED PRIMING ON THE GERMINATION AND GROWTH OF LENTIL LANDRACES (*LENS CULINARIS* MEDIK)

Sujan BHANDARİ[1], Susmita BHATTARAİ[1] , Shubh Pravat Singh YADAV[1*], Indira KATTEL[1], Puja YADAV[1], Sangita BHUJEL[1]

[1] G. P. Koirala College of Agriculture and Research Center (GPCAR), Purbanchal University, Gothgaun, Morang, Nepal

ARTICLE INFO

HISTORY

Received: 3 April 2023
Revised: 20 May 2023
Accepted: 23 May 2023
Online Published: 30 June 2023

KEYWORDS

Germination
Growth
Landraces
Lentil
Polyethylene glycol (PEG)
Seed priming

* CONTACT

sushantpy8500@gmail.com

A B S T R A C T

Seed priming was carried out to determine the effect of different priming agents on seed germination and growth of different landraces of lentils. The two factorial experiments were carried out in a completely blocked design of which one factorial is of 7 treatments, i.e., PEG (10%), boric acid (0.1%), urea (2%), PEG (5%), DAP (2%), $CaCO_3$ (2%) and Control. Other landraces, Sunwarshi-LR1 and Rangeli-LR2, collected from two different locations in the Morang district, were replicated three times. The overall germination performance is better on landraces Sunwarshi-LR1, but no significant difference was observed in individual treatment. The interaction between the two landraces seems effective in germination and germination energy, whereas non-significant in germination speed and vigor index. The shoot length seems non-significant at 10 and 20 DAS, and a significant result was obtained at 30 DAS. The root length seems important at 10 DAS, whereas non-significant at 20 & 30 DAS. Sunwarshi-LR1 shows better performance with PEG (10%).

Citation: Bhandari, S.,Bhattarai, S., Yadav, S.P.S., Kattel, I., Yadav, P., & Bhujel, S. (2023). Comparative analysis of seed priming on the germination and growth of lentil landraces (*Lens culinaris* Medik). *Turkish Journal of Food and Agriculture Sciences*, *5*(1), 26-38.

ORCİD>0000-0002-8902-4126 (SB), ORCİD >0000-0003-2704-3118 (SB), ORCİD >0000-0003-3987-5616 (SPSY), ORCİD >0009-0003-4054-9233 (IK), ORCİD >0000-0001-9035-255X (PY), ORCİD >0009-0008-6563-3630 (SB)

1. Introduction

Lentil (*Lens culinaris* Medik.) is a self-pollinated crop cultivated annually and is believed to have been first cultivated 7000-8000 years ago (Toklu, 2015). Lentil is generally considered a drought-tolerant species (Sağlam et al., 2010). During the critical growth stages, lentil frequently faces water deficiency as it is cultivated in rainfed condition. Some factors like heat stress, water stress, and salinity show a negative impact on lentils which causes significant yield losses due to different biotic and abiotic conditions (Amir et al., 2021). Lentil content is high in protein and is also a source of dietary fiber, folate, vitamin B1, and minerals, and it is resistant to drought conditions (Pakbaz et al., 2014; Bethapalli et al., 2020). The primary limiting factor for the growth and yield of lentils has been drought stress, which reduces biomass, harvest index, and grain yield (Ghasemi-golezani et al., 2013). It is crucial in maintaining soil health and is also used in animal and human nutrition (Sağlam et al., 2010). Irrigation is responsible for increasing the yield parameters; seed size, yield, biomass yield, and harvest index (Muscolo et al., 2014). It is usually planted in the month of mid-October to November and harvested in the months of March-April (Darai et al., 2008). It also fixes the atmospheric nitrogen and helps in fulfilling the requirement of nitrogen for the plant through biological nitrogen fixation (Sharma et al., 2017).

Priming is a well-known method for improving seed quality by the momentary activation of the pre-germinative metabolism, which includes antioxidant and DNA repair mechanisms (Tiwari, 2018), which is also known as a pre-seed treatment, which helps in increasing the yield (Ghobadi et al., 2022). Seed priming has shown a good impact on seedling growth of grass seed before germination and metabolic activity (Toklu, 2015). Pre-seeding technique like seed pretreatment alters the metabolic process before the root emergence, which helps in promoting the seed germination and seedling emergence, which shows an impact on how seedling develops (Ghobadi et al., 2022). Seed priming is a common practice to treat the seed to promote uniform plant growth and shorten the time between the planting date and the seedling formation stage (Toklu, 2015). In the case of improving the seed germination rate, priming has been successively utilized for emerging vegetable seeds and small seed grasses. It has also shown an advantageous effect on fields like wheat, sugar beet, maize, soybean, and sunflower (Sağlam et al., 2010). Treating the seed with the different mediums has shown a positive impact by decreasing the time between sowing and emergence, which increases the seedling vigor (Johnson et al., 2005). There are various priming techniques, i.e., osmo-priming (it is the process of soaking the seed in an osmotic solution, e.g., polyethylene glycol), halopriming (it is the process of soaking the seeds in a salt solution) and hydropriming (it is the process of soaking the seed in water). Among this priming technique, osmo-priming resulted in a better germination rate and seedling growth of different plant species (Golezanik et al., 2008). The positive result of priming is seen in many field crops, which includes chickpea and lentil (Eskandari and Alizadeh-Amraie, 2014). In this process, germination starts, but radical emergence is avoided; this is one of the strategies to produce a substantial crop stand, increase legumes' biological nitrogen fixation capacity, and add more benefit from poor fertile soils (Lhungdim et al., 2014). Increasing the salt concentration slows down the seed germination by delaying hydrolysis of storage compounds by restricting the alteration from storage tissues to developing axe (Bouallègue et al., 2019). After seed priming, seeds can be sown by surface drying or re-drying nearly too original weight, and after washing that surface-dried seed, they are directly planted (Farooq et al., 2020).

Seed priming is a pre-sowing technique that involves manipulating seed moisture content and temperature to enhance the speed and uniformity of seed germination. In this study, we investigated the effect of different concentrations of priming solution on the germination rate of lentils, intending to identify the optimal medium for promoting seed germination and growth. The objective of our study was to investigate and propose solutions to improve the low germination rate of lentils and provide potential solutions for lentil growers and associated researchers.

2. Materials and methods

2.1. Plant materials

The present study aimed to assess the effect of seed priming on the germination and growth performance of two lentil landraces, Sunwarshi-LR1 and Rangeli-LR2, collected from Sunwarshi and Rangeli Municipality of Morang district, Nepal. The experiment was conducted in a Completely Block Design (CBD) with two factors: Two landraces and seven different priming treatments (Table 1). The research was carried out at the G. P. Koirala College of Agriculture and Research Centre laboratory, located at Sundarharaicha, Morang, Nepal, with geographical coordinates of 26.4^0 North and 87.21^0 East latitude.

2.2. Methods

The priming was conducted from November 12 to December 12, 2022, under normal room temperature, averaging 30°C, and relative humidity of 75%. The seeds were soaked in different priming solutions for 18 h, then dried for two h. The germination test was conducted by placing 100 seeds from each treatment on germination paper, followed by regular watering with a water can. The number of seedlings that emerged was recorded daily for seven days. On the eighth day, 25 seedlings from each treatment were transplanted into a seedling tray filled with soil and vermicompost at a ratio of 5:1 to observe their growth performance. Root and shoot length and fresh and dry weight of plants were measured at 10, 20, and 30 days of sowing. The collected data were entered into MS-Excel (2019) and analyzed using Gen-stat (18th edition). DMRT was used to compare the means of each parametric data (Gomez and Gomez, 1984). In contrast, R-studio software (4.2.2 Version) was used to analyze the interaction effect between the landraces and treatments, employing daewr, gvlma, and agricolae packages.

Table 1. Landraces and priming agents utilized in the research

S. N.	Landraces	Symbols
1.	Sunwarshi-LR1	LR1
2.	Rangeli-LR2	LR2

S. N.	Treatment	Doses	Symbols
1	Polyethylene glycol (PEG)	10 %	T1
2	Boric acid	0.1 %	T2
3	Urea	2 %	T3
4	Polyethylene glycol (PEG)	5 %	T4
5	Diammonium phosphate (DAP)	2 %	T5
6	Calcium carbonate ($CaCO_3$)	2 %	T6
7	Control	-	T7

3. Results

3.1. Effect of priming agents on germination parameters

Priming is effective and significantly affects overall germination parameters related to lentils. Seed primed with PEG 10% resulted in higher germination percentage (97.33%). In contrast, a lower germination rate was observed when the seed was primed with Boric acid (0.1%), $CaCO_3$ (2%) and DAP (2%), but the highest germination speed was kept on $CaCO_3$ (97.79). Seed primed with PEG (5%) showed the highest germination energy (94.67%), whereas the lowest germination energy (89.67%) and germination speed (93.62) was also observed in the unprimed seed (Table 2). The vigor index was higher on the seed kept under control, whereas the lowest vigor index was observed when the seed was treated with boric acid (0.1%). Overall, Sunwarshi-LR1 was shown a better result on all the growth parameters than that Rangeli-LR2.

Table 3 shows the interaction effect of treatment on the different landraces of germination parameters. The interaction effect of the priming agent among the different landraces is effective and provides a significant result on germination percentage. Still, in the case of germination speed and vigor index, it showed a non-significant effect. All the germination parameters seem to be higher on the seed primed with $CaCO_3$ (2%) for Sunwarshi-LR1 and PEG (5%) for Rangeli-LR2, but the seed treated with PEG (5%) shows lower germination in Sunwarshi-LR1. Similarly, the Rangeli-LR2 had shown lower germination on Boric acid (0.1%). The germination speed seems more inadequate on DAP (2%) on LR1 and PEG (10%) on LR2. The germination energy was lower in DAP (2%) for LR1 and control for LR2. The vigor index was lower on seeds treated with $CaCO_3$ (2%) for LR1 and Boric acid (0.1%) for LR2.

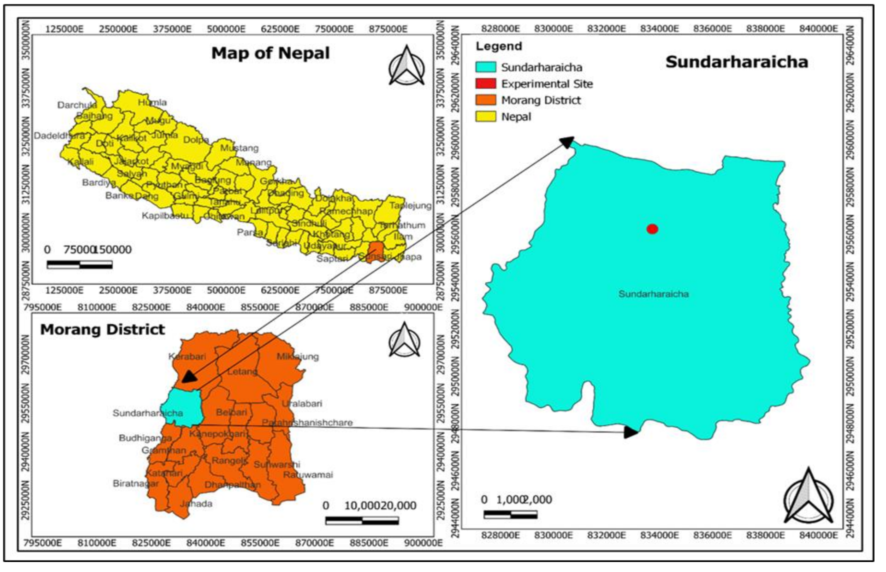

Figure 1. Experimental site of the research.

Table 2. Effect of different priming agents on germination parameters of lentil landraces.

Landraces	Germination (%)	Germination speed (%)	Germination energy (%)	Vigor index
Sunwarshi-LR1	98.67	97.10	95.81	1846
Rangeli-LR2	93.33	94.47	88.19	1766
Grand Mean	96.0	95.78	92.0	1806
SEM±	0.635	0.550	0.849	25.0
$LSD_{0.05}$	1.840	1.593	2.460	72.3
F-test	***	***	***	*
Treatments				
PEG (10%)	97.33	95.46	93.0	1803
Boric acid (0.1%)	95.0	96.05	91.33	1756
Urea (2%)	97.0	95.15	92.33	1814
PEG (5%)	97.0	97.60	94.67	1825
DAP (2%)	95.0	94.81	90.0	1781
$CaCO_3$ (2%)	95.0	97.79	93.0	1816
Control	95.67	93.62	89.67	1845
CV (%)	3.0	2.6	4.2	6.3
SEM±	1.189	1.029	1.589	46.7
$LSD_{0.05}$	3.443	2.980	4.602	135.2
F-test	NS	NS	NS	NS

*Significant at 5% level of significance, ***Significant at 0.1% level of significance, NSNon-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

3.2. Effect of priming agents on growth parameters

The study examined the effect of priming on root and shoot growth of various lentil landraces. The results indicated that priming had a non-significant effect on the overall growth parameters of lentils including shoot length and root length (Table 4 and Table 5). However, priming did enhance the rate of shoot length of lentil seedlings in some landraces. Specifically, landrace Rangeli-LR2 showed higher shoot length when primed with polyethylene glycol (PEG) (10%) compared to lentil landrace Sunwarshi-LR1, while root length was observed to be higher in landrace Sunwarshi-LR1 than in Rangeli-LR2.

Table 3. Interaction of different priming agents on germination parameters of lentil landraces

Interaction of treatments		Germination (%)	Germination speed (%)	Germination energy (%)	Vigor index
Landraces	Priming agents				
Sunwarshi-LR1	PEG (10%)	99.33[a]	98.65	98.0[ab]	1868
	Boric acid (0.1%)	99.33[a]	98.00	97.33[abc]	1826
	Urea (2%)	98.0[a]	96.57	94.67[abcd]	1803
	PEG (5%)	96.0[ab]	97.92	94.0[abcd]	1823
	DAP (2%)	98.0[a]	93.87	92.0[bcde]	1749
	$CaCO_3$ (2%)	100.0[a]	100.0	100.0[a]	1954
	Control	100.0[a]	94.67	94.67[abcd]	1897
Rangeli-LR2	PEG (10%)	95.33[abc]	92.27	88.0[de]	1738
	Boric acid (0.1%)	90.67[bc]	94.11	85.33[e]	1686
	Urea (2%)	96.0[ab]	93.73	90.0[cde]	1824
	PEG (5%)	98.0[a]	97.28	95.3[abcd]	1827
	DAP (2%)	92.0[bc]	95.75	88.0[de]	1813
	$CaCO_3$ (2%)	90.0[c]	95.57	86.0[e]	1679
	Control	91.33[bc]	92.58	84.67[e]	1793
CV (%)		3.0	2.6	4.2	6.3
SEM±		1.681	1.455	2.247	66.0
$LSD_{0.05}$		4.869	4.214	6.508	191.3
F-test		**	NS	*	NS

*Significant at 5% level of significance, **Significant at 1% level of significance, NSNon-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

Table 4. Effect of different priming agents on shoot and root length of lentil landraces

Landraces	Shoot length (cm)			Root length (cm)		
	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
Sunwarshi-LR1	9.36	12.09	14.23	5.01	7.14	8.30
Rangeli-LR2	9.62	12.65	14.60	5.0	6.88	8.02
Grand Mean	9.49	12.37	14.41	5.0	7.01	8.16
SEM±	0.219	0.309	0.191	0.178	0.203	0.191
$LSD_{0.05}$	0.107	0.127	0.073	0.113	0.108	0.098
F-test	NS	NS	NS	NS	NS	NS
Treatments						
PEG (10%)	10.10	12.67	14.80^{a}	3.87^{b}	6.59	7.55
Boric acid (0.1%)	9.21	11.09	13.17^{b}	5.71^{a}	7.78	8.49
Urea (2%)	9.47	12.77	14.73^{a}	4.31^{b}	7.18	7.66
PEG (5%)	9.49	13.55	14.86^{a}	4.03^{b}	6.51	7.91
DAP (2%)	9.13	11.78	14.19^{ab}	5.62^{a}	6.54	9.01
$CaCO_3$ (2%)	9.92	12.02	14.45^{a}	5.71^{a}	6.94	8.29
Control	9.14	12.62	14.69^{a}	5.77^{a}	7.53	8.18
CV (%)	5.5	5.7	3.1	8.1	6.5	5.4
SEM±	0.409	0.579	0.358	0.333	0.379	0.358
$LSD_{0.05}$	0.200	0.238	0.138	0.212	0.203	0.183
F-test	NS	NS	*	***	NS	NS

Data were transformed by √X before statistical analysis, but only non-transformed means are shown (where X is original value). *Significant at 5% level of significance, ***Significant at 0.1% level of significance, NS: Non-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

Table 5. Interaction of different priming agents on shoot and root length of lentil landraces

Interaction of treatments		Shoot length (cm)			Root length (cm)		
Landraces	Priming agents	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
Sunwarshi-LR1	PEG (10%)	10.43	12.84	14.61	3.49	6.77	8.29^{abc}
	Boric acid (0.1%)	8.63	11.27	13.18	5.76	7.82	8.47^{abc}
	Urea (2%)	9.21	11.95	14.73	3.95	7.70	7.67^{bc}
	PEG (5%)	10.24	13.55	14.87	4.03	6.41	7.89^{bc}
	DAP (2%)	8.76	10.99	13.27	5.95	6.43	8.13^{bc}
	$CaCO_3$ (2%)	9.65	11.87	14.82	5.83	7.16	9.30^{ab}
	Control	8.60	12.19	14.09	6.05	7.65	8.32^{abc}
Rangeli-LR2	PEG (10%)	9.76	12.50	14.99	4.25	6.40	6.82^{c}
	Boric acid (0.1%)	9.78	10.91	13.16	5.66	7.73	8.51^{abc}
	Urea (2%)	9.74	13.58	14.72	4.66	6.65	7.65^{bc}
	PEG (5%)	8.73	13.78	14.84	4.03	6.62	7.93^{bc}
	DAP (2%)	9.49	12.56	15.11	5.30	6.65	9.89^{a}
	$CaCO_3$ (2%)	10.19	12.18	14.08	5.59	6.73	7.27^{c}
	Control	9.67	13.06	15.28	5.50	7.40	8.05^{bc}
CV (%)		5.5	5.7	3.1	8.1	6.5	5.4
SEM±		0.578	0.818	0.506	0.470	0.536	0.506
LSD0.05		0.283	0.337	0.195	0.300	0.287	0.259
F-test		NS	NS	NS	NS	NS	*

Data were transformed by √X before statistical analysis, but only non-transformed means are shown (where X is original value). *Significant at 5% level of significance, NS: Non-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

The interaction between the treatment and different lentil landraces at every ten days interval was also analyzed. However, no significant difference was observed among the priming agents and landraces. Ten days after sowing (DAS), Sunwarshi-LR1 showed higher shoot growth on PEG (10%), while Rangeli-LR2 showed higher shoot growth on calcium carbonate ($CaCO_3$) (2%). The lower weight was observed on control and PEG (5%) in LR1 and LR2, respectively. At 20 DAS, higher shoot length was observed on PEG (5%) in both landraces, while lower growth was observed on DAP (2%) and boric acid (0.1%) in LR1 and LR2, respectively. Similarly, at 30 DAS, higher shoot length was observed on PEG (5%) in Sunwarshi-LR1 and DAP (2%) in Rangeli-LR2, while the lower shoot growth was observed on boric acid (0.1%) in both landraces.

Table 6 presents the fresh weight and dry weight data of primed lentil seedlings collected at intervals of 10, 20, and 30 DAS. The results indicate that Sunwarshi-LR1 showed a significantly higher weight than Rangeli-LR2. The experimental data revealed that the fresh weight of seedlings treated with boric acid (0.1%) was higher at 10 DAS (0.115g), whereas the control had a higher weight at 20 DAS (0.132g) and 30 DAS (0.16g). In contrast, seedlings treated with DAP (2%) had the lowest fresh weight at 10 DAS (0.078g) and 20 DAS, and 30 DAS. Similarly, the dry weight of the seedlings was higher in control at 10 DAS (0.015g), and 20 DAS (0.022g), but $CaCO_3$ (2%) treatment had a higher weight at 30 DAS. Moreover, Table 7 shows the interaction between different treatments and landraces at intervals of 10 days. At 10 DAS, both Sunwarshi-LR1 and Rangeli-LR2 had a higher fresh weight (0.124g and 0.106g, respectively) when treated with boric acid (0.1%), whereas a lower fresh weight was observed when treated with DAP (0.072g and 0.083g, respectively). In contrast, at 20 DAS, the control had a higher fresh weight (0.132g) on both landraces, whereas a lower fresh weight was observed when treated with DAP (0.091g and 0.093g on LR-1 and LR-2, respectively). Similarly, at 30 DAS, the control had a higher fresh weight (0.162g and 0.158g on LR-1 and LR-2, respectively), whereas a lower weight was observed when treated with DAP (0.106g and 0.114g on LR-1 and LR-2, respectively) and CaCO3. The dry weight of LR1 was higher when treated with boric acid (0.1%) at 10 and 30 DAS, whereas the control had a higher dry weight at 20 DAS. In contrast, in LR2, PEG (10%) had the highest dry weight at 10 and 20 DAS, whereas $CaCO_3$ control had the highest dry weight at 30 DAS.

4. Discussions

4.1. Effect of priming agents on germination parameters

According to Al-Tawaha and Al-Ghzawi (2013), Different types of results obtained in the seeding from germination to dry weight might be due to the tolerance capacity of the seed towards different types of treatment. We obtained the different germination rates in various treatments, which have a similar result to that of Ghasemi-golezani et al. (2013). The germination rate of the seed under untreated conditions or control differs from experiment to experiment, which might be due to environmental factors, landraces, and quality of the seed; this finding was supported by Eskandari and Alizadeh-Amraie (2014) and Kumar et al. (2019). PEG and control provide a satisfying result on the germination parameters of a lentil; this result is similar to the result obtained in Ghassemi-Golezani et al. (2008). The fastest germination rate was obtained when the seed was primed under 10% PEG, possibly due to the faster solution uptake and earlier initiation of metabolism processes on the seed. There is no significant difference in the PA on a germination parameter between primed seeds; this shows the toxicity of any primed medium on lentil seed. The above-primed result exhibited the better performance of the control or non-primed seed in the vigor index, supported by the result of Kumar et al. (2019).

4.2. Effect of priming agents on growth parameters

Similar types of differences in the weight of seeding have been obtained in Kumar et al. (2019); this might be due to the difference in treatment used for priming, which shows that the growth of the treated seed varies within primed agents. Bhateshwar et al. (2020) also observed similar growth parameters on seeding, but the result was not similar; this might be due to the differences in primed medium and the landraces. The effect of urea on growth is higher than that of PEG, and we can conclude that nitrogen can significantly improve the plant size or weight of the plants, similar to that of Hojjat (2016). This might be due to higher leaf numbers or

Table 6. Effect of different priming agents on fresh and dry weight of lentil landraces

Landraces	Fresh weight (g)			Dry Weight (g)		
	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
Sunwarshi-LR1	0.096	0.113	0.136	0.012	0.018	0.034
Rangeli-LR2	0.096	0.111	0.127	0.012	0.018	0.027
Grand Mean	0.096	0.112	0.132	0.012	0.018	0.030
SEM±	0.0031	0.0035	0.0036	0.0007	0.0011	0.0023
$LSD_{0.05}$	0.0057	0.0064	0.0064	0.0014	0.0021	0.0045
F-test	NS	NS	NS	NS	NS	*
Treatments						
PEG (10%)	0.094^{bc}	0.109^{bc}	0.128^{bc}	0.012	0.020	0.026
Boric acid (0.1%)	0.115^{a}	0.119^{ab}	0.137^{b}	0.011	0.016	0.033
Urea (2%)	0.095^{bc}	0.116^{ab}	0.132^{bc}	0.013	0.020	0.029
PEG (5%)	0.092^{bc}	0.107^{bc}	0.128^{bc}	0.009	0.013	0.028
DAP (2%)	0.078^{c}	0.092^{c}	0.115^{c}	0.011	0.016	0.022
$CaCO_3$ (2%)	0.097^{b}	0.107^{bc}	0.123^{bc}	0.013	0.019	0.041
Control	0.103^{ab}	0.132^{a}	0.160^{a}	0.015	0.022	0.031
CV (%)	1.2	1.3	1.3	0.3	0.5	1.0
SEM±	0.0057	0.0065	0.0067	0.0013	0.0020	0.0043
$LSD_{0.05}$	0.0107	0.0120	0.0121	0.0026	0.0039	0.0084
F-test	**	**	**	NS	NS	NS

Data were transformed by √(X+0.5) before statistical analysis, but only non-transformed means are shown (where X is original value). *Significant at 5% level of significance, **Significant at 1% level of significance, NS: Non-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

Table 7. Interaction of different priming agents on fresh and dry weight of lentil landraces

Interaction of treatments		Fresh weight (g)			Dry weight (g)		
Landraces	Priming agents	10 DAS	20 DAS	30 DAS	10 DAS	20 DAS	30 DAS
Sunwarshi-LR1	PEG (10%)	0.093	0.112	0.138	0.008^{c}	0.014^{bc}	0.026
	Boric acid (0.1%)	0.124	0.124	0.144	0.013^{abc}	0.020^{abc}	0.043
	Urea (2%)	0.087	0.110	0.139	0.011^{abc}	0.018^{abc}	0.032
	PEG (5%)	0.092	0.105	0.132	0.009^{bc}	0.014^{bc}	0.026
	DAP (2%)	0.072	0.091	0.106	0.014^{abc}	0.020^{abc}	0.022
	$CaCO_3$ (2%)	0.103	0.116	0.133	0.013^{abc}	0.018^{abc}	0.050
	Control	0.101	0.132	0.162	0.015^{ab}	0.022^{abc}	0.038
Rangeli-LR2	PEG (10%)	0.094	0.105	0.117	0.016^{a}	0.025^{a}	0.030
	Boric acid (0.1%)	0.106	0.114	0.130	0.008^{c}	0.012^{c}	0.024
	Urea (2%)	0.103	0.122	0.125	0.015^{ab}	0.022^{abc}	0.026
	PEG (5%)	0.092	0.110	0.124	0.009^{bc}	0.012^{c}	0.030
	DAP (2%)	0.083	0.093	0.124	0.008^{c}	0.013^{bc}	0.023
	$CaCO_3$ (2%)	0.091	0.099	0.114	0.014^{abc}	0.020^{abc}	0.032
	Control	0.105	0.132	0.158	0.015^{ab}	0.022^{ab}	0.025
CV (%)		1.2	1.3	1.3	0.3	0.5	1.0
SEM±		0.0081	0.0092	0.0095	0.0019	0.0028	0.0061
LSD0.05		0.0151	0.0169	0.0171	0.0037	0.0056	0.012
F-test		NS	NS	NS	**	*	NS

Data were transformed by √(X+0.5) before statistical analysis, but only non-transformed means are shown (where X is original value). *Significant at 5% level of significance, **Significant at 1% level of significance, NSNon-significant, LSD: Least significant difference, SEM: Standard error of the mean, CV: Coefficient of variation

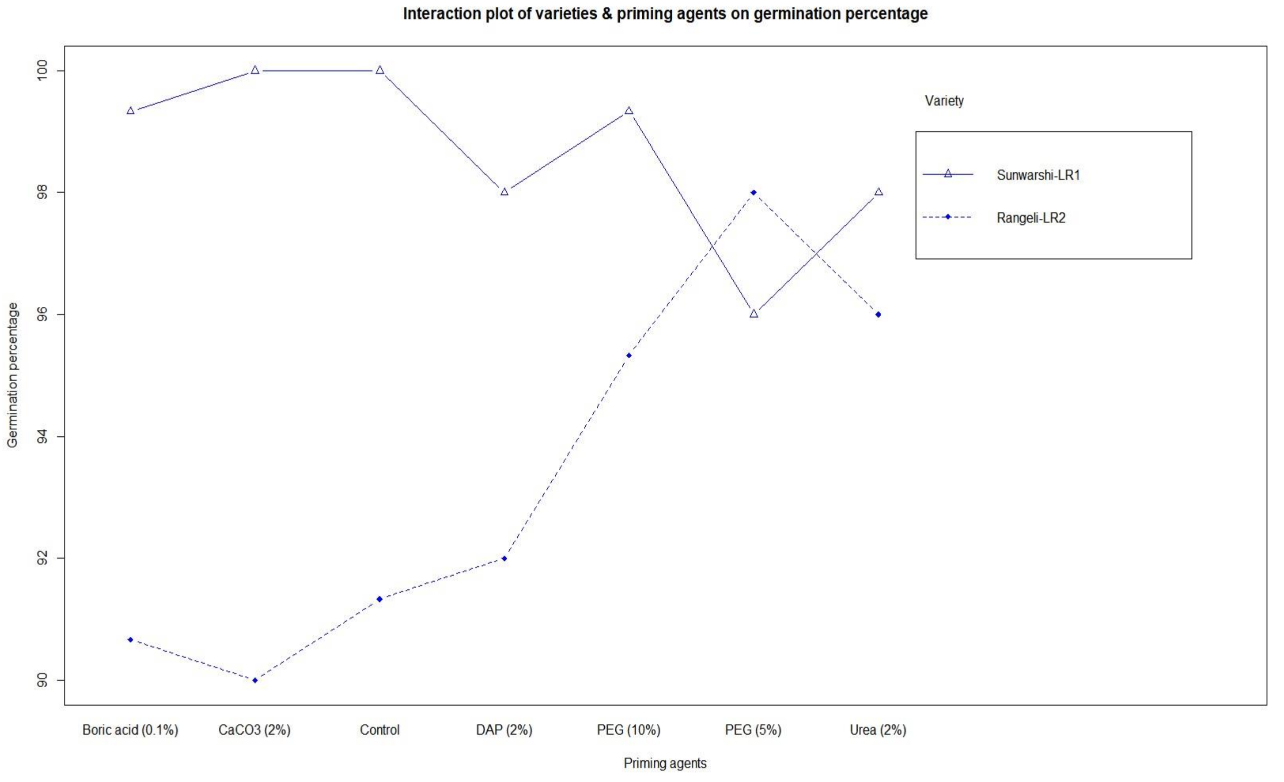

Figure 2. Interaction plot of landraces and priming agents on germination percentage

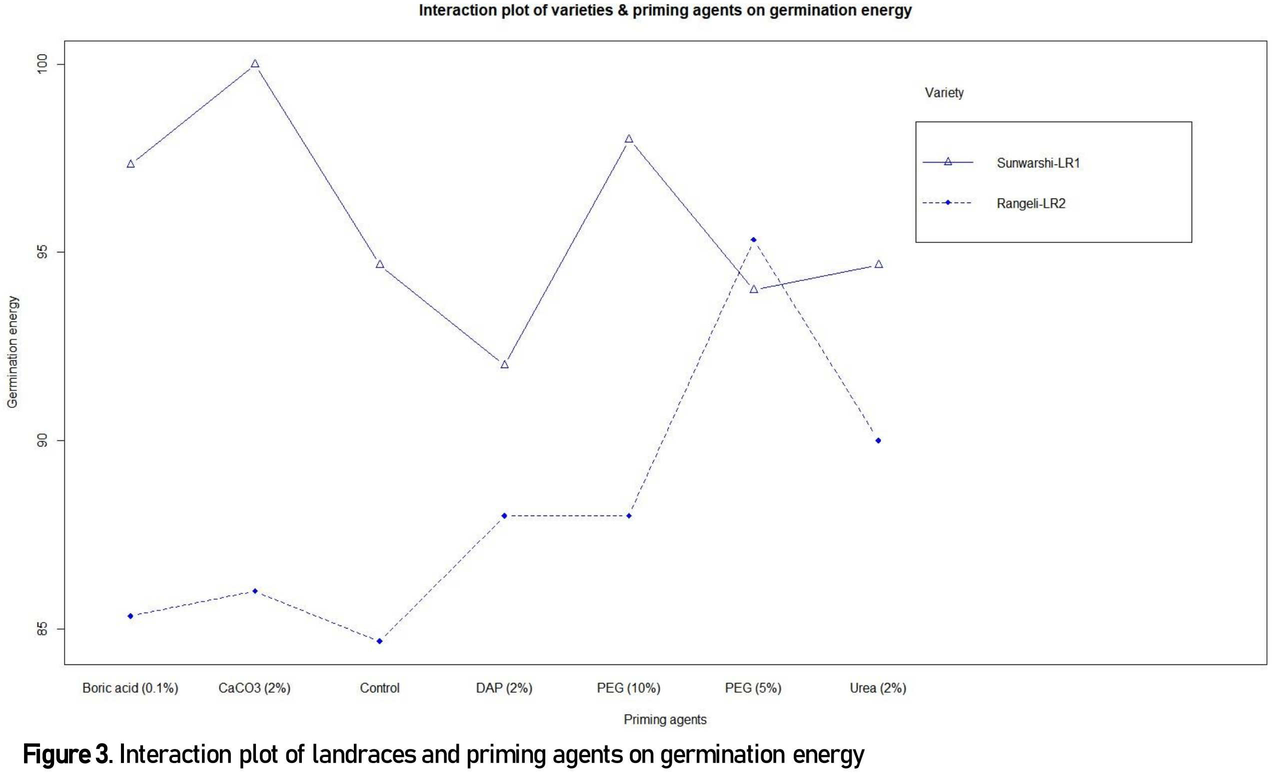

Figure 3. Interaction plot of landraces and priming agents on germination energy

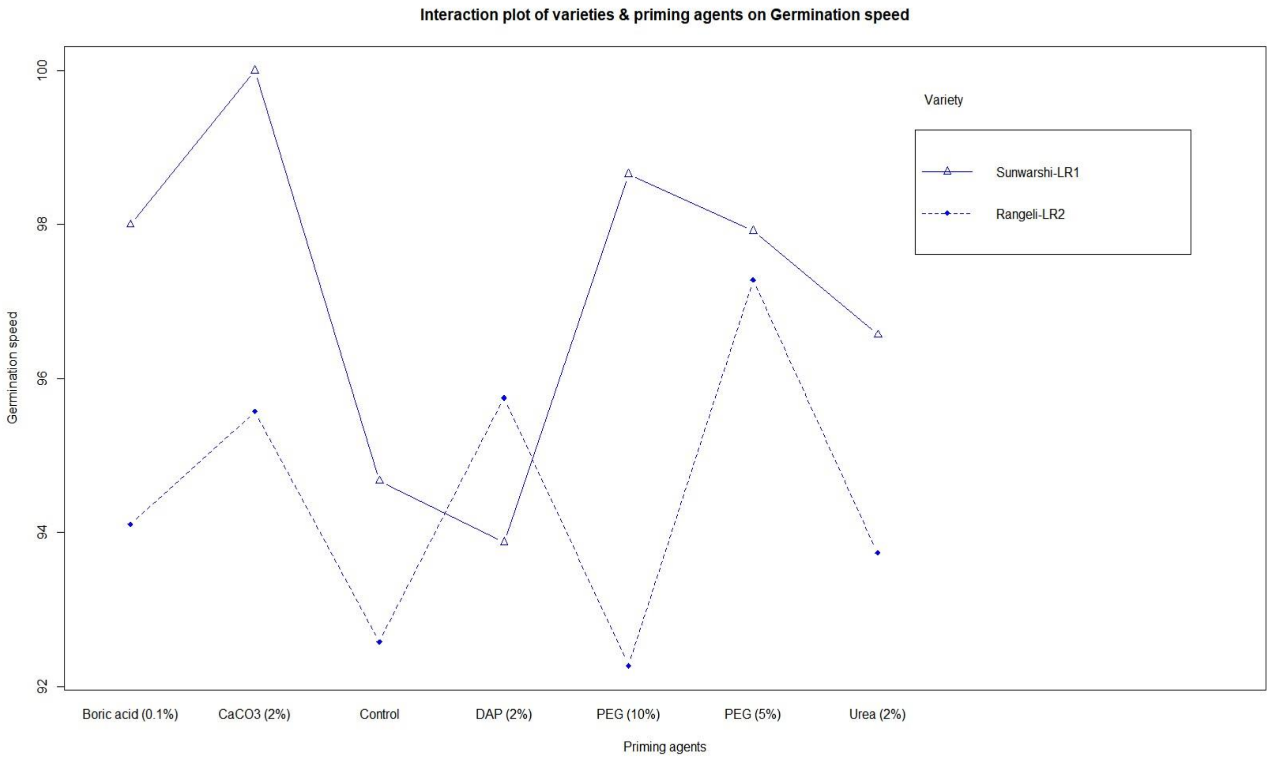

Figure 4. Interaction plot of landraces and priming agents on germination speed

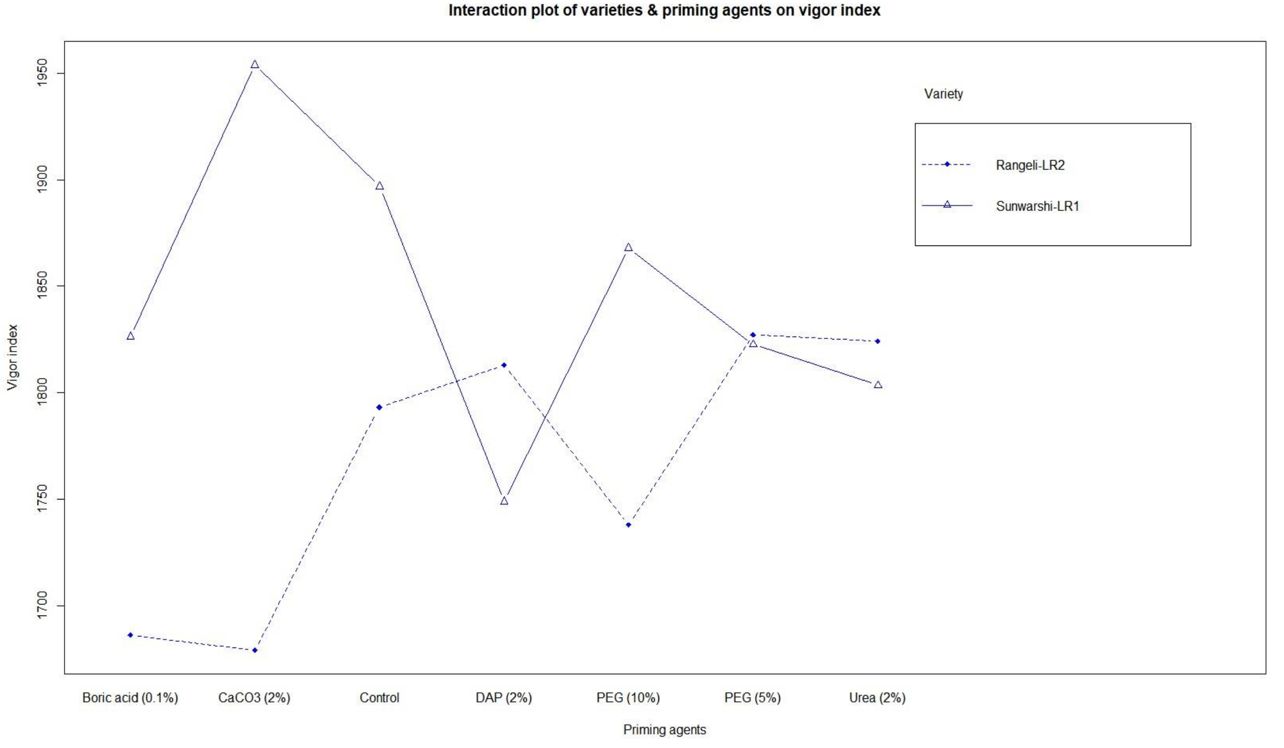

Figure 5. Interaction plot of landraces and priming agents on vigor index

a stem length. The effect of urea on growth is higher than that of PEG, and we can conclude that nitrogen can significantly improve the plant size or weight of the plants, similar to that of Hojjat (2016). This might be due to higher leaf numbers or longer stem lengths. Control shows the superior growth of the underground part of the plant at an early stage, and satisfactory results after 10DAS obtained data are similar to that of the finding Toklu (2015). The dry weight of the seed primed with 5% PEG and the conclusion of Ghassemi-Golezani et al. (2008), under PEG shows similar results but different with 10% PEG. This could be due to differences in the concentration of primed matter. Similarly, the dry weight of the primed seed was analyzed by Kumar et al. (2019), but the finding doesn't show an exact similar result which might be affected by the priming factor and landraces.

4.3. Interaction of effect of priming agents on germination and growth parameters

Based on previous studies by Ghassemi-Golezani et al. (2008), priming has been found to increase the speed of germination compared to the control group, as it increases the metabolic activity of the seed. However, the results of the current experiment did not support this hypothesis for both landraces, as Sunwarshi-LR1 showed 100% germination in the control group, while the control group for Rangeli-LR2 showed satisfactory results, as shown in Figure 2-5. Priming with different media resulted in higher shoot length, germination speed, and germination energy, as supported by the findings of Bhateshwar et al. (2020). However, the data obtained from the experiments showed that the control group also showed significantly satisfactory results at each observation step.

5. Conclusions

This study investigated the effects of seed priming with different media on the germination and growth of two lentil landraces, Sunwarshi-LR1 and Rangeli-LR2. Overall, Sunwarshi-LR1 showed higher germination and growth rates compared to Rangeli-LR2 when primed with the same media, except for root length. Specifically, seed priming with $CaCO_3$ and PEG 5% resulted in higher and similar germination rates compared to the control group in Sunwarshi-LR1. On the other hand, PEG (5%) showed higher growth parameters in Rangeli-LR2. In the early growth stage, priming with PEG 10% and $CaCO_3$ improved the growth parameters in both landraces, after which priming with PEG was more effective. These findings suggest that seed priming with different media can have varying effects on the germination and growth of different lentil landraces. Therefore, the selection of appropriate priming media should be based on the specific characteristics of the lentil landrace being studied. In addition, the results of this study could be used as a basis for further investigation into the mechanisms underlying the effects of priming media on seed germination and growth. Further research is needed to identify the biochemical and physiological changes induced by different priming media and their effects on seed germination and growth.

Compliance with Ethical Standards

Conflict of Interest

The authors declare no irreconcilable circumstances. Further, the final version of the manuscript was approved by all authors.

Authors' Contributions

Shubh Pravat Singh Yadav, Sujan Bhandari, and Sangita Bhujel: Conceived and designed the experiments. **Sujan Bhandari, Susmita Bhattarai, Shubh Pravat Singh Yadav, Indira Kattel and Puja Yadav:** Performed the experiments, interpreted the data, and wrote the paper. **Shubh Pravat Singh Yadav:** Conducted the data analysis and visualization of the data. **Sangita Bhujel:** Supervising the research.

Ethical approval

Not applicable.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

We humbly give consent for this article to be published.

References

Al-Tawaha, A. R. M., & Al-Ghzawi, A. L. A. (2013). Effect of chitosan coating on seed germination and salt tolerance of Lentil (*Lens culinaris* L.). *Research on Crops*, *14*(2), 489-491.

Amir, M., Singh, C. B., Jatav, A. L., Kumar, M., & Singh, D. P. (2021). Effect of seed priming technologies on planting value of lentil (Lens culinaris M) cultivars under sub-optimal condition. *The Pharma Innovation Journal*, *10*(12), 673–678.

Bethapalli, P. R. N., Rai, P. K., & Rai, A. kumar. (2020). Assessment of different seed priming methods on quality parameters of lentil (Lens culinaris Medik.). *International Journal of Current Microbiology and Applied Sciences*, *10*(3), 317–323. https://doi.org/10.20546/ijcmas.2020.911.366

Bhateshwar, D. C., Prabha, D., Jangid, D., & Salman, M. (2020). Effect of seed priming with botanicals on plant growth and seed yield of lentil (Lens culinaris M.). *International Journal of Current Microbiology and Applied Sciences*, *9*(7), 3484–3499. https://doi.org/10.20546/ijcmas.2020.907.407

Bouallègue, A., Souissi, F., Nouairi, I., Souibgui, M., Abbes, Z., & Mhadhbi, H. (2019). Physiological and biochemicals changes modulated by seeds' priming of lentil (*Lens culinaris* L.) under salt stress at germination stage. *Acta Scientiarum Polonorum, Hortorum Cultus*, *18*(5), 27–38. https://doi.org/10.24326/asphc.2019.5.3

Darai, R., Adhikari, B. N., Shrestha, R., & Wagle, B. P. (2008). Verification and dissemination of seed priming technologies on lentil for better crop establishments and seed yield under different environments of Nepal. 49, 69–73.

Eskandari, H., & Alizadeh-Amraie, A. (2014). Improvement of lentil germination performance under salt and drought conditions using seed priming treatments. *Seed Science and Technology*, *42*(1), 87–91. https://doi.org/10.15258/sst.2014.42.1.09

Farooq, M., Romdhane, L., Al Sulti, M. K. R. A., Rehman, A., Al-Busaidi, W. M., & Lee, D. J. (2020). Morphological, physiological and biochemical aspects of osmopriming-induced drought tolerance in lentil. *Journal of Agronomy and Crop Science*, *206*(2), 176–186. https://doi.org/10.1111/jac.12384

Ghasemi-golezani, K., Jabbarpour-bonyadi, Z., Shafagh-kolvanagh, J., & Nikpour-rashidabad, N. (2013). Effects of Water Stress and hydro-priming duration on field performance of lentil. *International Journal of Farming and Allied Sciences*, *2*(21), 922–925.

Ghassemi-Golezani, K., Aliloo, A. A., Valizadeh, M., & Moghaddam, M. (2008). Effects of different priming techniques on seed invigoration and seedling establishment of lentil (*Lens culinaris* Medik*). Journal of Food, Agriculture and Environment*, *6*(2), 222–226.

Ghobadi, M., Jalali Honarmand, S., & Mehrkish, M. (2022). Improving the germination characteristics of aged lentil (Lens culinaris L.) seeds using the ascorbic acid priming method. *Central Asian Journal of Plant Science Innovation*, *2*(1), 37–41. https://doi.org/10.22034/CAJPSI.2022.01.04

Golezanik, G., Aliloo, A. A., Valizadeh, M., & Moghaddam, M. (2008). Effects of hydro and osmo-priming on seed germination and field emergence of lentil (Lens culinaris Medik .). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *36*(1), 29–33. https://doi.org/10.15835/nbha36186

Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research (2nd ed., Vol. 6). John Wiley & Sons, Ltd.

Hojjat, S. S. (2016). The Effect of silver nanoparticle on lentil seed germination under drought stress. *International Journal of Farming and Allied Sciences*, *5*(3)208–212.

Johnson, S. E., Lauren, J. G., Welch, R. M., & Duxbury, J. M. (2005). A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. *Experimental Agriculture*, *41*(4), 427–448. https://doi.org/10.1017/S0014479705002851

Kumar, A., Jatav, A. L., Singh, P., Singh, C. B., & Singh, R. K. (2019). Effect of seed priming on growth parameters and yield of lentil (*Lens culinaris* Medic .). *Journal of Pharmacognosy and Phytochemistry*, *8*(5), 1587–1589.

Lhungdim, J., Chongtham, S. K., Koireng, R. J., & Neupane, M. P. (2014). Seed invigoration and yield of lentil (*Lens culinaris* Medikus) through seed priming under different seeding rates. *Environment and Ecology*, *32*, 527-531.

Muscolo, A., Sidari, M., Anastasi, U., Santonoceto, C., & Maggio, A. (2014). Effect of PEG-induced drought stress on seed germination of four lentil genotypes. *Journal of Plant Interactions*, *9*(1), 354–363. https://doi.org/10.1080/17429145.2013.835880

Pakbaz, N., Barary, M., Mehrabi, A. A., & Hatami, A. (2014). Effect of seed priming on growth and yield of lentil (Lens culinaris L.) genotypes under rainfed and supplemental irrigation conditions. *International Journal of Biosciences*, *5*(9), 131–139. https://doi.org/10.12692/ijb/5.9.131-139

Sağlam, S., Day, S., Kaya, G., & Gürbüz, A. (2010). Hydropriming increases germination of lentil (Lens culinaris Medik.) under water stress. *Notulae Scientia Biologicae*, *2*(2), 103-106.

Sharma, P. K., Chaurasia, A. K., & Mishra, S. N. (2017). Effect of organic and inorganic seed priming on seed quality parameters in Lentil (*Lens culinaris* M .)" seeds. *The Pharma Innovation Journal*, *6*(10), 18–21.

Tiwari, D. N. (2018). Review on efficient approaches to seed invigoration for quality enhancement. *International Journal of Agriculture and Environmental Research*, *4*(05), 1103–1118.

Toklu, F. (2015). Effects of different priming treatments on seed germination properties, yield components and grain yield of lentil (*Lens culinaris* Medik.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *43*(1), 153–158. https://doi.org/10.15835/nbha4319832