Effect of seed priming on germination behavior and emergence of wheat (*Triticum aestivum* L.)

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. 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 after both 12 and 24 hours of priming. The experiment was designed as a factorial experiment and 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, they 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 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 seed priming is useful to enhance uniform germination, speed 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. Wheat is a member of the Poaceae family and ranks second, followed by rice. Bangladesh is an over-populated 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 may provide financial and agronomic benefits. Multiple studies have found that priming increases germination rate, uniformity, seedling growth [21, 23] 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 inhomogeneous seedling growth can cause significant financial losses by reducing different mechanization possibilities or lower prices for inhomogeneous plant samples. [15]. Seed priming accelerates the establishment of many crops such as maize, wheat, rice, and canola [5,14,15]. Seed priming initiates 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 [7], polyethylene glycol (PEG) [8], and potassium chloride (KCL) [28] 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. Seeds were treated with four different priming agents: hydropriming (T_1) as a control (seeds soaking 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, 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 will be placed in each petri dish with 10 ml of distilled water. Seeds will be kept at room temperature. Seeds will be considered germinated when the radical protrudes for 1.0mm. Germination progress will be measured at 24-hour intervals and continued until no further germination occurs. To evaluate the germination behavior of wheat seeds in laboratory studies, the following tests and observations will be made by initial signs of radical emergence and maximum emergence were recorded after 7 days.Germination percentage (GP) on the basis of normal seedling under laboratorywas calculated as described formula:

$$GP = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds in each replication}} \times 100$$

Root and shoot length and seedling fresh weights were recorded 14 days after sowing.

2.2 Vigour Index

Seed vigor index is the sum total of all attributes of seeds which indicates the potential level and activity of seed during germination and seedling emergence. Daily count of germination of seed was taken to calculate data on vigor index. It can be calculated by the following formula [26].

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

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

2.3 Seedling length

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

2.4 Speed of emergence (SPE)

To investigate the effects of different priming agents on seedling emergence rate. To measure SPE of 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. Seedling emergence speed was calculated using the formula described by [6].

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

2.5 Statistical Analysis

The recorded data were compiled and tabulated for statistical analysis. The experiment was designed as a factorial experiment and conducted using a completely randomized design (CRD) followed by four replications. 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 5% level of significance.

3. RESULTS

The experimental results were showed the effect of various treatments on the germination of seeds and growth of seedlings. The treatments were hydro prime (as control), 2% KCL, 1% KNO_3, and 10% PGE-6000. The results indicate that the treatments had a significant effect on the percent of germination and emergence, speed of emergence, vigour index, seedling length, and seedling fresh weight by 12 hours and 24 hours.

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

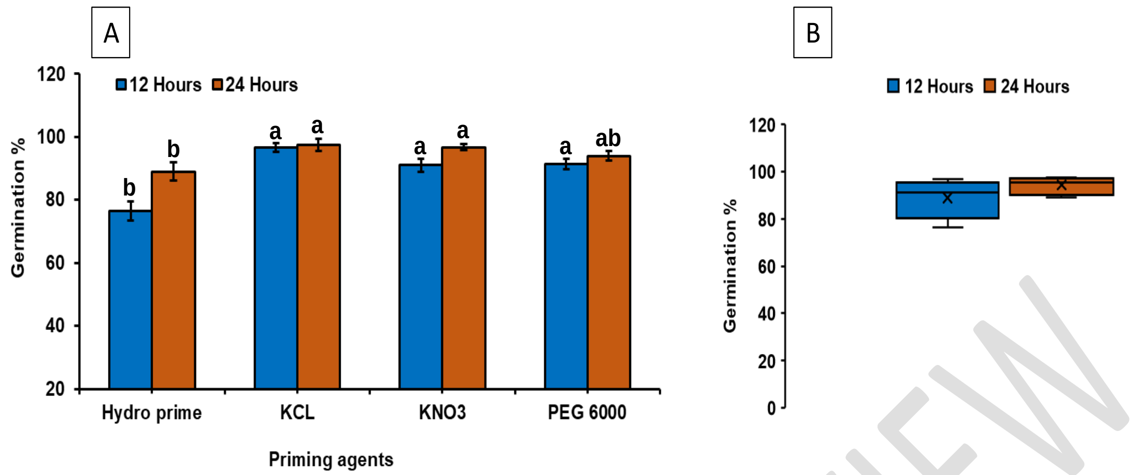

Fig. 1.(**A**) Effect of seed priming agents on germination percentage at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P*= .05) as determined by least significant differences (LSD) tests. Each bar represents the mean of four replicates. Significant differences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

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 effective way to increase the germination rate. Hydro prime (P1), on the other hand, generally exhibits lower germination rates compared to KCL but still shows respectable germination percentages.

3.2 Seedling emergence (%)

The seedling emergence rate was measured after 12 hours and 24 hours of priming, and figure 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%).

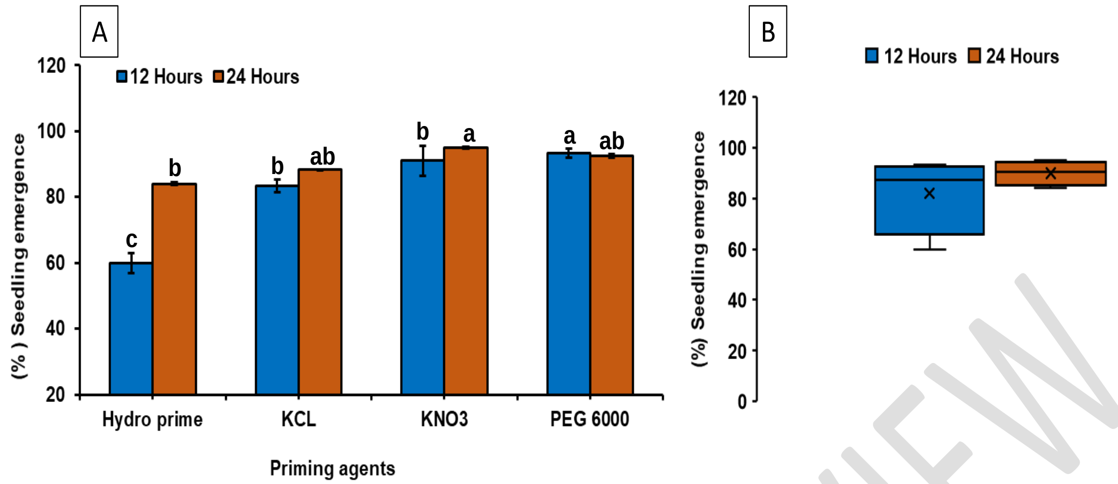

Fig. 2.(**A**) Effect of seed priming agents on seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P*= .05) as determined by least significant differences (LSD)tests. Each bar represents the mean of four replicates. Significant differences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

Among the treatments, KNO3 consistently shows the highest emergence rates for 12hours and 24hours priming durations. It performs well in promoting seed emergence. KCL also demonstrates relatively high emergence rates and is competitive with KNO_3. Hydro prime exhibits lower emergence rates than KNO_3 and KCL, especially for the 12hours priming duration. PGE-6000 shows relatively consistent emergence rates, with only slight decline for the 24hours priming duration.

3.3 Speed of seedling emergence (%)

Figure 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.

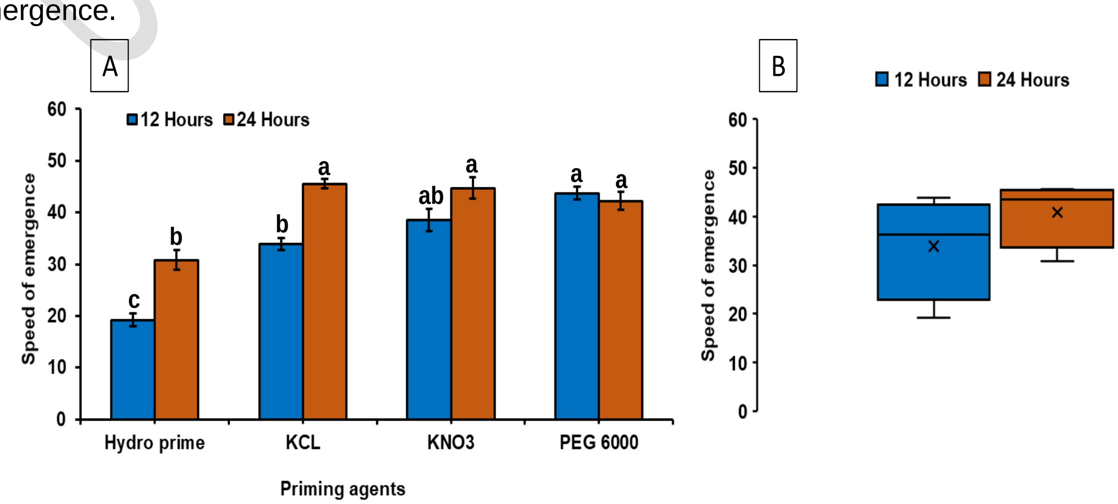

Fig. 3.(**A**) Effect of seed priming agents on speed of seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P*= .05) as determined by least significant differences (LSD)tests. Each bar represents the mean of four replicates. Significant differences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

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 24hours of priming duration consistently resulted in higher vigour index values compared to the 12hours duration for all treatments. This suggests that longer priming periods have a more favorable impact on seed vigour (Figure 4).

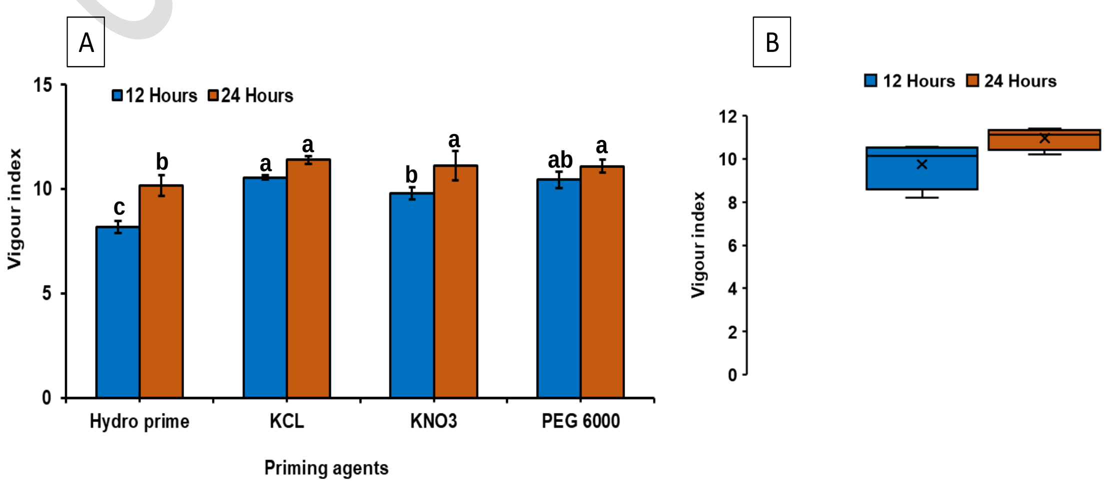

Fig. 4. (**A**) Effect of seed priming agents on vigour index at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P*= .05)as determined by least significant differences (LSD)tests. Each bar represents the mean of four replicates. Significant differences among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

Among the treatments, KCL consistently exhibited the highest vigour index values (10.55 and 11.40) for both 12hours and 24hours of priming durations. It is the most effective treatment for enhancing seed vigour. PGE-6000 (10.45 and 11.10) and KNO3 (9.79 and 11.14) also showed substantial improvements in vigour index, with slightly lower values compared to KCL. 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 (Figure 5).

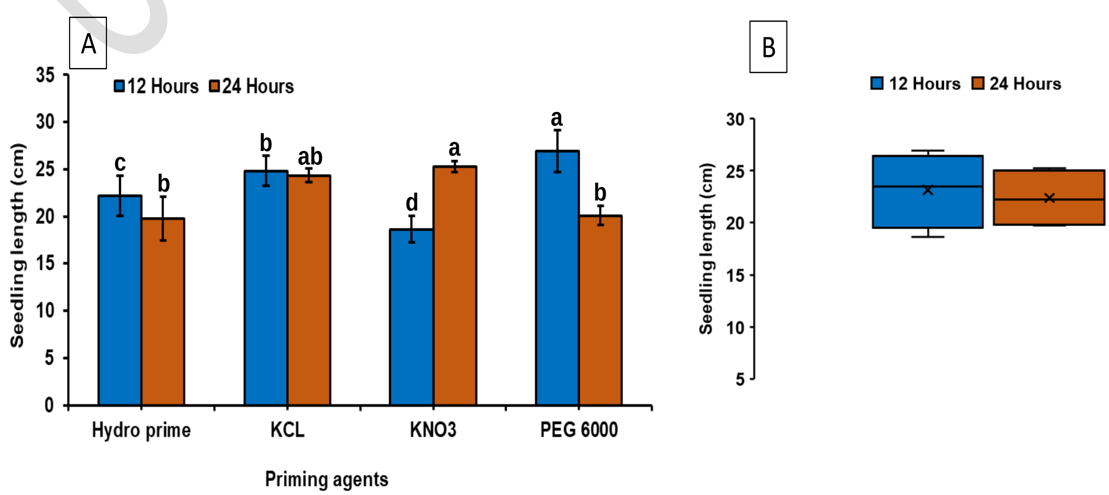

Fig. 5. (**A**) Effect of seed priming agents on seedling length at 12 and 24 hours. Treatments that do not have the same letters are significantly different (P= .05)as determined by least significant differences (LSD)tests. Each bar represents the mean of four replicates. Significant differences among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

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. PGE-6000 produced longer seedlings after 24 hours (20.10 cm) than after 12 hours (26.92 cm).

3.6 Seedling fresh weight (gm)

Among the various treatments, figure 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.

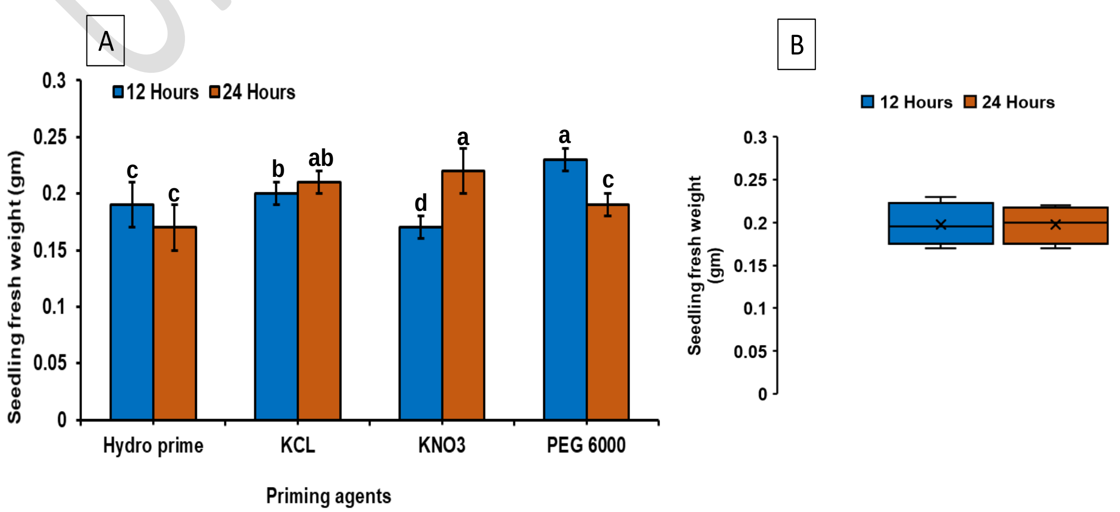

Fig. 6. (**A**) Effect of seed priming agents on seedling emergence at 12 and 24 hours. Treatments that do not have the same letters are significantly different (*P*= .05)as determined by least significant differences (LSD)tests. Each bar represents the mean of four replicates. Significant differences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

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. The application of PGE-6000 resulted in the greatest seedling fresh weight following at 24 hours priming period (0.19 gm), however a reduction in weight was observed after 12 hours of priming (0.23 gm). 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.

These findings suggest that priming with different agents can improve the speed of emergence, vigour index, seedling length, and seedling fresh weight of wheat seeds, with different treatments being more effective at different times. The variability is represented as standard deviations. These values indicate the extent of variation or dispersion in the data. Smaller standard deviations suggest less variability and greater consistency in emergence rates.

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, more excellent germination uniformity, and, at times, more significant total germination percentage [5] and plant performance.

4.1 Germination (%)

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, potassium chloride (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 [10], 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 [36] it was shown that the application of 1.0% KNO_3 at the imbibition stage of 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 [43], 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 [40]. KCl priming can activate enzymes involved in the mobilization of stored nutrients in the seed, promoting germination and early seedling growth [2, 11].

4.2 Seedling emergence (%)

Results illustrated the influence of different priming treatments and durations on seed emergence rates. Longer priming durations generally lead to higher emergence rates. KNO3 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 [1]. Similarly, seed priming treatments using KNO_3 have effectively improved seed emergence under improper conditions, such as salt stress on wheat seedlings [42].

4.3 Speed of seedling emergence (%)

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 [36], 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. This is evidenced by studies conducted [27], which report an increase in the field emergence percentage, enhanced seedling establishment, and improved seedling growth and vigour as a result of this priming technique.

4.4 Vigour index

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.

4.5 Seedling length (cm)

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.[31] observed that the applications of 2.5% and 5% KCl and KOH showed improvement 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

The objective of the study was to investigate the impact of a number of priming treatments, such as KCl, KNO_3, PGE-6000, and Hydro Prime, on the germination, emergence rate, vigour index, seedling length, and seedling fresh weight of wheat seeds after 12 and 24 hours of priming. In general, the priming technique greatly improved the germination, emergence, and growth of the seedlings. Longer periods of priming, especially over 24 hours, led to enhanced performance across various criteria. All treatments resulted in higher germination rates, with KCl consistently exhibiting the highest rate of 97.50% after 24 hours of priming. The priming agent KNO_3

consistently showed the highest rates of emergence, whereas KCl demonstrated the fastest emergence, reaching a rate of 45.55% within 24 hours. The vigour index was positively impacted by longer priming periods for all treatments, with KCl consistently exhibiting the highest values (11.40 at 24 hours). The effect of several treatments on the length of seedlings varied depending on the time of priming. Among the treatments, KNO_3 was shown to be the most effective after 24 hours, resulting in a seedling length of 25.27 cm. The seedlings treated with KNO_3 (0.23 gm at 24 hours), KCl (0.21 gm at 24 hours), and Hydro Prime exhibited the greatest increase in weight compared to other treatments. The findings underscore the effectiveness of priming with different agents in improving various aspects of wheat seed performance, with specific treatments proving more effective at different durations. The study emphasizes the importance of considering both the type of priming treatment and the duration for optimizing seed performance. The varying results, shown by standard deviations, indicate data variability, with smaller deviations suggesting less variability and more consistent emergence rates.

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