Turkish Journal of Agriculture - Food Science and Technology, 12(4): 561-567, 2024
DOI: https://doi.org/10.24925/turjaf.v12i4.561-567.6649

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Improvement of Seed Germination and Seedling Growth of Faba Bean (*Vicia Faba* L.) through Seed Priming

Sumiaya Parvin[1,a], Md. Parvez Anwar[2,b], Md. Sojib Kabiraj[3,c], Md. Harun Rashid[4,d], Swapan Kumar Paul[5,e,*]

[1]*Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh*
[*]*Corresponding author*

ARTICLE INFO

Research Article

Received : 02.01.2024
Accepted : 01.03.2024

Keywords:
Seed coat
Seed vigour
Priming agents
Growth speed
Seedling development

ABSTRACT

In a lab experiment using seed priming, the faba bean (*Vicia faba* L.) seed germination and seedling development were studied. Twenty different priming techniques were utilized in the study, each comprising varying concentrations of NaOCI, $CaCl_2$, KNO_3, Manitol, PEG, KCL, H_2O and a control group that received no priming. Four replications of a completely randomized design (CRD) were used in the experiment. Among the three priming treatments, there were substantial differences in the seedling growth metrics and germination rate. When 500 ppm NaOCl was used as a treatment, the highest seed germination percentage (96%) was attained. Although 100 ppm PEG had the greatest germination index (42.92), 10000 ppm NaOCl had the quickest mean germination time (8.27). Additionally, at a concentration of 1500 ppm NaOCl, the greatest seedling vigor index (29.79) and maximum germination coefficient (12.28) were likewise obtained. With H_2O treatment, the maximum shoot length (21.09 cm) was observed for seedling growth parameters. The largest root length was produced by a 10000 ppm KNO_3 treatment (11.19 cm). With 20000 ppm KNO_3, the maximum root dry weight was achieved (88.50 mg), whereas H_2O produced the highest shoot dry weight (51.0 mg). Additionally, it was discovered that a treatment with 10000 ppm KNO_3 had the best root-shoot ratio (0.72). The research thus supports the possible use of seed priming as a method to improve faba bean seed germination and seedling growth. NaOCl and KNO_3 seemed to work best for faba bean seed germination and seedling growth.

[a] *sumaiyaparvin2359@gmail.com* *https://orcid.org/0009-0001-6094-4084*
[b] *parvezanwar@bau.edu.bd* *https://orcid.org/0000-0002-6853-9382*
[c] *msojibinfo@gmail.com* *https://orcid.org/0000-0002-5841-8974*
[d] *mhrashid@bau.edu.bd* *https://orcid.org/0000-0001-6087-3469*
[e] *skpaul@bau.edu.bd* *https://orcid.org/0000-0002-0163-3251*

Introduction

Only a few species of leguminous crops are now exploited in agriculture, despite the fact that they have a significant role in dietary needs for both human and animals (Cernay et al., 2016; Mouradi et al., 2018). The faba bean (*Vicia faba* L.), which has a high nutritional value and is a great source of proteins, complex carbohydrates, dietary fiber, choline, lecithin, minerals, and secondary metabolites such as phenolics, distinguishes it as a unique legume crop (Paul and Gupta, 2021; Roy et al., 2022). Faba beans is an excellent crop for cropping systems because of its remarkable ability to symbiotically fix atmospheric N_2, which is highly dependent on sufficient populations of productive rhizobia that can extract N from both soil and the environment (Singh and bhatt, 2012).

One of the greatest and least expensive sources of lysine-rich protein is the green cotyledon of faba beans which is mostly consumed as a vegetable. It is the world's fourth-largest pulse crop after dry beans, dry peas and chickpeas making it one of the effective methods to combat hunger, especially in underdeveloped nations. Asia accounts for 41% of output on a global scale, followed by Africa and Europe and more than 66 nations throughout the world produce it (Paul and Gupta, 2021). It has a high concentration of L-dopa, which is a medication used to treat Parkinson's disease (Ramirez-Moreno et al., 2015). The faba bean also referred to as Kalimator, Baklakalai, and Bhograkalai locally, is cultivated in a few specific areas in Bangladesh's Central and Northern regions during the *rabi* season (Paul et al., 2022). This bean requires less input to flourish in less rich soil than other typical legume crops. Germination failure or in rare cases, a hard seed coat, is the major problem with faba bean farming in the field.

Seed priming is a method for partly hydrating non radicle emergence seeds according to Farooq et al. (2007). Priming seeds is largely used to increase uniformity and germination of different crops in unfavourable settings. Priming increases the viability of the seed and is typically used to get a straight, healthy crop stand (Draganic and Lekic, 2012). The water that was consumed by the primed treated seeds during priming was sufficient for hydration and was necessary for internal metabolic functions. Seeds that had been primed had a speedier germination time than seeds that hadn't been primed (Dezfuli et al., 2008). Compared to non-primed seed, priming treatments hasten emergence, increase the size of seedling shoots and increase fresh weight (Shim et al., 2009). Priming treatments had a considerable influence on germination and other growth metrics for seedling development as well as on the seedlings' ability to survive in the field (PK Roy et al., 2013; Dey et al., 2013).

Numerous methods of priming have been applied to synchronize and speed up seed germination. Hormone priming, hydro priming, osmo-conditioning, osmo-hardening, the use of ascorbate, solid matrix and wetting and drying primers are examples of typical techniques, according to Farooq et al. (2009). After seed priming, the seed's antioxidant activity increased. Seed priming enhances plant performance, according to several research findings, germination rates, synchronizes germination and produces seedlings that are strong and resistant to weed competition (Kaya et al., 2006; Basra et al., 2005). The goal of the study was to identify the most effective seed priming method with the goal of increasing faba bean seed germination and seedling vigor from this angle.

Materials and Methods

Description of the Experimental Site

At the Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University, the laboratory test was conducted in January 2022. The testing location was located at latitude 23°22' N and longitude 90°33' E, 18 meters above sea level, and in a subtropical environment. The Laboratory received plant materials from the Bangladesh Agricultural Research Institute (BARI). Until they were utilized, seeds were kept in the fridge at 5°C in sealed containers. The seeds had an initial moisture content of about 10%, according to the oven drying process. Six priming agents of high laboratory quality were used in the experiment (Table 1).

Experimental Treatments and Design

One factor i.e. seed priming technique, was used in the experiment. Twenty techniques of seed priming were: i) 500 ppm NaOCl, ii) 1000 ppm NaOCl, iii) 1500 ppm NaOCl, iv) 10000 ppm $CaCl_2$, v) 20000 ppm $CaCl_2$, vi) 30000 ppm $CaCl_2$, vii) 10000 ppm KNO_3, viii) 15000 ppm KNO_3, ix) 20000 ppm KNO_3, x) 40000 ppm Manitol, xi) 60000 ppm Manitol, xii) 80000 ppm Manitol, xiii) 50 ppm PEG, xiv)100 ppm PEG, xv) 150 ppm PEG, xvi) 10000 ppm KCl, xvii) 20000 ppm KCl, xviii) 30000 ppm KCl, xix) H_2O and xx) Control (no priming). The experiment which was set up using a completely randomized design (CRD) included four replications.

Seed Priming

Individual faba bean seeds were submerged for 18 hours while using different priming agent solutions (previously produced with distilled water) at room temperature (25±2°C). The weight of the seeds to the volume of the solution was 1:5 (g/mL). The seeds were then removed from the priming agent solution and washed repeatedly in distilled water to remove any last bits of chemical residue. To get the seeds as near to their initial moisture content as possible, they were then forced-air dried for 36 hours at 28±2°C. Before being used for germination in the control treatment which did not receive any prior seed priming, the dried seeds were kept in sealed polythene bags and kept in a refrigerator at 5±1°C for 10 days.

Preparation of Germination Media and Seed Placement

Petridishes with measurements of 12 cm in diameter and 5 cm in depth were employed as the container, and sterilized sand was used as the germination media. The medium was irrigated with distilled water every morning to maintain a moisture level of around 80% of the field capacity. Fifty seeds were placed in 0.5 cm of moist sand in each petridish. Petridishes were placed on the laboratory desk at room temperature (25±2°C temperature, 70±5% relative humidity) with 11/13 h of light and darkness.

Procedure of Data Collection

Seed germination was monitored daily and final measurements were taken 14 days after sowing (DAS). Twenty seedlings were removed from each pot at 14 DAS in order to get data on seedling growth.

Germination Percentage (%)

The germination rate is the proportion of seeds that actually sprout from the quantity of seeds sown overall. The germination rate (GP) was determined using the following formula.

$$\text{GP: } \frac{\text{No. of germinated seeds at final count}}{\text{No. of seeds sown}} \times 100$$

Table 1. Information about the priming agents

SL. No.	Priming agent	Chemical formula	Manufacturer
1	Sodium hypochlorite	NaOCl	MERCK, India
2	Calcium chloride	$CaCl_2$	MERCK, India
3	Potassium nitrate	KNO_3	MERCK, India
4	Manitol	$C_{12}H_{24}O_{11}$	MERCK, India
5	Polyethylene glycol	PEG	LOBAL Chemie, India
6	Potassium chloride	KCl	MERCK, India

Mean Germination Time (MGT)

The following equation was used to get the mean germination time (Ellis and Roberts, 1981).

$$\text{Mean germination time} = \frac{\sum Dn}{\sum n}$$

Where, n is the number of seeds that germinated on day D and D is the number of days counting backward from the day germination began.

Germination Index (GI)

Time is estimated (in days) using the Germination Index (GI). It can only occur if a particular germination percentage is met. The Association of Official Seed Analysis used the following procedure to calculate the germination index (GI).

$$\text{GI} = \frac{\text{NGS}}{\text{DFC}} + \cdots + \frac{\text{NGS}}{\text{DLC}}$$

NGS: Number of germinated seeds
DFC: Days of first count
DLC: Days of final count

Seedling Vigor Index (SVI)

$$\text{SVI} = \frac{\text{Seedling length (cm)} \times \text{Germination percentage}}{100}$$

Where, seedling length = Root length + Shoot length

Germination Co-efficient (GC)

Using the formula shown below, the co-efficient of germination was computed (Copeland, 1976).

$$\text{Germination co-efficient} = \frac{N100(A1+A2.....An)}{A1T1+A2T2+\cdots.....AnTn}$$

Where, T is the time that corresponds to A, where n is the number of days left before the final tally and A is the number of seeds that have already sprouted.

Shoot Length

The length of the shoot, stated in centimetres, was calculated from the seedling's the biggest leaf measured from base to tip.

Root Length

The length of the roots indicated in centimetres was calculated from the seedling's the biggest leaf measured from base to tip.

Shoot Dry Weight

After drying the shoots of 20 seedlings used in the sample in a 60°C oven for 72 hours, the dry matter of the shoots was measured. Finally, each seedling's shoot dry weight was computed and represented in mg.

Root Dry Weight

After drying the roots of 20 seedlings for 72 hours at 60°C in an oven, root dry matter was calculated. Each seedling's root dry weight was ultimately estimated and reported in mg.

Root-Shoot Ratio

The ratio of root length to shoot length was used to calculate the root-shoot ratio.

Statistical Analysis

The recorded information was compiled and summarized for statistical analysis. Using the computer program MSTAT, an analysis of variance (ANOVA) was carried out. The mean differences between the treatments using the Duncan's Multiple Range Test (Gomez and Gomez (1984) with a 5% level of significance.

Results

Germination Percentage

The seed priming technique has a considerable impact on the faba bean's germination percentage (Figure 1). With the exception of KCl priming, all priming techniques led to increased germination rates. When seeds were primed with 500 ppm NaOCl, the final germination percentage of faba beans was found to be (96%), which was statistically comparable to those recorded with many other priming methods like 10000, 20000, and 30000 ppm $CaCl_2$, control, 1500 ppm KCl, any concentration of NaOCl, 10000 ppm KNO_3, and 150 ppm PEG. The lowest germination rate (64%) was obtained while priming with 30000 ppm KCl. No priming resulted in (94%) germination.

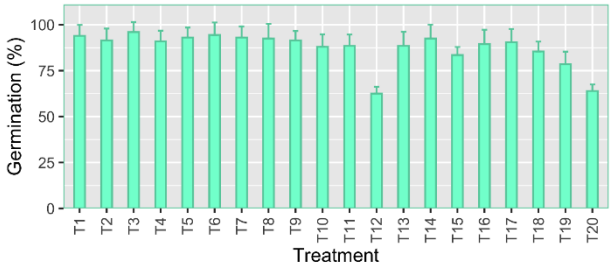

Figure 1. Germination percent of faba bean as influenced by seed priming method

T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

Mean Germination Time

The technique seed priming has a substantial impact on the germination period of faba beans (Table 2). The longest mean germination time was achieved with no priming (control) when compared to all other priming techniques. When seeds were not primed, the final mean germination period of faba beans was shown to be the longest (9.22 days). The shortest mean germination time (8.27 days) was obtained after priming with 1000 ppm NaOCl, followed by 1500 ppm NaOCl, H_2O, 100 ppm and 150 ppm PEG, and 10000 ppm and 20000 ppm $CaCl_2$.

Germination Index

The seed priming procedure had a considerable impact on the faba bean's germination index (Figure 2). The ultimate germination index of faba beans was found to be the greatest (96.93) when seeds were primed with 1500 ppm NaOCl. This value was statistically comparable to those reported with numerous other priming techniques, including H_2O, 20000 ppm $CaCl_2$, 500 ppm, and 1000 ppm NaOCl. The least favorable germination index (45.51) was obtained after priming with 30000 ppm KCl.

Seedling Vigor Index

The method of seed priming had a considerable impact on the seedling vigor index of the faba bean (Table 2). When seeds were primed with 1500 ppm NaOCl, the faba bean's ultimate seedling vigor index was found to be at its greatest value (29.79), which was statistically comparable to results obtained with several other priming techniques, such as 500 ppm NaOCl, H_2O, and $CaCl_2$ at any concentration. The lowest seedling vigor index (13.15), which was statistically comparable, was obtained after priming with 30000 ppm KCl, followed by priming with 40000 ppm Manitol and 20000 ppm KCl.

Germination Co-efficient

The seed priming technique has a considerable impact on the faba bean's germination coefficients (Table 2). The ultimate germination coefficient of faba bean was found to be the greatest (12.28) when seeds were primed with 1500 ppm NaOCl, which was statistically comparable to those reported with several other priming techniques such 150 ppm PEG, 1000 ppm NaOCl, and H_2O. The lowest germination coefficient (11.01) from priming with no priming technique control was statistically comparable to that of priming with 15000 ppm KNO_3 and 30000 ppm KCl.

Shoot Length

The seed priming strategy has a substantial impact on faba bean shoot length (Table 3). When seeds were primed with water, the ultimate shoot length of the faba bean was found to be the highest (21.09 cm), which was statistically comparable to those recorded with several other priming techniques including 500 ppm and 1000 ppm NaOCl, 20000 ppm $CaCl_2$, and 50, 500, and 150 ppm PEG, respectively. The lowest shoot length (11.14 cm) was statistically obtained while priming with 30000 ppm KCl, which was statistically followed by priming with 40000 & 80000 ppm Manitol, 20000 ppm KCl, 1500 ppm NaOCl, and 10000 ppm $CaCl_2$.

Root Length

The seed priming technique had a substantial impact on the length of the faba bean roots (Table 3). The maximum roots length (11.19 cm) of the faba bean was discovered when seeds were primed with 10000 ppm KNO_3 which was statistically comparable 20000 ppm KNO_3. The lowest roots length of faba bean (7.08 cm) after priming was achieved with 30000 ppm KCl.

Shoot Dry Weight

The seed priming strategy had a considerable impact on the shoot dry matter of the faba bean (Figure 3). When seeds were primed with water, the ultimate shoot dry weight of the faba bean was discovered to be the greatest (51.00 mg), which was identical to those reported with several other priming techniques like 10000 ppm NaOCl and 20000 ppm $CaCl_2$ correspondingly. The lowest shoot dry matter (26.50 mg) was produced by priming with 30000 ppm KCl, which was statistically equal to priming with 80000 ppm Manitol.

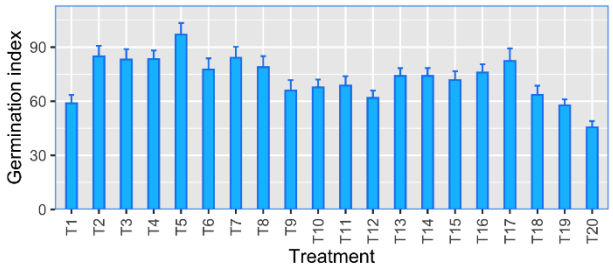

Figure 2. Germination index of faba bean as influenced by seed priming

T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

Table 2. Seed germination, seedling vigor and germination co-efficient of faba bean as influenced by seed priming method.

Treatment	Mean germination time (days)	Seedling vigor index	Germination co-efficient
T_1	9.22a	27.75a-d	11.01d
T_2	8.46f-h	28.95ab	11.80ab
T_3	8.64c-h	29.76a	11.58bc
T_4	8.27h	27.57a-d	11.80ab
T_5	8.33gh	29.79a	12.28a
T_6	8.65c-h	28.58ab	11.52b-d
T_7	8.58d-h	28.20a-c	11.75b
T_8	8.73b-g	25.09b-e	11.45b-d
T_9	9.00a-c	22.61e-g	11.13cd
T_{10}	9.02a-c	23.80d-f	11.06cd
T_{11}	8.82a-f	27.04a-d	11.32b-d
T_{12}	8.77b-f	15.38h	11.35b-d
T_{13}	8.90a-e	24.11c-f	11.31b-d
T_{14}	8.74b-g	20.85fg	11.45b-d
T_{15}	9.13ab	24.16c-f	11.16cd
T_{16}	8.64c-h	25.41b-e	11.33b-d
T_{17}	8.51e-h	26.24a-e	11.81ab
T_{18}	9.02a-c	23.84d-f	11.18cd
T_{19}	8.73b-g	19.63g	11.50b-d
T_{20}	8.94a-d	13.15h	11.07cd
$S\bar{x}$	0.06	1.01	0.07
Sig. level	**	**	**
CV (%)	2.85	10.58	2.86

Different letters in the same column indicated significant differences at 5 % level of probability; ** 1% level of significance. T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

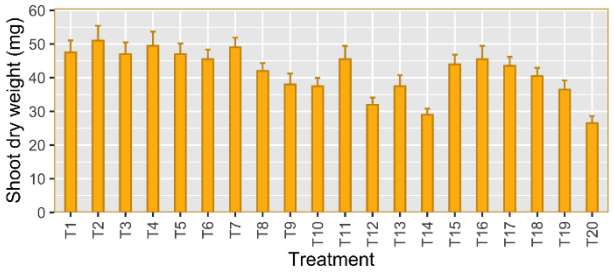

Figure 3. Shoot dry weight of faba bean as influenced by seed priming

T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

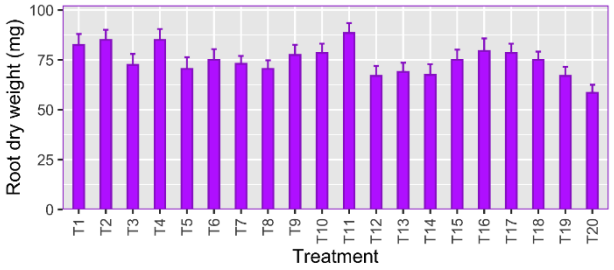

Figure 4. Root dry weight of faba bean as influenced by seed priming method

T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

Root Dry Weight

The seed priming approach had a considerable impact on the root dry matter of the faba bean (Figure 4). When seeds were primed with 20000 ppm KNO_3, the ultimate root dry weight of the faba bean was found to be the greatest (88.50 mg), which was statistically comparable to those recorded with several other priming techniques such H2O, 1000 ppm NaOCl, control, 10000 & 15000 ppm KNO_3, 100 & 150 ppm, respectively. The lowest root dry matter (58.50 mg) was obtained after priming with 30000 ppm KCl. This was followed by priming with 40000 & 80000 ppm Manitol and 20000 ppm KCl.

Root: Shoot

The seed priming technique has an impact on the root-shoot ratio of faba beans. According to (Table 3), the faba bean's root-shoot ratio was highest (0.72) when seeds were primed with 10000 ppm KNO_3 and lowest (0.43) when seeds were primed with 100 ppm PEG.

Discussion

The germination percentage was greater with all priming techniques except KCl (at any concentration). The highest final germination percentage of faba beans was observed when seeds were primed with 500 ppm NaOCl, which was statistically comparable to those recorded with other priming methods like 10000, 20000, and 30000 ppm $CaCl_2$, control, 1500 ppm KCl, any concentration of NaOCl, H_2O, 10000 ppm KNO_3, and 150 ppm PEG. The lowest germination rate was obtained after priming with 30000 ppm KCl. The frequency of germination with no priming was 94% (Table 2). Production of proteins and growth inhibitors being released (Khan et al., 1977), as well as the repair of deteriorating DNA in seeds (Di Girolamo and Barbanti, 2012), may be the causes of better germination by priming. According to Pukacka and Ratajczak (2005), priming stimulates antioxidant enzymes that minimize peroxidation in the seed and might hasten germination, maintaining seed vigor. According to Abbas et al. (2018), pressing dirt into a solid matrix for 12 hours and osmo priming with PEG-6000 are both recommended for enhancing crop germination and growth. Raun et al. (2002) found that KCl priming of rice seeds improved germination rates. According to Basra et al. (2005) and Ghiyasi et al. (2008), vitamin C priming can hasten and uniformize germination, which enhances germination and establishment in a number of field crops, including faba bean.

The sole method of treatment without priming or a control had the longest mean germination time of all the treatments. The results indicated that when the seeds were not primed using any other priming strategies, the faba bean's ultimate mean germination time was the longest. According to Farooq et al. (2010), the seed undergoes biochemical changes as a result of seed priming, including hydrolysis, enzyme activation and dormancy breaking which might significantly shorten the time it takes for a seed to emerge and boost its final germination rate. Karmore and Tomar (2015) found that seed priming over 24 hours resulted in a much quicker time for 50% emergence than untreated seeds, which needed the mean minimum germination time. The faba bean germination index changed equally regardless of the seed priming technique. The highest final germination index for faba beans was found when seeds were pre-treated with 1500 ppm NaOCl, which was statistically equivalent to those reported with several other priming strategies such H_2O, 20000 ppm $CaCl_2$, 500 ppm, and 1000 ppm NaOCl. While priming with 30000 ppm of KCl (Table 2), the lowest germination index was attained. It has been demonstrated that hydro-priming increases germination rate in a variety of crop species, especially under challenging growing environments (Jisha et al., 2018).

The final seedling vigor index for the faba bean was discovered to be at its highest when seeds were primed with 1500 ppm NaOCl. This result was statistically similar to those found with a number of different priming methods, including 500 ppm NaOCl, H_2O, and $CaCl_2$ at any concentration. As shown in (Table 2), priming with 30000 ppm KCl resulted in the lowest seedling vigor index, which was statistically followed by priming with 40000 ppm Manitol and 20000 ppm KCl. Seeds that were primed produced seedlings with a higher seedling vigor index than seeds that were not primed. Mahender et al. (2015) defined that the growth of robust seedlings in any form of environmental condition is known as seedling early vigor. When seeds were pre-treated with 1500 ppm NaOCl, the ultimate germination coefficient of faba beans was discovered to be at its highest level.

Table 3. Seedling growth of faba bean as influenced by seed priming method

Treatments	Shoot length (cm)	Root length (cm)	Root-shoot ratio
T_1	19.16a-d	10.36a-c	0.54c-e
T_2	21.09a	10.53ab	0.50de
T_3	20.47ab	10.53ab	0.52c-e
T_4	20.63ab	9.65a-c	0.47de
T_5	19.61a-c	9.93a-c	0.51c-e
T_6	19.39a-c	10.88ab	0.57cd
T_7	20.40ab	9.94a-c	0.49de
T_8	17.35b-e	9.78a-c	0.57cd
T_9	15.96d-f	11.19a	0.72a
T_{10}	16.51c-e	10.56ab	0.64a-c
T_{11}	19.44a-c	11.13a	0.58cd
T_{12}	15.60ef	9.03bc	0.59b-d
T_{13}	16.11d-f	9.01bc	0.57cd
T_{14}	13.25fg	9.31a-c	0.70ab
T_{15}	19.62a-c	9.38a-c	0.49de
T_{16}	19.91ab	8.51cd	0.43e
T_{17}	19.61a-c	9.27a-c	0.48de
T_{18}	17.83a-e	9.99a-c	0.56cd
T_{19}	15.92d-f	9.10bc	0.58cd
T_{20}	11.14g	7.08d	0.64a-c
$S\bar{x}$	0.60	0.22	0.02
Sig. Level	**	**	**
CV (%)	11.28	11.73	13.83

Different letters in the same column indicated significant differences at 5 % level of probability; ** 1% level of significance. T_1 = Control; T_2 = H_2O; T_3 = NaOCl (500 ppm); T_4 = NaOCl (1000 ppm); T_5 = NaOCl (1500 ppm); T_6 = $CaCl_2$ (10,000 ppm); T_7 = $CaCl_2$ (20,000 ppm); T_8 = $CaCl_2$ (30,000 ppm); T_9 = KNO_3 (10,000 ppm); T_{10} = KNO_3 (15,000 ppm); T_{11} = KNO_3 (20,000 ppm); T_{12} = Manitol (40,000 ppm); T_{13} = Manitol (60,000 ppm); T_{14} = Manitol (80,000 ppm); T_{15} = PEG (50 ppm); T_{16} = PEG (100ppm); T_{17} = PEG (150 ppm); T_{18} = KCl (10,000 ppm); T_{19} = KCl (20,000 ppm); T_{20} = KCl (30,000 ppm)

This number was statistically equivalent to the results obtained with a variety of alternative priming methods, such as 150 ppm PEG, 1000 ppm NaOCl, and H_2O. The priming with no priming technique control had the statistically lowest germination coefficient, which was followed by priming with 15000 ppm KNO_3 and 30000 ppm KCl (Table 2). According to Karmore and Tomar (2015), who discovered that seed priming procedures had a favorable impact on root and shoot length in comparison to untreated seed. Farooq et al. (2012) provided additional evidence for the current similar, increased ability of osmopriming with $CaCl_2$ to hasten germination, vigor index, and seedling vigor in spring maize.

The largest faba bean ultimate shoot length was discovered when seeds were water-primed. This outcome was statistically equivalent to numerous other priming methods, including 50, 500, and 150 ppm PEG, 20000 ppm $CaCl_2$, 500, and 1000 ppm NaOCl, and 500, 1000, and 20000 ppm $CaCl_2$. The statistical analysis revealed that priming with 30000 ppm KCl resulted in the lowest shoot length, which was then followed by priming with 40000 ppm and 80000 ppm Manitol, 20000 ppm KCl, 1500 ppm NaOCl, and 10000 ppm $CaCl_2$ (Table 3). According to research by Lee et al. (2000), seed priming affects plumule and radicle length more significantly under optimal soil moisture conditions than it does under insufficient or excessive soil moisture. The faba bean's ultimate shoot dry matter was discovered to be the highest when seeds were moistened. This result was statistically equivalent to other priming methods, such as 10000 ppm NaOCl and 20000 ppm $CaCl_2$, respectively. The priming with 30000 ppm KCl resulted in the statistically lowest shoot dry matter, which was followed by 80000 ppm Manitol (Table 3). The faba bean's final root dry matter was discovered to be the highest when seeds were pre-treated with 20000 ppm KNO_3. This result was statistically equivalent to those obtained with a number of different priming methods, including H_2O, 1000 ppm NaOCl, control, 10000 & 15000 ppm KNO_3, 100 & 150 ppm, etc. Priming with 30000 ppm KCl resulted in the statistically lowest root dry matter, which was statistically followed by priming with 40000 ppm & 80000 ppm Manitol and 20000 ppm KCl (Table 3). Different pea types and seed priming methods have an impact on the total dry weight (g/plant), shoot and root dry weights, and total dry weight (g/plant). It was observed that seed priming with H_2O_2 enhanced shoot dry weight after ten additional priming procedures, including the concentration of PEG, KH_2PO_4, H_2O_2, KNO_3, ABA, and hydropriming (Yanglem et al., 2021). The ratio of root and shoot of the faba bean was shown to be largest when seeds were pre-treated with 10000 ppm KNO_3 or 100 ppm PEG, and vice versa (Table 3).

Conclusion

Faba bean seed germination and seedling growth may be aided by seed priming according to studies which supports this theory. The optimal priming agent was found to be seed priming with NaOCl or KNO_3. These results point to new paths for the development of faba bean seed priming for improved seed germination and increased seedling growth under various stress situations to ensure good plant establishment, better growth and higher yield.

Acknowledgements

The authors extend his gratefulness to Ministry of Science and Technology, Government of the People's Republic of Bangladesh for financial support to conduct the study.

Conflict of Interests

The authors certify that they have no financial or other competing interests to disclose with relation to the current work.

References

Abbas, M. W., Khan, M., Ahmad, F., Nawaz, H., Ahmad, J., Ayub, A., & Fahad, S. (2018). Germination and seedling growth of wheat as affected by seed priming and its duration. *Agricultural Research and Technology*, 18(3), 155-159. *https://doi.org/10.19080/ARTOAJ.2018.18.556062*

Basra, S. M. A., Farooq, M., & Tabassum, R. (2005). Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice (*Oryza sativa* L.). *Journal of Seed Science Technology*, 33(3), 623- 628. https://doi.org/10.15258/sst.2005.33.3.09

Cernay, C., Pelzer, E., & Makowski, D. (2016). A global experimental dataset for assessing grain legume production. *Scientific Data*, 3, 160084. https://doi.org/10.1038/sdata.2016.84

Copeland, L. O. (1976). Principles of seed science and technology. *Springler Science and Business Media,* 164-165.

Dey, A., Sarkar, M. A. R., Paul, S. K., & Roy, P. K. (2013). Effect of hydropriming on field establishment of seedlings obtained from primed seeds of *Boro* rice cv. BRRI dhan29. *International Journal of Applied Sciences and Biotechnology,* 1(4), 220-223.https://doi.org/10.3126/ijasbt.v1i4.9102

Dezfuli, P. M., Sharif-Zadeh, F., & Janmohammadi, M. (2008). Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays* L.). *Journal of Agricultural and Biological Science,* (3), 22-25.

Di Girolamo, G., & Barbanti, L. (2012). Treatment conditions and biochemical processes influencing seed priming effectiveness. *Italian Journal of Agronomy,* 7(2), 25. https://doi.org/10.4081/ija.2012.e25

Draganic, I., & Lekic, S. (2012). Seed priming with antioxidants improves sunflower seed germination and seedling growth under unfavorable germination Conditions. *Turkish Journal of Agriculture,* 36, 421−428. https://doi.org/10.3906/tar-1110-16

Ellis, R. H., & Roberts, E. H. (1981). The quantification of ageing and survival in orthodox seeds. *Seed Science and Technology,* 9, 373-409.

Farooq, M., Basra, S. M. A., & Khan, M. B. (2007). Seed priming improves growth of nursery seedlings and yield of transplanted rice. *Archives of Agronomy and Soil Science,* 53, 315-326. doi: 10.1080/03650340701226166.

Farooq, M., Basra, S. M. A., Wahid, A., Khaliq, A., & Kobayashi, N. (2009). Rice seed invigoration. *Sustainable Agriculture Reviews,* 137- 175. https://doi.org/10.1007/978-1-4020-9654-9_9

Farooq, M., Wahid, A., Basra, S. M. A., & Siddique, K. H. M. (2010). Improving crop resistance to abiotic stresses through seed invigoration. Handbook of Plant and Crop Stress, CRC Press, USA, 1031-1050.

Farooq, M., Wahid, A., & Siddique, K. H. M. (2012). Micronutrient application through seed treatments: A review. *Journal of Soil Science and Plant Nutrition,* 12(1), 125- 142. https://doi.org/10.4067/S0718-95162012000100011

Ghiyasi, M., Seyahjam, A. A., Tajbakhs, M., Amrma, R., & Salehzade, H. (2008). Effect of osmopriming with polyethylene glycol (8000) on germination and seedling growth of wheat (*Triticum aestivum* L.) seeds under salt stress. *Journal of Biological Science,* 3(10), 1249-1251.

Gomez, K. A., & Gomez, A. A. (1984). Statistical Procedures for Agricultural Research 2nd Edition A Willy Inter-Science Publications, John and Sons, New York, 202-215.

Jisha, K. C., & Puthur, J. T. (2018). Seed hydropriming enhances osmotic stress tolerance potential in vignaradiata. *Agricultural Research,* 7, 145-151. https://doi.org/10.1007/s40003-018-0306-x

Kaya, M, D., Okcub, G., Ataka, M., Cikilic, Y., & Kolsaricia, O. (2006). Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.). *European Journal of Agronomy,* 24, 291-295. https://doi.org/10.1016/j.eja.2005.08.001

Karmore, J. V., & Tomar, G. S. (2015). Effects of seed priming methods on germination and seedling development of winter maize (*Zea mays* L.). *Advance Research Journal of Crop Improvement,* 6(2), 88-93. https://doi.org/10.15740/HAS/ARJCI/6.2/88-93

Khan, A. A., Tao, K., Knypl, J. S., Borkowska, B., & Powell, L. E. (1977). Osmotic conditioning of seeds: physiological and biochemical changes. *Acta Horticulturae,* 83, 267-278. https://doi.org/10.17660/ActaHortic.1978.83.35

Lee, S. S., & Kim, J. H. (2000). Total Sugars, α-amylase Activity and germination after priming of normal and aged rice seeds. *Korean Journal of Crop Science,* 45(3), 108-111.

Mahender, A., Anandan, A., & Pradhan, S.K. (2015). Early seedling vigour, an imperative trait for direct-seeded rice: An overview on physio-morphological parameters and molecular markers. *Planta,* 241, 1027. https://doi.org/10.1007/s00425-015-2273-9

Mouradi, M., Farissi, M., Makoudi, B., Bouizgaren, A., & Ghoulama, C. (2018). Effect of Faba bean (*Vicia faba* L.) Rhizobia symbiosis on barley's growth, phosphorus uptake and acid phosphatase activity in the intercropping system. *Annals of Agrarian Science,* 17(3), 297-303. https://doi.org/10.1016/j.aasci.2018.05.003

Paul, S. K., & Gupta, D. R. (2021). Faba bean (*Vicia faba* L.), A Promising grain legume crop of Bangladesh: A Review. *Agricultural Reviews,* 42, 292-299. https://doi.org/10.18805/ag.R-203

Paul, S. K., Gupta, D. R., Mahmud, N. U., Muzahid, A. N. M., & Islam, M. T. (2022): First report of collar and root rot of faba bean caused by *Rhizoctonia solani* AG-2-2 IIIB in Bangladesh. *Plant Disease,* 106, 1072. https://doi.org/10.1094/PDIS-08-21-1603-PDN

Pukackas, & Ratajczak, E. (2005). Production and scavenging of reactive oxygen species in seeds during storage at varied temperature and humidity. *Journal of Plant Physiology,* 162, 873- 885. https://doi.org/10.1016/j.jplph.2004.10.012

Ramirez-Moreno, J. M., Salguero, B. I., Romaskevych, O., & Duran-Herrera, M. C. (2015). Broad bean (*Vicia faba*) Consumption and Parkinson's disease: Natural source of L-dopa to Consider. *Neurologia,* 30, 375-376. https://doi.org/10.1016/j.nrleng.2013.08.006

Raun, S., Xue, Q., & Tylkowska, K. (2002). Effect of seed priming on germination of rice seeds. *Seed Science and Technology,* 3051-58.

Roy, S., Das, S., Saha, K. K., Rahman, M. R., Sarkar, S. K., Rashid, M. H., & Paul, S. K. (2022). Growth and seed yield of faba bean (*Vicia faba* L.) as influenced by zinc and boron micronutrients. *Fundamental and Applied Agriculture,* 7(2), 139-149. https://doi.org/10.5455/faa.106842

Roy, P. K., Sarkar, M. A. R., Paul, S. K., & Dey, A. (2013). Effect of osmopriming of boro rice seeds on field establishment of seedlings. *International Journal of Applied Sciences and Biotechnology,* 1(4), 228-232. https://doi.org/10.3126/ijasbt.v1i4.9131

Shim, K. B., Cho, S. K., Hwang, J. D., Pae, S. B., Lee, M. H.., Ha, T. J., Park, C. H., Park, K. Y., & Byun, J. C. (2009). Effect of seed priming treatment on the germination of sesame. *Korean Journal of Crop Science,* 54, 416-421.

Singh, A. K., & Bhatt, B. P. (2012). Faba bean: Unique Germplasm Explored and Identified. *Horticulture Flora Research Spectrum,* 1(3), 267-269.

Yanglem, S. D., Ram, V., Rangappa, K., & Deshmukh, N. (2021). Effects of seed priming on root- shoot behavior and stress tolerance of pea (Pisum sativum L.). *Bangladesh Journal of Botany,* 50(2), 199-208. https://doi.org/10.3329/bjb.v50i2.54074