__Original Research Article__

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 to priming treatments on seed germination, bulb production and quality of onion.

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

Place and Duration of the Study: The experiment was conducted on 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 T_1 (water 12 hr)), T_2 (water 24 hr), T_3 (PEG 12 hr), T_4 (PEG 24 hr), T_5 (IAA 12 hr), T_6 (IAA 24 hr), T_7 (KCl 12 hr) and T_8 (KCl 24 hr).

Results: The maximum germination percentage (93%), plant height (25.93 cm), total chlorophyll (28.47 mg/g), bulb yield (19.96 t/ha), total soluble solid (14.05 °Brix), reducing sugar (7.41%) and phenolic content (11.12 mg/100 g) was recorded in T_3 treatment. However, the maximum leaves/plant (3.73) and ascorbic acid content (7.20 mg/100 g) was recorded in T_4 treatment.

Conclusion: It can be concluded that Seed priming with PEG 6000 (10%) for 12 hours improved growth, yield, and quality more than 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 quality of Allium spp. has been conducted on bulb onions [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 imported from foreign countries. 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 grain production caused by GA_3 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 germinationand 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 will be 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.The treatments were consisted of T_1 (water 12 hr)), T_2 (water 24 hr), T_3(PEG 12 hr), T_4 (PEG 24 hr), T_5 (IAA 12 hr), T_6 (IAA 24 hr), T_7 (KCl 12 hr) and T_8 (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 onion seeds were seeded in a poly house using a completely randomized design with eight treatments under natural light, temperature, and humidity conditions. One hundred seedlings were planted in a PVC tank with dimensions of (1.2×0.6×0.6 m)and sand sieved through 0.8 mm screen. During the growing period, 60% humidity, 13 hours of light exposure, and 25±2°C temperature were measured. Germinated seedlings were counted every day until the experiment's 15th day, and the germination percentage (GP) was calculated as follows: GP (germination percentage) = (total germinated seeds after 15 days/total number of seeds) × 100

2.3 Field experiment

35-day-old seedlings were transplanted in a net house on a raised bed 1.2 m wide and 30 cm high, with a spacing of 20 cm row to row and 10 cm plant to plant, in three replicates of 15 seedlings each. During the growing period, the average temperature was 28±2°C, and the average relative humidity was 60%. All cultural practices, including as fertilization and weed control, will be carried out in accordance with established agricultural methods in the area. Three center rows were harvested to determine bulb yield, and 10 randomly selected plants were assessed for morpho-physiological and yield traits.

2.4 Relative water content

Smart and Bingham [8] were used to calculate the relative water content (RWC). Three 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:

RWC % = ((FW−DW)/(TW−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:

Chlorophyll *a* (mg g-1 tissue) = $\frac{[12.7(OD663) - 2.69(OD645)] \times V}{1000} \times W$

Chlorophyll *b* (mg g^{-1} tissue) = $\frac{[22.9(OD645) - 4.68(OD663)] \times V}{1000} \times W$

Total Chlorophyll (mg g^{-1} tissue) = $\frac{[8.02(OD663) + 20.20(OD645)] \times V}{1000} \times W$

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) contentand 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

A completely randomized design (CRD) was utilized in the studies, with four replications for each treatment and five plants in each replicate. 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 ± 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 observed from the treatment T_3followed by T_1(91.33%) and the minimum germination percentage was found in T6 and T8 treatments both in 77% (Fig 1). According to Esmaielpour *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. The study found that PEG priming increased the water uptake capacity of seeds, which helped them to cope with the water stress.

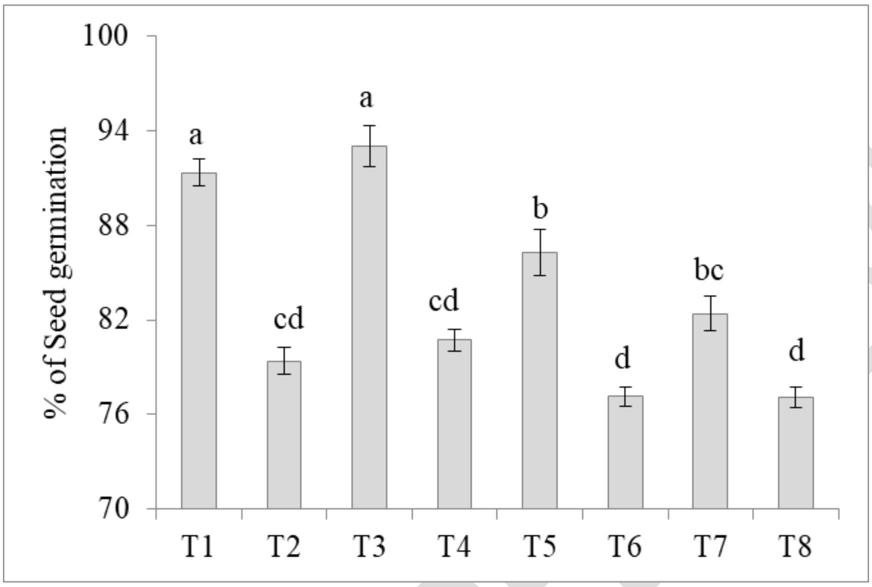

Fig. 1. Seed germination (%) of onion in response to various seed priming treatments.Standard error bars are shown on each column.T_1= water 12 hr, T_2=water 24 hr, T_3= PEG 12 hr, T_4= PEG 24 hr, $T_{5=}$ IAA 12 hr, T_6= IAA 24 hr, T_7= KCl 12 hr and T_8= KCl 24 hr.

3.2 Morphological parameters

Plant height and leaf number were taken during bulb formation stage (Figure 2). There was a significant difference in plant height and leaf number was observed in different seed priming treatments.The highest plant height was recorded in T_3 treatment, approximately 25.93 cm and the lowest plant height was recorded T_6 treatment 21.20 cm (Fig 2A).These findings support the findings of Devaraju *et al.*[15], 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[16]. The maximum number of leaf was recorded in T_4(3.73) treatment and the lowest leaf numberwere recorded in T_2 treatment (2.82) followed by T_7 (2.84) treatment (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, the higher the yield [17]. The leaf number of plants grown from primed seeds was greater than that of un-primed seeds [18].

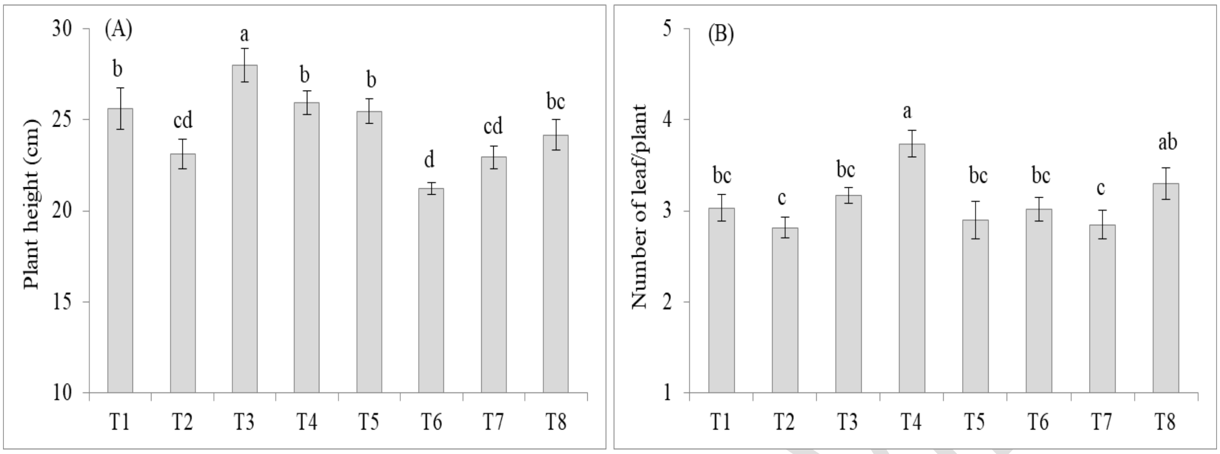

Fig.2. Effect of different seed priming treatments on plant height of onion during bulb formation stage. T_1: control 12 hours, T_2: Control 24 hours, T_3: PEG 12 hours, T_4: PEG 24 hours, T_5:IAA 12 hours, T_6: IAA 24 hours, T_7: KCl 12 hours, T_8: KCl 24 hours

3.3 Physiological and yield contributing parameters

The highest content of chlorophyll a, chlorophyll b and total chlorophyll were found in T3 treatment i.e. 22.59 mg/g, 10.00 mg/g and 28.47 mg/g respectively and the lowest was found in T_1 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 [19].Seed priming protects chlorophyll breakdown and increases pigment concentrations in photosynthetic pigments [20].There was a significant difference in relative water content was observed in seed different seed priming treatments (Table 1).The maximum RWC was recorded in T_3 treatment (83.78%) and the minimum was recorded in T_7 treatment (70.22%).Priming onion seeds with PEG improved the RWC in onion leaf compared to other primed and unprimed seeded plants[21]. The seed priming treatments were found to be significant in individual weight of onion bulbs (Table 1). T_3 treatment recorded the maximum bulb weight i.e., 16.24 g; followed by T_4 treatment with 14.68 g. Minimum bulb weight was recorded in T_7 treatment with 7.47 gfollowed by T_2 treatment with 8.26 g. Similarly, the seed priming treatments were found to be significant in bulb yield. T_3 treatment recorded maximum bulb yield (19.96 t/ha)followed by T_4 treatment (17.78 t/ha). However, minimum bulb yield was recorded in T_7 treatment with (8.95 t/ha) followed by T_2 treatment

(9.91 t/ha).Using PEG for seed priming is a useful method for increasing the yield of canola crop[22].

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)	RWC (%)	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, T_1: control 12 hours, T_2: Control 24 hours, T_3: PEG 12 hours, T_4: PEG 24 hours, T_5: IAA 12 hours, T_6: IAA 24 hours, T_7: KCl 12 hours, T_8: KCl 24 hours

3.4 Quality parameters

The highest TSS content was recorded in T3 treatment (14.05 °Brix), which was statistically equivalent to the treatments ofT1, T2, T3, T4, T5 and T6. The minimum TSS (11.70 °Brix) was recorded from the treatment combination of T_7 (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 results indicated that an increase in pH of the soaking solution when onion seeds were primed with PEG for 12 hours. This might be because of the release of amino acids and other chemical substances from the seeds during PEG imbibition.The maximum ascorbic acid (7.20mg/100g) was observed from the treatment combination of T_4 which was statistically identical to the treatment combination of T_3 (6.72), T_2 (6.24) and T_8 (6.24). The minimum ascorbic acid (5.28mg/100g) was recorded from the treatment T_1 that was statistically similar to the treatment combination of T_6(5.60) (Table 2). Priming onion seeds with PEG could significantly increase ascorbic acid content in onion bulbs[23].The highest phenolic compound (11.12mg GAE/100g) was observed from the treatment T_3

followed by T_1 (10.72mg GAE/100g), T_7(10.45mg GAE/100g) and T_5(10.39mg GAE/100g). The lowest phenolic compound (7.89mg GAE/100g) was observed in T_8 treatment of which was statistically similar to the treatment combination of T_2 (8.35mg GAE/100g), T_4(8.67mg GAE/100g) and T_6 (8.29mg GAE/100g) (Table 2). PEG-treated seedlings had greater total phenols levels than seedlings treated with other priming treatments[24].The treatment T_3 had the highest reducing sugar concentration (7.41%), which was significantly different from the other treatments. The minimum content of reducingsugar (5.71%) was recorded from the treatment T_7 that was significantly different from other treatments (Table 2). Zhang*et al.*[25] showed that seed priming with PEG increased the reducing sugar content in the sorghum seedlingscompared to non-primed plants.

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

Treatments	TSS (°Brix)	pH	Ascorbic acid (mg/100g)	Phenolic content (mgGAE/100g)	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,T_1: control 12 hours, T_2: Control 24 hours, T_3: PEG 12 hours, T_4: PEG 24 hours, T_5:IAA 12 hours, T_6: IAA 24 hours, T_7: KCl 12 hours, T_8: KCl 24 hours

4. CONCLUSION

Different seed priming treatments and soaking durations had a significant effect on germination percentage, plant growth, yield, and quality attributes. For all priming media, 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 determined to be useful and beneficial for increasing onion bulb production and quality.

REFERENCES

1. Benkeblia N, Shiomi N. Chilling effect on soluble sugars, respiration rate, total phenolics, peroxidase activity and dormancy of onion bulbs. Scientia Agricola. 2004; 61:281-5.
2. Borowski E, Michałek S. Effect of seed conditioning on emergence and growth of celery and parsley seedlings. Acta Agrophysica. 2006;8(2):309-18.
3. Islam MA, Shamsuddoha ATM, Bhuiyan MSI, Hasanuzzaman M. Response of Summer Onion to Potash and its Application Methods. American-Eurasian Journal of Agronomy.2008;1(1):10-15.
4. Bruggink GT, Ooms JJ, Van der Toorn P. Induction of longevity in primed seeds. Seed Science Research. 1999;9(1):49-53.
5. Lemrasky MG, Hosseini SZ. Effect of seed priming on the germination behavior of wheat. International Journal of Agriculture and Crop Sciences (IJACS). 2012;4(9):564-7..
6. Gghassemi-Golezani k, Aliloo AA, Valizadeh M, MOGHADDAM M. Effects of hydro and osmo-priming on seed germination and field emergence of lentil (Lens culinaris Medik.). NotulaeBotanicae Horti Agrobotanici Cluj-Napoca. 2008 30;36(1):29-33.
7. Iqbal M, Ashraf M. Gibberellic acid mediated induction of salt tolerance in wheat plants: Growth, ionic partitioning, photosynthesis, yield and hormonal homeostasis. Environmental and experimental botany. 2013; 86:76-85.
8. Smart RE, Bingham GE. Rapid estimates of relative water content. Plant physiology. 1974;53(2):258-60.
9. Moran R, Porath D. Chlorophyll determination in intact tissues using N, N-dimethylformamide. Plant physiology. 1980 Mar 1;65(3):478-9.
10. Tee ES, Young SI, Ho SK, Mizura SS. Determination of vitamin C in fresh fruits and vegetables using the dye-titration and microfluorometric methods. Pertanika. 1988;11(1):39-44.
11. Singleton VL, Orthofer R and Lamuela-Raventós RM (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Methods in Enzymology. 1999;299:152-178.
12. DuBois M, Gilles KA, Hamilton JK, Rebers PT, Smith F. Colorimetric method for determination of sugars and related substances. Analytical chemistry. 1956;28(3):350-6.

13. Esmaielpour B, Ghassemi-Golezani K, Khoei FR, Gregoorian V, Toorchi M. The effect of NaCl priming on cucumber seedling growth under salinity stress. Journal of Food Agriculture and Environment. 2006;4(2):347.
14. Vijay D, Chaurasia AK, Bineeta MB and Sahi VP. Enhancement of Seed Germination and Seedling Vigour through Different Seed Priming Treatments in Blackgram (*Vigna mungo* L.). Legume Research. 2022;8:1-6.
15. Devaraju PJ, Nagamani S, VeereGowda R, Yogeesha HS, Gowda R, Nagaraju KS, Shashidhara N. Effect of chemo priming on plant growth and bulb yield in onion. International Journal of Agriculture, Environment and Biotechnology.2011;4(2): 121-123.
16. Vanangamudi K, Kulandaivelu R. Presowing seed treatment for dryland farming. Seeds Farms.1989.15(9): 33-34.
17. Latif MA, Choudhury MSH, Rahim MA, Hasan MK, Pal BK. Effects of spacing and age of seedling on the growth and yield of summer onion. Journal of Agroforestry and Environment. 2010;3(2):129-133.
18. Bajehbaj AF. The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. African Journal of Biotechnology.2010;12: 1764-1770.
19. Din AF, Ibrahim MF, Farag R, El-Gawad HG, El-Banhawy A, Alaraidh IA, Rashad YM, Lashin I, El-Yazied AA, Elkelish A, Elbar OH. Influence of polyethylene glycol on leaf anatomy, stomatal behavior, water loss, and some physiological traits of date palm plantlets grown in vitro and ex vitro. Plants. 2020;9(11):1440.
20. Piri R, Moradi A, Balouchi H and Salehi A (2019). Improvement of cumin (*Cuminum cyminum*) seed performance under drought stress by seed coating and biopriming. *Scientia Horticulturae*. 257: 108667.
21. Aluko M, Ayodele OJ, Salami AE and Olaleye OE (2020). Seed priming technique as innovation to improve germination in onion (*Allium cepa* L.). *Middle East Journal of Applied Sciences.* 10(1):7-17.
22. Elahi NN, Farrukh NU A, Jalaluddin S, Ahmed HM, Saima S, Mustafa S, Danish S (2023). Comparing the Positive Impacts and Stress Induction by Polyethylene Glycol (PEG 6000) Variable Levels on Canola (*Brassica napus* L.) Growth, Yield, and Oil Contents. *ACS omega*. 8(32): 29046-29059.

23. Pagano A, Macovei A, Xia X, Padula G, Hołubowicz R and Balestrazzi A (2023). Seed priming applied to onion-like crops: State of the art and open questions. *Agronomy*. 13(2): 288.
24. Alzubaidi AI, Elfeel AA and Bakhashwain AA (2021). Interactive effects of seed priming and watering frequency on *Acacia tortilis* seedlings growth performance in arid saline field. *Life Science Journal*. 18(2):17-24.
25. Zhang F, Yu J, Johnston CR, Wang Y, Zhu K, Lu F, Zhang Z and Zou J (2015). Seed priming with polyethylene glycol induces physiological changes in sorghum (Sorghum bicolor L. Moench) seedlings under suboptimal soil moisture environments. *PLoS One*. 10(10): p.e0140620.