

Effects of priming on onion seed germination and field performance during summer sowing

ABSTRACT

Aims:The aim of this study was to determine the suitable priming treatments on seed germination, bulb production and quality of onion.

Study Design:The experiment was set up in randomized complete block design (RCBD) with three replications.

Place and Duration of the Study:The experiment was conducted in Horticulture farm at Sher-e Bangla Agricultural University, Dhaka, Bangladesh from April to October 2021.

Methodology:Seeds were immersed in each priming media for 12 and 24 hours, including distilled water, IAA (100 ppm), KCl (2.5%), and PEG-6000 (10%). The treatments were consisted of T₁ (water 12 hr), T₂ (water 24 hr), T₃ (PEG 12 hr), T₄ (PEG 24 hr), T₅ (IAA 12 hr), T₆ (IAA 24 hr), T₇ (KCl 12 hr) and T₈ (KCl 24 hr).

Results:The maximum germination percentage (93%), plant height (25.93 cm), total chlorophyll (28.47 mg/g) of onion leaves, bulb yield (19.96 t/ha), total soluble solid (14.05 °Brix), reducing sugar (7.41%), and phenolic content (11.12 mg/100 g) of onion bulbs were recorded in the T₃ treatment. However, the maximum fresh leaves/plant at bulb formation stage (3.73) and ascorbic acid content of onion bulb (7.20 mg/100 g) was recorded in T₄ treatment.

Conclusion:It can be concluded that seed priming with PEG 6000 (10%) for 12 hours improved growth, yield, and quality compared to other priming treatments.

Keywords: Bulb yield; onion, priming, photosynthetic pigments; reducing sugar

1. INTRODUCTION

Onion (*Allium cepa* L.) is a major spice crop grown all over the world. The majority of research on the impact of physiological stress on the growth and yield of onions has been conducted [1]. So far, very little emphasis has been placed on producing high-quality onions. Unfortunately, onion seeds are typically of poor quality, resulting in slow and asynchronous germination as well as a high number of aberrant seedlings, particularly after planting in early spring under field stress conditions [2]. Sowing high-quality seeds is essential for achieving

rapid and uniform seedling emergence, which has a significant impact on final output and quality.

The average yield of onion is very low in Bangladesh as compared to other developed countries in the world. As a result, a large amount of onion is **needed to be** imported from foreign countries **every year**. Onion is a common element in Bangladeshi cuisine, and it is now grown twice a year; in the winter and summer. However, the summer onion production is very low compared to winter. Due to severe weather conditions, cultivation is limited throughout the summer season [3]. High temperatures and heavy rainfall coincide, making management difficult and resulting in an excess of water in the root system. However, for maintaining steady supply in the market, summer onion plays a major role. The production of summer onion has several advantages i.e. increases total production per annum and fulfill the demand of fresh onion in the market. Summer onion provides high price as compared to winter season onion.

Seed priming is increasingly regarded as a superior method of boosting speedy and uniform emergence, as well as achieving high seedling vigor and yields in vegetables, floriculture, and several field crops[4]. Primed crops grew faster, bloomed earlier, and produced better yields[5]. Osmo-priming, halo priming, hydro priming, matri-priming, and hardening (alternating soaking of seeds in tap water and drying before sowing) are all common priming strategies [6]. The increase in **crop** production caused by **seed** priming was related to the modification of ions absorption, partitioning, and hormone balance in saline circumstances[7]. The study therefore set out to examine the impact of seed priming treatments on onion quality, bulb production, plant growth, and seed germination and to find out the suitable priming treatments for onion production.

2. MATERIALS AND METHODS

2.1 Materials and seed priming treatments

The seeds of onion variety BARI onion 5 were used as research materials in this study. Newly harvested seeds **were** obtained from Spices Research Centre, Mohasthangarh, Bogra, Bangladesh. IAA (100 ppm), KCl (2.5%), PEG-6000 (10%), and distilled water (control) were used as priming medium. 250 g of seeds were washed in the solution for 12 and 24 hours at room temperature in a dark environment. One liter of priming media was prepared for each priming application. Following the priming application, the seeds were cleaned with distilled water, let to air dry on paper towels, and then allowed to reclaim their normal moisture

content(7-8%). The treatments were consisted of T₁ (water 12 hr), T₂ (water 24 hr), T₃ (PEG 12 hr), T₄ (PEG 24 hr), T₅ (IAA 12 hr), T₆ (IAA 24 hr), T₇ (KCl 12 hr) and T₈ (KCl 24 hr).

2.2 Determination of germination percentage and early seedling growth

The study was conducted in a net house at Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh. Primed 100 onion seeds were seeded in a PVC tank with dimensions of (1.2×0.6×0.6 m) and sand sieved through 0.8 mm screen in a poly house using a completely randomized design with eight treatments under natural light, temperature, and humidity conditions. During the germination period, average relative humidity and temperature were 60% and 25±2°C respectively. Germinated seedlings were counted every day until 15th day after sowing, and the germination percentage (GP) was calculated as follows: GP (germination percentage) = (total germinated seeds after 15 days/total number of seeds sown) × 100

2.3 Field experiment

Seedlings (35-days-old) were transplanted in a net house on raised bed of plot size 1.2m ×0.3m, with a spacing of 20cm×10cm in three replicates of 15 seedlings each. During growing period, the average temperature was 28±2°C, and the relative humidity was 60-65%. All cultural practices, including fertilization and weed control, carried out in accordance with established agricultural methods. To determine bulb yield, and 10 randomly selected plants were assessed for morpho-physiological and yield traits.

2.4 Relative water content

Relative water content (RWC) was calculated according to Smart and Bingham [8]. Three fully grown fresh leaves were pooled for each replicate, and their fresh weights (FW) were determined. The leaves were subsequently soaked in water at room temperature for twelve hours to restore turgidity; the turgid tissue was swiftly blotted to remove excess water, and their turgid weights (TW) were calculated. The samples were subsequently dried for 24 hours in an oven at 65 °C to measure the dry weights (DW). The following formula was used:

$$\text{RWC \%} = (\text{FW} - \text{DW}) / (\text{TW} - \text{DW}) * 100.$$

2.5 Photosynthetic pigments

Moran and Porath [9] approach was used to detect photosynthetic pigments. Liquid nitrogen was used to grind 0.2 g of leaf tissue into a powder, which was then homogenized with 1 ml of 100% N, N-dimethylformamide (DMF). To collect the supernatant, homogenized materials were centrifuged at 10,000 g for 10 minutes. The samples were centrifuged after another 1 ml

of DMF was added. After removing the supernatant, 1 ml DMF was added. A spectrophotometer was used to measure absorbance at 663 and 645 nm. Calibration was performed with a 100% DMF blank. The following formulas were used to determine chlorophyll a, b, and total chlorophyll:

$$\text{Chlorophyll } a \text{ (mg g}^{-1} \text{ tissue)} = \frac{[12.7(OD_{663}) - 2.69(OD_{645})] \times V}{1000} \times W$$

$$\text{Chlorophyll } b \text{ (mg g}^{-1} \text{ tissue)} = \frac{[22.9(OD_{645}) - 4.68(OD_{663})] \times V}{1000} \times W$$

$$\text{Total Chlorophyll (mg g}^{-1} \text{ tissue)} = \frac{[8.02(OD_{663}) + 20.20(OD_{645})] \times V}{1000} \times W$$

Where OD is the optical density at the respective nm, V is the final volume of chlorophyll extract, and W is the fresh weight of the extracted tissue.

Bulb yield

The bulbs were taken separately for each treatment when more than 70% of the necks fell at the end of the season. After harvesting, the fresh and dried weights of the bulbs were measured.

2.6 Total soluble solids (TSS) content and pH determination

The TSS content of onion was determined using a hand refractometer. Using a dropper, a drop of onion juice was obtained and placed on the refractometer prism. Total soluble solids were measured using a refractometer. Different treatment strawberries' fruit juices were filtered individually, and pH was determined with a digital pH meter.

2.7 Ascorbic acid, phenolic and reducing sugar content

The Vitamin C content of onion was determined using the Oxidation Reduction Titration Method [10]. The phenol content was determined using the method of Singleton, Orthofer, and Lamuela-Raventós [11]. The phenol-sulfuric acid method was used to quantify reducing sugars [12].

2.8 Statistical analyses

The Statistical Analysis System (SAS) (SAS Institute, Cary, NC, USA) version 9.4 was used for the statistical analyses. When $P < 0.05$, the mean value across the treatments was determined statistically significant. The mean \pm SE of the replicates was used to present all the results.

3. RESULTS AND DISCUSSION

3.1 Germination percentage

The maximum germination percentage (93%) was recorded from the treatment T₃ followed by T₁(91%) and the minimum germination percentage (77%) was found both in T₆ and T₈ treatments (Fig. 1). According to Esmailpour *et al.*[13], seed priming increased overall emergence and emergence rate in cucumber. Vijay *et al.*[14] discovered that priming onion seeds with PEG 6000 at a 20% concentration for 12 hours greatly boosted the percentage of germination when compared to unprimed seeds. PEG primed onion seeds performed better in the field and in a greenhouse in terms of germination rate and uniformity [15].

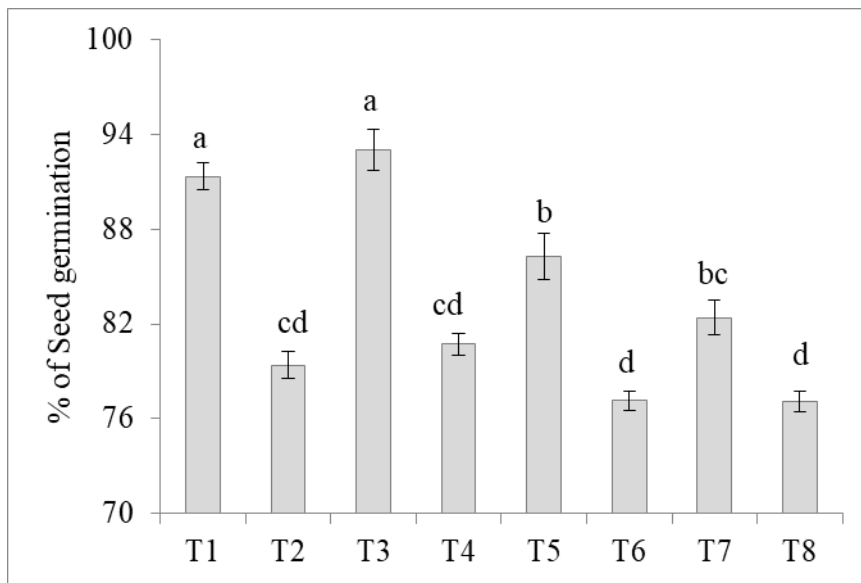


Fig. 1. Seed germination (%) of onion in response to various seed priming treatments. Standard error bars are shown on each column. T₁= water 12 hr, T₂=water 24 hr, T₃= PEG 12 hr, T₄= PEG 24 hr, T₅= IAA 12 hr, T₆= IAA 24 hr, T₇= KCl 12 hr and T₈= KCl 24 hr.

3.2 Morphological parameters

Plant height and leaf number were taken during bulb formation stage (Fig. 2). There was a significant difference in plant height and leaf number in different seed priming treatments. The highest plant height was recorded in T₃ treatment (25.93 cm) and the lowest plant height (21.20 cm) was recorded T₆ treatment (Fig. 2A). These findings support the findings of Devaraju *et al.*[16], who found that priming treatments significantly increased plant height and leaf number. Priming stimulates metabolic activity in the first stage of germination prior to sowing, resulting in improved emergence, growth, and establishment of seedlings in the field [17]. The maximum number of leaf was recorded in T₄ (3.73) treatment and the lowest leaf number were recorded in T₂ treatment (2.82) (Fig. 2B). An increase in leaves is a sign of

healthy crop growth and development and is correlated with higher bulb yields. The maximum number of leaves, the greater the photosynthetic area and, thus, higher the yield [18]. The leaf number of plants grown from primed seeds was greater than that of un-primed seeds [19].

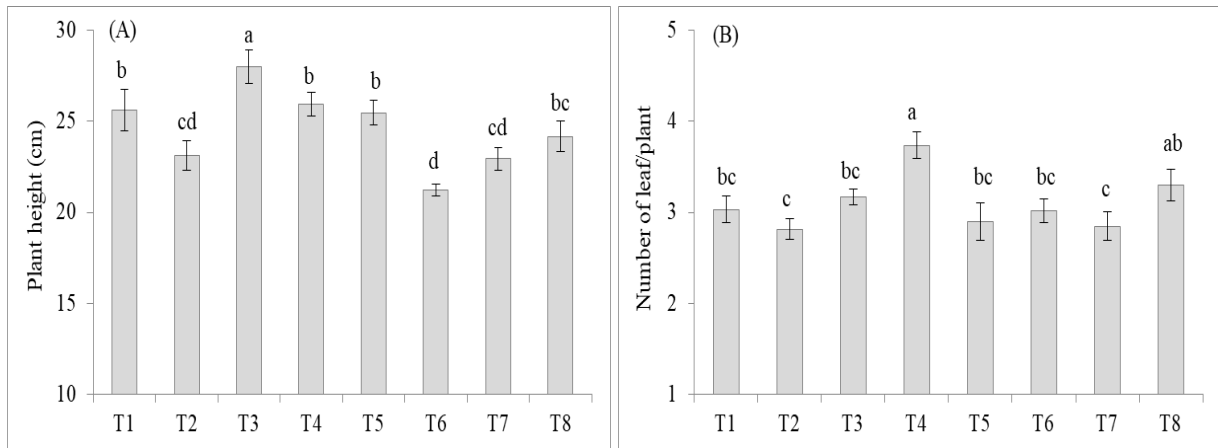


Fig.2. Effect of different seed priming treatments on plant height of onion during bulb formation stage. T₁: control 12 hours, T₂: Control 24 hours, T₃: PEG 12 hours, T₄: PEG 24 hours, T₅: IAA 12 hours, T₆: IAA 24 hours, T₇: KCl 12 hours, T₈: KCl 24 hours

3.3 Physiological and yield contributing parameters

The highest content of chlorophyll a, chlorophyll b and total chlorophyll were found in T₃ treatment (22.59 mg/g, 10.00 mg/g and 28.47 mg/g respectively) and the lowest was found in T₁ treatment (12.94 mg/g, 5.17 mg/g and 19.35 mg/g respectively) (Table 1). PEG application significantly increased Chlorophylls a, b and carotenoids concentrations in date palm plantlets [20]. Seed priming protects chlorophyll breakdown and increases pigment concentrations in photosynthetic pigments [21]. There was a significant difference in relative water content (RWC) in seed from different seed priming treatments (Table 1). The maximum RWC was recorded in T₃ treatment (83.78%) and the minimum was recorded in T₇ treatment (70.22%). Priming onion seeds with PEG improved the RWC in onion leaf compared to other primed and unprimed seeded plants [22]. The seed priming treatments were found significant in individual weight of onion bulbs (Table 1). T₃ treatment recorded the maximum bulb weight (16.24 g) followed by T₄ treatment (14.68 g). Minimum bulb weight was recorded in T₇ treatment (7.47 g) followed by T₂ treatment (8.26 g). Similarly, the seed priming treatments were found to be significant in bulb yield. T₃ treatment recorded maximum bulb yield (19.96 t/ha) followed by T₄ treatment (17.78 t/ha). However, minimum bulb yield was

recorded in T₇ treatment (8.95 t/ha) followed by T₂ treatment (9.91 t/ha). Using PEG for seed priming is a useful method for increasing yield of canola crop [23].

Table 1. Effect of different seed priming treatments on physiological and yield contributing parameters of onion

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll (mg/g)	Relative water content (%)	Individual bulb weight (g)	Bulb yield (t/ha)
T ₁	12.94 c	5.17 c	19.35 c	75.53 c	11.44 c	14.16 b
T ₂	14.79 c	6.85 bc	21.57 bc	79.56 b	8.26 d	9.91 c
T ₃	22.59 a	10.00 a	28.47 a	83.78 a	16.24 a	19.96 a
T ₄	20.26 ab	9.23 ab	27.65 ab	82.19 ab	14.68 ab	17.78 a
T ₅	18.78 b	6.22 c	25.00 abc	80.13 ab	11.31 c	13.56 b
T ₆	20.50 ab	8.89 ab	28.45 a	80.86 ab	12.96 bc	11.72 bc
T ₇	15.64 c	7.39 bc	23.31 abc	70.22 d	7.47 d	8.95 c
T ₈	15.11 c	9.25 ab	25.16 abc	79.16 bc	11.14 c	14.08 b
CV%	9.60	8.57	8.45	7.72	9.59	10.64
LSD _{0.05}	2.97	2.42	2.72	3.76	1.96	3.52

Means followed by same letter(s) in a column do not differ significantly at 5 % level of LSD. Here, T₁: control 12 hours, T₂: Control 24 hours, T₃: PEG 12 hours, T₄: PEG 24 hours, T₅: IAA 12 hours, T₆: IAA 24 hours, T₇: KCl 12 hours, T₈: KCl 24 hours

3.4 Quality parameters

In most of the treatments there was no significant difference on total soluble solid (TSS) content. However, the highest TSS content was recorded in T₃ treatment (14.05 °Brix), and the lowest TSS (11.70 °Brix) was recorded in T₇ treatment (Table 2). In our result, seed priming did not improve TSS content of onion bulb. The highest pH was noted in T₃ treatment (5.53), which was significantly different from the other treatments. The treatment T₆ had the lowest pH value (4.73), which was statistically similar to T₁ (4.75) but distinct from the other treatments (Table 2). The findings showed that after priming onion seeds with PEG for 12 hours, the pH increased in onion bulb. This might be because of the release of amino acids and other chemical substances from the seeds during PEG imbibition. The maximum ascorbic acid (7.20 mg/100g) was recorded in T₄ treatment which was statistically identical to the treatment of T₃ (6.72), T₂ (6.24) and T₈ (6.24). The minimum ascorbic acid (5.28 mg/100g) was recorded in T₁ treatment that was statistically similar to of T₆ (5.60) treatment (Table 2). Priming onion seeds with PEG could significantly increase ascorbic acid content in onion bulbs [24]. The highest phenolic compound (11.12 mg GAE/100g) was recorded from the

treatment T₃ followed by T₁ (10.72mg GAE/100g), T₇(10.45mg GAE/100g) and T₅(10.39mg GAE/100g). The lowest phenolic compound (7.89mg GAE/100g) was recorded in T₈ treatment (Table 2). PEG-treated seedlings had greater total phenols levels than seedlings treated with other priming treatments[25]. The treatment T₃ had the highest reducing sugar concentration (7.41%), which was significantly different from the other treatments. The minimum content of reducing sugar (5.71%) was recorded from the treatment T₇ that was significantly different from other treatments (Table 2). Zhanget *al.*[26] showed that seed priming with PEG increased the reducing sugar content in the sorghum seedlings compared to non-primed plants.

Table 2. Effect of different seed priming treatments on quality parameters of onion

Treatments	Total soluble solid (°Brix)	pH	Ascorbic acid (mg/100g)	Phenolic content (mgGAE/100)	Reducing sugar (%)
T ₁	13.05 abc	4.75 d	5.28 c	10.72 a	5.88 cd
T ₂	13.00 abc	5.22 bc	6.24 abc	8.35 b	6.37 bc
T ₃	14.05 a	5.53 a	6.72 ab	11.12 a	7.41 a
T ₄	13.00 abc	5.27 b	7.20 a	8.67 b	6.42 bc
T ₅	13.65 a	5.01 c	5.92 bc	10.39 a	6.70 b
T ₆	13.43 ab	4.73 d	5.60 c	8.29 b	6.21 bcd
T ₇	11.70 c	5.13 bc	5.76 bc	10.45 a	5.71 d
T ₈	12.00 bc	5.15 bc	6.24 abc	7.89 b	5.96 cd
CV%	6.64	0.96	10.34	7.31	5.29
LSD _{0.05}	1.51	0.21	1.10	1.21	0.58

Means followed by same letter(s) in a column do not differ significantly at 5 % level of LSD. Here, T₁: control 12 hours, T₂: Control 24 hours, T₃: PEG 12 hours, T₄: PEG 24 hours, T₅: IAA 12 hours, T₆: IAA 24 hours, T₇: KCl 12 hours, T₈: KCl 24 hours

4. CONCLUSION

Different seed priming treatments and soaking durations have a substantial impact on germination percentage, plant growth, yield, and quality attributes. For all priming treatments, 12 hrs soaking duration showed better performance compared to 24 hrs soaking duration. Among the priming treatments, PEG6000 showed the best effect in improving all the growth, yield, and biochemical characteristics. Overall, the priming technology was found to be useful and beneficial for increasing onion bulb production and quality.

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