Journal of Agriculture and Ecology Research International

Volume 25, Issue 2, Page 53-61, 2024; Article no.JAERI.114017
ISSN: 2394-1073

Effect of Seed Priming on Germination Behavior and Emergence of Wheat (*Triticum aestivum* L.)

Md. Anowarul Haque [a*]

[a] *School of Agriculture and Rural Development, Bangladesh Open University, Gazipur, Bangladesh.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JAERI/2024/v25i2584

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114017

Original Research Article

Received: 02/01/2024
Accepted: 07/03/2024
Published: 11/03/2024

ABSTRACT

The study aimed to evaluate the effects of different priming treatments on the germination, seedling emergence, speed of emergence, vigour index, seedling length, and seedling fresh weight of wheat seeds at the School of Agriculture and Rural Development, Bangladesh Open University, Gazipur, from November to December 2022. Four treatments: Hydro Prime (T_1), 2% KCl (T_2), 1% KNO_3 (T_3), and 10% PGE-6000 (T_4) were administered, and assessments were conducted Following two intervals viz., 12 and 24 hours of priming. The experiment was conducted using a completely randomized design (CRD) followed by four replications. Notably, 2% KCl consistently demonstrated the highest germination rates, reaching 97.50% after 24 hours of priming. 1% KNO_3 also performed well, outclassing other treatments in enhancing germination rates. While Hydro Prime generally exhibited lower germination rates and remained respectable. In terms of emergence, 1% KNO_3 consistently showed the highest rates, followed by 10% PGE-6000 and 2% KCl. Hydro Prime displayed lower emergence rates, particularly at the 12-hours. The speed of emergence increased for all treatments, with 2% KCL consistently outperforming others, reaching 45.55% after 24 hours. Longer priming durations consistently resulted in higher vigour index values, with 2% KCL exhibiting the highest at 11.40 after 24 hours. The impact on seedling length varied; 1% KNO_3 was most effective after 24 hours, reaching 25.27 cm, while 10% PGE-6000 excelled after 12 hours at

**Corresponding author: E-mail: haquejp@gmail.com;*

26.92 cm. 1% KNO_3 also yielded the highest seedling fresh weight (0.23 gm) after 24 hours, with 2% KCl showing significant increases (0.21 gm). Hydro Prime consistently demonstrated the lowest weights. From the present study, it may be concluded that 2% KCL and 24 hours of seed priming is useful to achieve uniform germination, seedling emergence, and vigour index in wheat.

Keywords: Seed priming; germination; priming duration; wheat.

1. INTRODUCTION

Wheat is an important cereal crop cultivated worldwide and is scientifically known as *Triticum aestivum* L., a member of the Poaceae family. Wheat is the leading cereal crop globally in terms of production, according to FAOSTAT data, with an estimated production of 785 million metric tons in 2023. Bangladesh is an overpopulated country. Increasing agricultural production on a per-acre basis in Bangladesh is becoming the most crucial step to deal with the country's current population growth rate. Wheat can be a valuable additive to rice and is essential for feeding this enormous population. The lack of plant nutrients, uneven germination, weed competition, insect attack, disease infection, and irrigation water are among the most significant factors causing low grain yield in wheat.

Priming plants has the potential to provide both financial and agronomic benefits. Multiple studies have found that priming increases germination rate, uniformity, seedling growth [1,2] and stress resistance. Rapid emergence and seedling establishment are essential for the production of high-quality grains. Pre-sowing seed treatments are promising in the arid and semi-arid tropics. Uneven or poor germination followed by inconsistent seedling growth can cause significant financial losses by reducing different mechanization possibilities or lowering prices for inconsistent plant samples [3]. Seed priming accelerates the establishment of many crops, such as maize, wheat, rice, and canola [4,5,3]. Seed priming initiates the metabolic processes necessary for germination. Seed priming is commonly used to reduce the time between seed sowing and seedling emergence, and to synchronize seedling emergence. Potassium pyrophosphate (KH_2PO4), monobasic [6], polyethylene glycol (PEG) [7], and potassium chloride (KCL) [8] solutions have shown promising potential to improve wheat germination, emergence, growth, and grain yield.

The present investigations were, therefore, planned to assess the effects of priming agents on seed germination and seedling emergence of wheat (*Triticum aestivum* L.).

2. MATERIALS AND METHODS

The effects of priming agents on germination and seedling growth of the wheat cultivar BARI Gom-28 were investigated in an experiment at the School of Agriculture and Rural Development, Bangladesh Open University, Gazipur, from November to December 2022. Seeds were treated with four different priming agents: hydro priming (T_1) as a control (seeds soaked with tap water), 2% potassium chloride (KCl) priming (T_2), 1.0% potassium nitrate (KNO_3) priming (T_3), and 10% polyethylene glycol (PEG-6000) priming (T_4). Distilled water was used to prepare all priming media at non-aerated conditions, and seeds were fully immersed for 12 or 24 hours at 28°C. After priming, the seeds were rinsed with distilled water and hand-dried lightly using blotting paper.

2.1 Germination Test

The germination experiment was conducted in a germinator at 25°C in 9-cm Petri dishes (20 in each) between the layers of moist filter paper. Thirty (30) seeds from each of the treatments were placed in each petri dish with 10 ml of distilled water. Seeds were considered germinated when the radical protruded for 1.0 mm. Germination progress was measured at 24-hour intervals and continued until no further germination occurred. Germination percentage (GP) on the basis of normal seedlings in the laboratory was calculated as described in the formula [9]:

$$GP = \frac{Total\ number\ of\ seeds\ germinated}{Total\ number\ of\ seeds} \times 100$$

2.2 Seedling Emergence (%)

To explore the impact of priming agents on seedling emergence percentage, twenty seeds from each treatment were subjected to 12-hour and 24-hour treatments. These treated seeds were then planted one inch deep in pots filled with moist sand and placed in open field conditions. After 12 days, the percentage of seedling emergence was recorded. The experiment was replicated three times to validate the findings. The percentage of seedling emergence was calculated using the formula [2].

$$\text{\% Seedling emergence} = \frac{\text{Total number of emerged seedlings at 12 DAS}}{\text{Total number of seeds}} \times 100$$

2.3 Speed of Emergence (SPE)

In order to measure the SPE of the seed, twenty seeds from each treatment underwent 12-hour and 24-hour treatments. Subsequently, the treated seeds were sown one inch deep in pots containing moist sand, which were kept under open field conditions. The experiment was repeated three times to ensure the reliability of the results. The seedling emergence speed was calculated using the formula described by [10].

$$\text{SPE} = \frac{\text{Number of seedlings emerged at 5 DAS}}{\text{Number of seedlings emerged at 11 DAS}} \times 100$$

2.4 Vigour Index

Seed vigor index is the sum total of all attributes of seeds, which indicates the potential level and activity of the seed during germination and seedling emergence. Daily count of the germination of seeds was taken to calculate the vigour index. It can be calculated using the following formula [5].

$$\text{VI} = \frac{x1}{n1} + \frac{x2}{n2} + \ldots\ldots\ldots\ldots\ldots\ldots + \frac{xn}{nn}$$

Where:

x_1 = number of seedlings at first count
n_1 = number of days at first count
x_2 = number of seedlings at second count
n_2 = number of days at second count
x_n = number of seedlings at final count
n_n = number of days at final count

2.5 Seedling Length (cm)

The length of the seedling was expressed in centimeters and measured from the tip of the shoot to the end of the root at 14 DAS.

2.6 Seedling Fresh Weight (g)

Twenty seeds from each treatment were carefully placed in separate 9-cm Petri dishes lined with moist filter paper. Each dish received 10 ml of distilled water. The Petri dishes were then kept at room temperature for 14 days. Seedlings were gently collected after this period to minimize damage. Each seedling was thoroughly washed under running tap water to remove debris. The roots and shoots were gently patted with blotting paper to remove excess moisture. Finally, the weight of each seedling was meticulously measured using a sensitive weighing scale. The weight was recorded immediately to ensure accuracy.

2.7 Statistical Analysis

The analysis of variance (ANOVA) and means of the parameters were compared using Statistix 10.0. The mean differences among the treatments were adjudged by least significant differences (LSD) at the 5% level of significance.

3. RESULTS

3.1 Germination (%)

The germination rate was measured after 12 hours and 24 hours of priming and showed that all four treatments increased the germination rate, but the increase was greater at 24 hours of priming than at 12 hours of priming treatment (Fig. 1). This suggests that longer priming periods have a more favourable impact on germination. Among the treatments, KCL consistently showed the highest germination rates for both 12-hours and 24-hours priming durations. Furthermore, the highest germination rate after 12 hours of priming was observed for KCl (96.75%), followed by PGE-6000 (91.50%), KNO_3 (91.00%), and Hydro prime (76.50%).

The highest germination rate after 24 hours of priming was observed for KCl (97.50%), followed by KNO_3 (96.75%), PGE-6000 (94.00%), and Hydro prime (89.00%). The increase in germination rate between 12 hours and 24 hours of priming was greatest for Hydro prime (12.50%), followed by PGE-6000 (2.50%), KNO_3 (5.75%), and KCl (0.75%). So, KCL and KNO_3 showed outperforms the other treatments in terms of an effective way to increase the germination rate. Hydro prime (P1), on the other hand, generally exhibited lower germination rates compared to KCL but still showed respectable germination percentages.

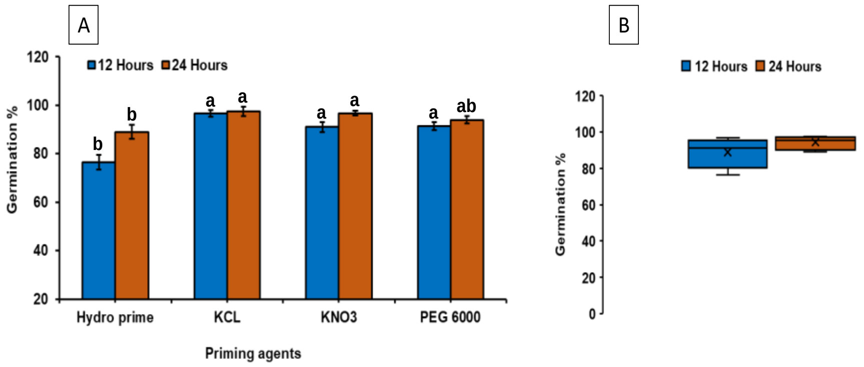

Fig. 1. (A) Effect of seed priming agents on germination percentage at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of seedling germination (%)

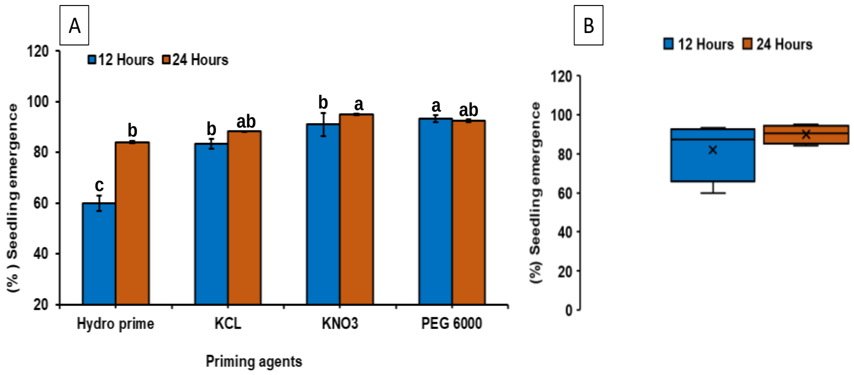

Fig. 2. (A) Effect of seed priming agents on seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of seedling emergence (%)

3.2 Seedling Emergence (%)

The seedling emergence rate was measured after 12-hours and 24-hours of priming, and Fig. 2 showed that all four treatments increased the emergence rate of the seeds. The highest emergence rate after 12 hours of priming was observed for PGE-6000 (93.25%), followed by KNO_3 (91.00%), KCl (83.50%), and Hydro prime (60.00%). The highest emergence rate after 24 hours of priming was observed for KNO_3 (95.00%), followed by PGE-6000 (92.50%), KCl (88.25%), and Hydro prime (84.00%). The increase in emergence rate between 12 hours and 24 hours of priming was most significant for Hydro prime (24.00%), followed by KCl (4.75%), KNO_3 (4.00%), and PGE-6000 (-0.75%).

Among the treatments, KNO_3 consistently showed the highest emergence rates for 12-hours and 24-hours priming durations. It performed well in promoting seed emergence. KCL also demonstrated relatively high emergence rates and was found to be competitive with KNO_3. Hydro prime exhibits lower emergence rates than KNO_3 and KCL, especially with 12-hours priming duration. PGE-6000 showed relatively consistent emergence rates and exhibited a slight decline with 24 hours priming duration.

3.3 Speed of Seedling Emergence (%)

Fig. 3 clearly showed that the 24-hours of priming duration consistently resulted in higher percentages of speed of emergence compared to the 12-hours of priming for all treatments. These findings indicate that a longer priming period positively influences the speed of emergence.

Among the treatments, KCL exhibited the highest speed of emergence percentages after 12-hours (33.90%) and 24-hours (45.55%) of priming. This treatment consistently outperformed the others. KNO_3 also showed a significant positive effect on the speed of emergence. After 12-hours of priming, it resulted in a speed of emergence of 38.53%, which increased to 44.75% after 24-hours of priming. PGE-6000 had a relatively high speed of emergence of 43.73% after 12-hours of priming, but this decreased slightly to 42.25% after 24-hours of priming. Hydro prime had the lowest speed of emergence percentages for 12 hours (19.23%) and 24-hours (30.78%) of priming. However, it's worth noting that even the lowest-performing treatment still showed an improvement in speed of emergence compared to the control.

3.4 Vigour Index

The 24-hours of priming duration consistently resulted in higher vigour index values compared to 12-hours duration for all the treatments. This suggested that longer priming periods had a profound impact on seed vigour (Fig. 4).

As far as the treatments concerned, KCL consistently exhibited the highest vigour index values (10.55 and 11.40) for both 12-hours and 24-hours of priming durations. It is the most effective treatment for enhancing seed vigour. PGE-6000 and KNO_3 also showed substantial improvements in vigour index, with slightly lower values compared to KCL (10.45 and 11.10) and (9.79 and 11.14) at both priming durations. Hydro prime (8.19 and 11.10) had the lowest vigour index values among the treatments for both priming durations.

3.5 Seedling Length (cm)

The impact of priming treatments on seedling length varied based on the duration of priming. KNO_3 emerged as the most effective treatment for enhancing seedling length after 24-hours of priming, while PGE-6000 proved highly effective after 12-hours of priming. Hydro prime and KCL yielded intermediate results for both priming durations (Fig. 5).

Hydro prime led to longer seedlings after 12-hours (22.20 cm) than 24-hours (19.75 cm). In contrast, KCL showed a slight decrease in seedling length from 24.82 cm at 12-hours of priming to 24.35 cm at 24-hours of priming. KNO_3 exhibited a significant seedling length increase from 18.65 cm at 12-hours of priming to 25.27 cm at 24-hours of priming. However, priming with PGE-6000 produced significantly longer seedlings after 12-hours (26.92 cm) than at 24-hours (20.10 cm).

3.6 Seedling Fresh Weight (g)

Among the various treatments, Fig. 6 showed that the application of KNO_3 resulted in the highest seedling fresh weight, measuring 0.23 gm, following a priming duration of 24-hours.

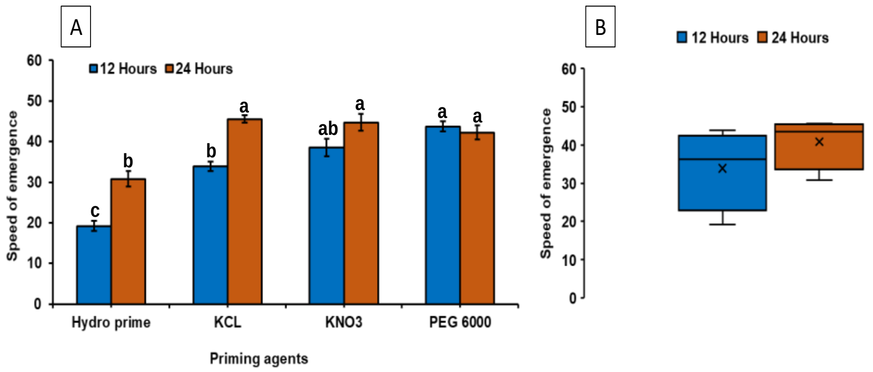

Fig. 3. (A) Effect of seed priming agents on speed of seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of speed of seedling emergence

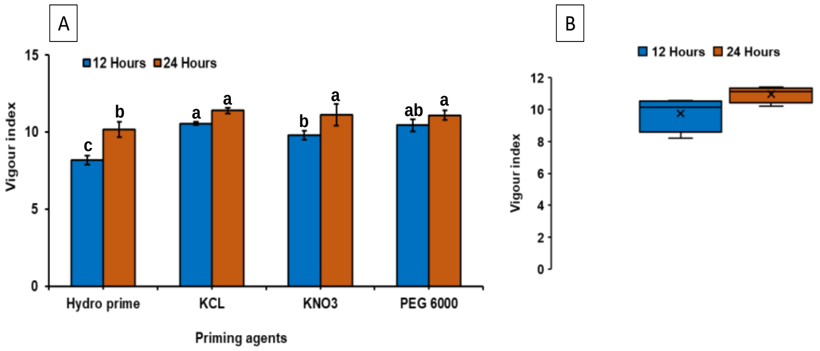

Fig. 4. (A) Effect of seed priming agents on vigour index at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of seedling vigour index

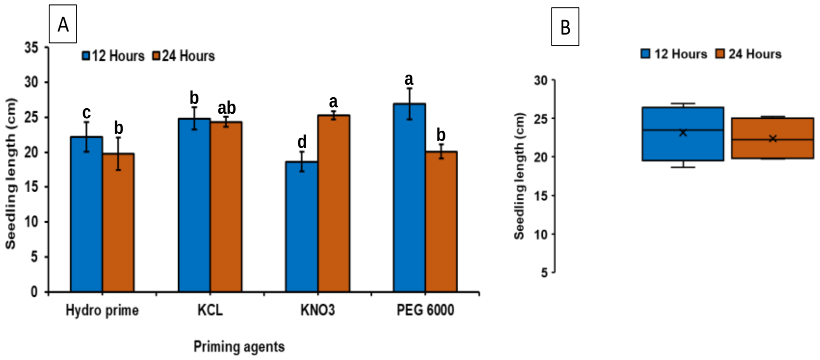

Fig. 5. (A) Effect of seed priming agents on seedling length at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of seedling length (cm)

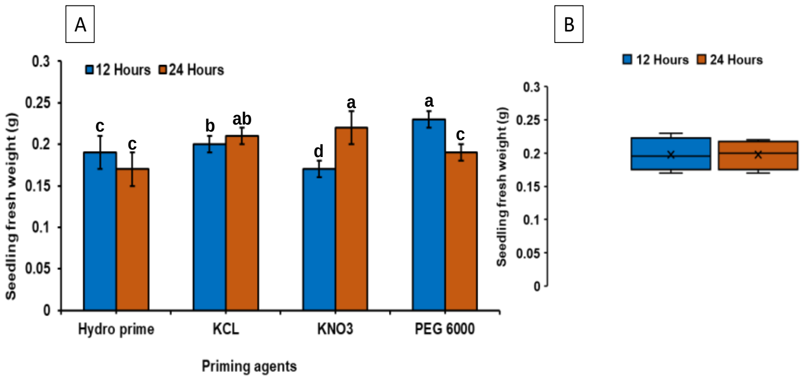

Fig. 6. (A) Effect of seed priming agents on seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P* = .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences among treatments were determined using a two-way analysis of variance (ANOVA). (B) Range of seedling fresh weight (g)

The application of KCL was found to result in a significant increase in seedling fresh weight, which was shown to progressively increased from 0.20 gm to 0.21 gm as the duration of priming was increased. PGE-6000 increased the seedling fresh weight after 24-hours (0.19 gm); however, after 12-hours (0.23 gm), weight decreased. The results indicate that Hydro prime demonstrated the least seedling fresh weights (0.19 and 0.17 gm) for both priming durations in comparison to KNO_3 and KCL.

4. DISCUSSION

Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to the emergence of the radicle. Generally, it enhances germination rate, excellent germination uniformity, and, at times, a more significant total germination percentage [3] and plant performance.

The highest germination rates were observed in the KCL and KNO_3 treatments following both 12 and 24-hours of priming. Extended priming for a duration of 24-hours resulted in notable enhancements in germination rates. Notably, KCl consistently exhibited the highest rates, surpassing the performance of other treatments. Hydro Prime, despite having lower rates compared to KCL, exhibited commendable germination percentages. KNO_3 and KCl have been identified as having the highest rates of germination for wheat seeds in multiple research studies. The application of priming treatment using KNO_3 and KCl has demonstrated positive effects on various physiological and morphological characteristics, including seedling shoot length, seedling root length, seedling fresh and dry biomass, as well as germination parameters. According to a study conducted by [11,12], the application of a seed priming treatment using a 0.1% KNO_3 solution yielded the most favourable outcomes and enhanced various germination parameters in sunflower seed germination. In a study conducted by [6] it was shown that the application of 1.0% KNO_3 at the imbibition stage of the early phase had a positive impact on the germination, speed, and uniformity of rice seeds. However, the presented results were nearly identical to those of [1], who found that 12 hours of KCl priming resulted in the highest seedling vigour parameters, which was comparable to 24 hours of soaking wheat seed. The effect of halo (KCl) priming on the germination of wheat genotypes and the initial growth of seedlings was assessed in a laboratory setting. The study revealed that KCl priming significantly positively influenced seed germination and early seedling growth [13]. KCl priming can activate enzymes involved in the mobilization of stored nutrients in the seed, promoting germination and early seedling growth [14,15].

Results illustrated the influence of different priming treatments and durations on seed emergence rates. Longer priming durations generally lead to higher emergence rates. KNO_3 consistently has the highest emergence rates among the treatments tested, while KCL also performs well. Hydro prime exhibits lower emergence rates, especially for the 12-hours priming duration, and PGE 6000 maintains relatively consistent emergence rates. Seed priming with KNO_3 can improve rice's emergence and seedling growth under drought conditions observed [16]. Similarly, seed priming treatments using KNO_3 have effectively improved seed emergence under improper conditions, such as salt stress on wheat seedlings [17].

The choice of priming agent can also influence the degree of enhancement in germination speed. The findings demonstrated that the application of priming treatments had a substantial positive impact on the germination rate of wheat seeds, resulting in faster emergence compared to the control at both the 12-hours and 24-hours durations. At 12-hours, PGE-6000 showed the highest efficacy among the treatments, followed by KNO_3, KCl, and hydro prime. PGE-6000 and KNO_3 were the best performers at 24-hours, followed by KCl and hydro prime. According to a study conducted by [18], the application of KNO_3 as a seed priming technique has been found to enhance the consistency and efficiency of rice seed germination. The application of KCl and PEG-6000 as priming agents has been seen to yield favourable outcomes in terms of the germination rate and subsequent growth of wheat seeds.

In contrast, the priming agents exhibited their effects after a duration of 12-hours. Among these agents, KCl demonstrated the highest efficacy in terms of the vigour index, followed by PGE 6000, KNO_3, and hydro prime. After a duration of 24-hours, both KCl and KNO_3 were found to be the most effective priming agents.

The seedling length was shown to be most significantly raised by PGE-6000 after 12-hours, whereas KNO_3 had the highest efficacy in promoting seedling growth after 24-hours. The experimental results indicate that the seedling fresh weight was highest at the 24-hours when treated with KNO_3 and KCl. However, at the 12-hours, PGE-6000 exhibited the most significant effect on seedling fresh weight. [19] observed that the applications of 2.5% and 5% KCl and KOH showed improvements of germination percentage, seedling shoot length, seedling root length, seedling fresh and dry biomass under saline as well as non-saline conditions in pea.

5. CONCLUSION

Overall, priming significantly enhanced germination, emergence, and seedling growth. Longer priming durations, especially exceeding 24 hours, led to enhanced performance across all evaluated criteria. KCl treatment consistently achieved the highest germination rate of 97.50% after 24 hours. KNO_3 exhibited the highest emergence rates, while KCl demonstrated the fastest emergence within 24 hours. Longer priming durations positively impacted vigor index, with KCl showing the highest values at 24 hours (11.40). Treatment effects on seedling length varied, with KNO_3 being most effective after 24 hours, resulting in a length of 25.27 cm. Seedlings treated with KNO_3, KCl, and Hydro Prime displayed the greatest weight increase. These results highlight the efficacy of priming agents in enhancing wheat seed performance, emphasizing the need to optimize both treatment type and duration.

ACKNOWLEDGEMENT

It is an honour to express my deepest gratitude to the authorities of Bangladesh Open University (BOU), Gazipur, for their invaluable financial support in making my research on "Effect of seed priming on germination behaviour and emergence of wheat (T*riticum aestivum* L.)" a reality. The financial support provided has been instrumental in facilitating various aspects of my research, including the procurement of essential materials, equipment, and resources.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Verma, Reena. Effect of osmopriming with potassium chloride on seed germination and seedling vigour of wheat seed. Conference: XIV national seed seminar Food Security through Augmented Seed Supply Under Climatic Uncertainties. New Delhi, India At: IARI, New Delhi, India; 2017, January 28-30.
2. Taylor KR, Staggenborg SA, Godsey CB, Schlegel AJ, Kochenower RD. A method to evaluate seeder performance. GSTF Journal on Agricultural Engineering. 2014; 1(1):38-42. Available:https://doi.org/10.5176/2345-7848_1.1.5
3. McCarthy J, Lalrammawii C, Kumar V, Kumar Bansal K, Srivastava H, Attri M. Seed priming on crop establishment of late sown wheat crop. Environment and Ecology Research. 2023;41(1B):507–512.
4. Das JC, Choudhury AK. Effect of seed hardening, potassium fertilizer, and paraquat as anti-transpirant on rainfed wheat (*Triticum aestivum* L.) Indian Journal of Agronomy. 1996;41:397-400.
5. Maguire JD. Speed of germination-aid in selection and evaluation for seedling emergence and vigour. Crop Science. 1962;2:176-177.
6. Èanak P, Jockovic M, Æiriæ M, Mirosavljeviæ M, Mikliæ V. Effect of seed priming with various concentrations of KNO3 on sunflower seed germination parameters in in vitro drought conditions. Research on Crops. 2014;15(1):154-159.
7. Farooq M, Basra SMA, Saleem BA. Seed priming enhance the performance of late sown wheat by improving chilling tolerance. Journal of Agronomy and Crop Science. 2008;194:55-60.
8. Misra NM, Dwivedi DP. Effects of pre-sowing seed treatments on growth and dry matter accumulation of high yielding wheat under rain-fed conditions. Indian Journal of Agronomy. 1980;25:230-234.
9. International Seed Testing Association. The germination tests. In International Rules for Seed Testing. Zurich, Switzerland: International Seed Testing Association. 2015;1-5-56.
10. Dell Aquila A, Taranto G. Cell division and DNA synthesis during osmopriming treatment and following germination in aged wheat embryos. Seed Science and Technology. 1986;14:333-341.
11. Ghiyasi M, Miyandoab MP, Tajbakhsh M, Salehzade, H, Meshkat MV. Influence of different osmopriming treatments on emergence and yield of maize (*Zea mays* L.) Research Journal of Biological Sciences. 2008b;3(12):1452-1455.

12. Ghiyasi M, Seyahjani AA, Tajbakhsh M, Amirnia R, Salehzade H. Effect of osmopriming with polyethylene glycol (8000) on germination and seedling growth of Wheat (*Triticum aestivum* L.) seeds under salt stress. Research Journal of Biological Sciences. 2008a;3(10):1249-1251.
13. Solangi SB, Chachar QI, Chachar SD, Chachar NA. Effect of halo (KCl) priming on seed germination and early seedling growth of wheat genotypes under laboratory conditions. Journal of Agricultural Technology. 2014;10(6):1451-1464.
14. Askari Nejad H. The effects of seed priming techniques in improving germination and early seedling growth of *Aeluropus macrostachys*. International Journal of Advanced Biological and Biomedical Research. 2013;1(2):86-95.
15. Gupta PK. Vermicomposting for sustainable agriculture. Agrobios. India. 2003;188.
16. Ali LG, Nulit R, Ibrahim MH, Yien CYS. Efficacy of KNO3, SiO2 and SA priming for improving emergence, seedling growth and antioxidant enzymes of rice (*Oryza sativa*), under drought. Scientific Reports. 2021; 11(1):3864. DOI:org/10.1038/s41598-021-83434-3
17. Steiner, Fábio, Zuffo, Alan, da Silva Oliveira, Carlos, Honda, Guilherme, Machado, Juan. Potassium nitrate priming mitigates salt stress on wheat seedlings. Revista de Ciencias Agrarias. 2018;41: 121-130.
18. Ruttanaruangboworn A, Chanprasert W, Tobunluepop P, Onwimol D. Effect of seed priming with different concentrations of potassium nitrate on the pattern of seed imbibition and germination of rice (*Oryza sativa* L.) Journal of Integrative Agriculture. 2017;16(3):605–613.
19. Naz E, Gul H, Hamayun M, Sayyed A, Husna, Sherwani SK. Effect of NaCl Stress on *Pisum sativum* Germination and Seedling Growth with the Influence of Seed Priming with Potassium (KCL and KOH) American-Eurasian Journal of Agricultural & Environmental Sciences. 2014;14(11):1304-1311.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/114017