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Studies on priming technology for enhancing seed quality of Wheat (*Triticum aestivum*) in Hanumangarh district Rajasthan

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Abstract

The present research was carried out at the laboratories of Department of Seed Science & Technology, SKD University, Rajasthan to evaluate the effect of seed priming treatment on seed quality in wheat (*Triticum aestivum*). The material comprised of a variety "HD-2851" which was grown in the research farm of Department of Seed Science & Technology with twelve treatment combinations of inorganic salt and PGR. All the treatments were assessed for different seed yield, quality parameters. Among the priming treatments, Halopriming-Soaking in KNO₃(@0.3%) solution recommended exhibited better performance in terms of yield and its attributes as compared to control. It was observed that application of Halopriming-Soaking in KNO₃(@0.3%) solution and drying followed by Halopriming-Soaking in ZnSO₄(@0.5%) solution and drying had maximum vigour potential in terms of test weight, was recorded in the treatment Halopriming-Soaking in KNO₃(@0.3%). it was noticed that treatment combination of Halopriming-Soaking in KNO₃(@0.3%) followed by Halopriming-Soaking in ZnSO₄(@0.5%) showed better performance in all the seed quality and yield in comparison to other treatments in wheat variety HD-2851 can be recommended for sowing to the farmers.

Keywords: Germination, ZnSO₄, Vigour index, KNO₃, MgSO₄

Introduction

Wheat (*Triticum aestivum* L.) belongs to the family *Gramineae* and is one of the most vital cereal crops for human nutrition. In terms of global grain production, it ranks second after maize and is followed by rice. Wheat serves as the staple food for nearly 10 billion people across 43 countries, which makes up about 35% of the world's population. In global production, China stands first while India holds the second position. Other leading wheat-producing nations include the Russian Federation, the United States, France, Australia, and Canada. The growing demand for wheat worldwide is largely due to the presence of gluten proteins in its flour, which accelerate the processing of food products. Wheat (*Triticum aestivum* L.) remains one of the most significant cereal crops globally. According to FAO estimates, global wheat production in 2024 stood at around 787 million tonnes, showing a marginal decline of about 0.1% compared to the previous year, while projections for 2025 indicate a modest rise to nearly 796 million tonnes. In India, wheat output was reported at 113.3 million tonnes in 2024, and the country is expected to achieve a record production of 115.4 million tonnes in 2025, encouraged by higher minimum support prices. Globally, wheat continues to be the third-largest cereal after maize and rice, with demand projected to grow steadily. The OECD-FAO Agricultural Outlook (2025–2034) forecasts that world wheat consumption will rise by about 11% by 2034, mainly driven by food demand in Asia, particularly in India and China. These trends reaffirm wheat's role as a staple food for a major share of the world's population and highlight the increasing importance of enhancing productivity to meet future requirements.

This involves soaking seeds in a salt solution, such as sodium chloride (NaCl) that induces osmotic stress and enhances salt tolerance in plants (Seraphy *et al.* 2021). Halo-priming can also increase antioxidant enzyme activity and membrane stability in seeds. This involves soaking seeds in a chemical solution, such as potassium nitrate (KNO₃), hydrogen peroxide (H₂O₂), or calcium chloride (CaCl₂), that modulates various physiological and biochemical processes in

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seeds. Chemical priming can improve seed germination under adverse conditions, such as high temperature, heavy metal toxicity, and disease infection.

Materials and Methods

The field experiment was conducted during the *Rabi* season of 2022-23 and 2023-24 at the Agriculture Research Farm, SKDU University, Hanumangarh Rajasthan, India. Hanumangarh district is characterized by a subtropical, sub-humid climate, falling under the Subtropical Steppe Climate (BSH) category as per the Köppen classification. Situated at an elevation of approximately 183.17 meters (600.95 feet) above sea level, the region endures intense summer heat accompanied by relatively mild winter conditions hallmarks of Rajasthan's arid and semi-arid climatic zones.

The experiment consisted of seven seed priming treatments, including one untreated control and 11 priming solutions. The treatments were: Control (unprimed), Hydropriming (water), Salicylic Acid Treat with 75 ppm, Gibberellic Acid (GA₃) at 50 ppm, ZnSO₄ at 0.5%, NaCl at 0.5%, CaCl₂ at 0.5%, FeSO₄ at 0.5%, KNO₃ at 0.3%, KCL at 0.3%, CaSO₄ at 0.3%, and a Na₂NO at 0.5% solution. After priming, seeds were shade-dried back to their original moisture content (approximately 12%) to ensure safe handling and uniform germination before sowing.

The field experiment was laid out in a Randomized Block Design (RBD) with three replications, while laboratory observations on germination and vigor were conducted under a Completely Randomized Design (CRD). Respectively Field preparation included ploughing, harrowing, and leveling to achieve a fine tilth. Sowing was done in the second week of October 2022-23-2023-24. Recommended agronomic practices were followed throughout the crop period, and uniform irrigations were applied at critical growth stages such as tillering, flowering, and spike filling to ensure healthy crop establishment.

Observations Recorded

1. Germination Percentage (%)

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds sown}} \times 100$$

2. Seedling Length (cm)

$$\text{Seedling length} = \text{Root length} + \text{Shoot length}$$

3. Seedling Dry Weight (g)

Determined after oven-drying ten representative seedlings at 80 °C for 24 hours.

4. Seedling Vigour Index-I

$$\text{VI-I} = \text{Germination (\%)} \times \text{Seedling length (cm)}$$

5. Seedling Vigour Index-II

$$\text{VI-II} = \text{Germination (\%)} \times \text{Seedling dry weight (g)}$$

Data Collection and Analysis

Germination percentage was recorded 14 days after sowing from the mean of four samples of 100 seeds each. Laboratory

observations on seed quality were conducted under a Completely Randomized Design (CRD). At final count, ten seedling per sample were sampled for germination%, Seedling length, and seedling dry weight. Seed vigour-I, seed vigour-II from each sample and 1000-seed weight was recorded from laboratory samples. Data were analyzed through ANOVA, and treatment means were compared using the Critical Difference (CD) test at 5% probability ($P = 0.05$).

Results and Discussion

Methods of seed priming

Several types of seed priming methods have been developed and used successfully in order to invigorate the seeds and alleviate the environmental stress.

Hydro priming

Hydro-priming is the simplest method of seed priming. It is the simple soaking of seeds in water for a definite period of time. This process is especially useful in dry farming and dry land farming areas. In hydro priming, seeds are either soaked in water with or without aeration (Taylor *et al.* 1998) ^[14].

Halopriming

Halo priming is the treatment of seed with inorganic solutions such as sodium chloride (NaCl), potassium nitrate (KNO₃), calcium chloride (CaCl₂), and calcium sulfate (CaSO₄) to improve germination. It is well-known that halo priming plays an important role in germination, seedling emergence, and plant growth at all developmental stages of the plants.

Role of seed priming in sustainable agriculture

Seed priming of simple cost-effective technique which can be easily adopted by the farmers to improve the plant behavior in field. Research evidences on seed germination, plant growth, nutrient use, stress tolerance etc. (Anju B. Raj and Sheeja K. Raj-2019) ^[13].

Present status of seed priming

On-farm seed priming increased the yield of maize in Zimbabwe and India to a tune of 22 per cent, sorghum in Zimbabwe and Pakistan to a tune of 31 per cent, wheat in India and Pakistan to a tune of 37 percent and upland rice in West Africa to a tune of 70 percent (Das *et al.* 2015) ^[5].

Results and discussion

Mean performance

All the performance of 12 treatments for 05 parameters and one variety HD-2851 was shown in Influence of seed priming treatments under study were found to be most effective for significant increasing the seed germination% in HD-2851. The highest higher percent germination (96.30) was observed with halo-priming in KNO₃ (@0.3%) solution (T₉) followed by halo-priming ZnSO₄ (@0.5%) solution (T₅: 95.51), Halo-priming-Soaking in Na₄NO₃ (@0.5%) (T₁₁: 95.33) of treatments on the basis of pooled data. Our finding corroborates the finding of various scientists According to the recent researches, seed priming of crop seeds is most effective techniques for increasing germination, seedling growth, emergence and yield, it has been observed that use of ZnSO₄ and ZnCl₂ as these substances acted positively on wheat germinated in terms of rate and final germination through MTZ (Rahman 2015) ^[12].

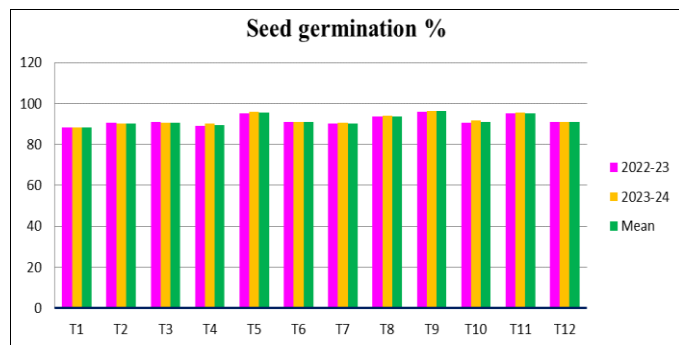


Fig 1: Effects of seed priming on seedling dry weight in wheat cultivar

Among the different treatments, halo-priming in KNO_3 (@0.3%) solution (T_9) has showed maximum seedling length (32.88) which was at par with treatment halo-priming ZnSO_4 (@0.5%) solution (T_5 : 32.00) and Halo-priming-Soaking in Na_4NO_3 (@0.5%) (T_{11} : 31.69) it was reported that silicon, KNO_3 and Silicon dioxide application improved seedling growth and drought resistance of rice, barley, wheat, maize and sorghum seedlings.

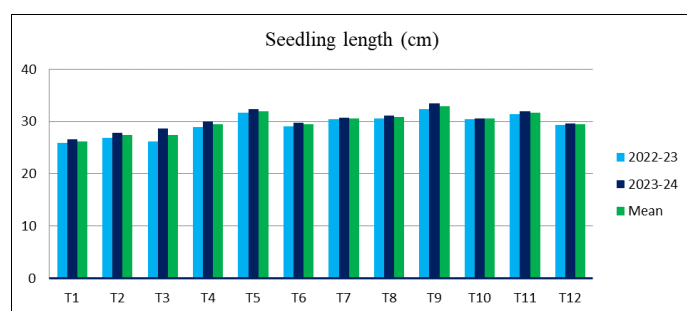


Fig 2: Effects of seed priming on seedling length (cm) in wheat cultivar

there were significant differences in dry weight with the application of different treatment combinations. Maximum dry weight (0.165) was recorded in halo-priming in KNO_3 (@0.3%) solution (T_9) followed by treatment combination of halo-priming ZnSO_4 (@0.5%) solution (T_5 : 0.159), halo-priming-Soaking in FeSO_4 (@0.5%) (T_8 : 0.155) pooled basis. The improvement in seedling dry weight observed under halo-priming treatments may be attributed to enhanced metabolic activity and better nutrient availability during early seedling growth. Similar positive effects of seed priming on germination, seedling vigor, and crop establishment have also been reported by David Harris *et al.* (1999) [9].

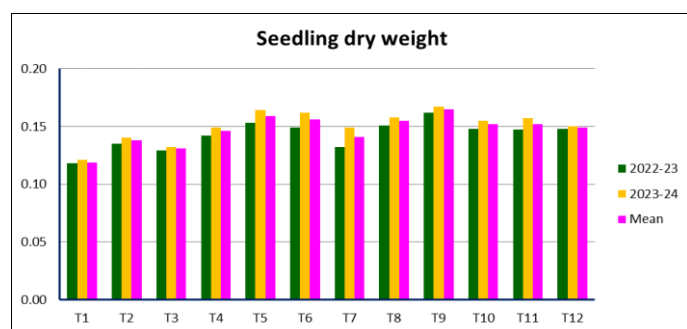


Fig 3: Effects of seed priming on seedling dry weight (cm) in wheat cultivar

Exhibited the influence of various priming treatments on seed vigour index- I. Higher values were recorded (3165.93) in the

seeds of treatment halo-priming in KNO_3 (@0.3%) solution (T_9) which was at par with halo-priming ZnSO_4 (@0.5%) solution (T_5 : 3055.43) and Halo-priming-Soaking in Na_4NO_3 (@0.5%) (T_{11} : 3020). However, lower vigour index-I (2312.42) and seed vigour index-II with different treatments. The maximum values (15.84) were obtained in the treatment halo-priming in KNO_3 (@0.3%) solution (T_9) followed by halo-priming ZnSO_4 (@0.5%) solution (T_5 : 15.14) and Halo-priming-Soaking in Na_4NO_3 (@0.5%) (T_{11} : 14.49) whereas the minimum vigour index-II (26) seed priming in the zinc solution had a positive effect on seed vigour index-I and II (ajouri 2004) [3]. This shows a vital physiological function of Zinc during germination.

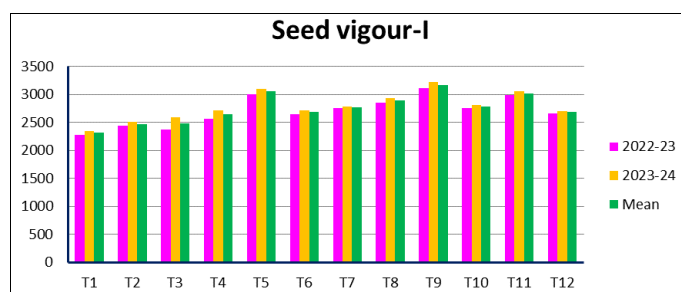


Fig 4: Effects of seed priming on seedling vigour-I (cm) in wheat cultivar

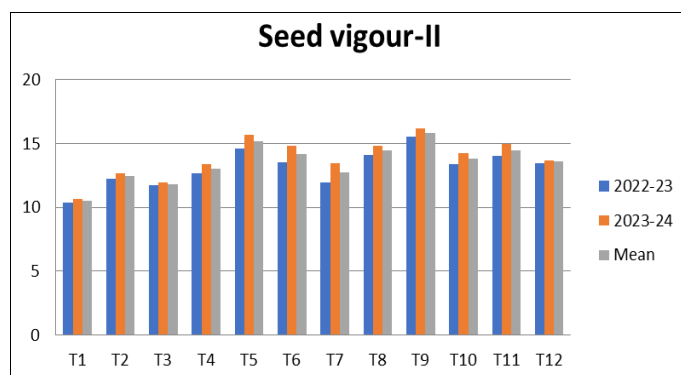


Fig 5: Effects of seed priming on seedling vigour-II in wheat cultivar

Seed priming with inorganic salt and PGR are presented in table 1 and fig.5 Seed priming treatment with halo-priming in KNO_3 (@0.3%) solution (T_9) showed significantly higher seed viability (93.67) which was at par with halo-priming ZnSO_4 (@0.5%) solution (T_5 : 92.83) on the basis of pooled data. Improvement in seed viability and seedling vigor under seed priming treatments may be attributed to enhanced metabolic activity and repair of cellular components during imbibition. Similar results of improved germination and seedling vigor due to seed priming were also reported by Iftikhar Afzal *et al.* (2005) [2].

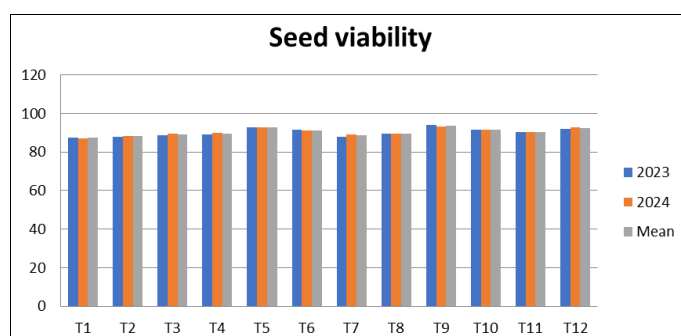


Table 1: Effect of different seed priming treatments on seed quality parameters of wheat

Treatment	Seed germination			Seedling length			Seedling dry weight			Seed vigour I		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T ₁	88.14	25.88	88.19	25.88	26.54	26.21	0.118	0.121	0.119	2282.19	2342.66	2312.42
T ₂	90.45	26.91	90.28	26.91	27.80	27.36	0.135	0.140	0.138	2434.03	2505.40	2469.71
T ₃	90.84	26.13	90.69	26.13	28.64	27.39	0.129	0.132	0.131	2375.19	2593.94	2484.56
T ₄	88.94	28.89	89.55	28.89	30.05	29.47	0.142	0.149	0.146	2568.93	2709.37	2639.15
T ₅	95.20	31.61	95.51	31.61	32.39	32.00	0.153	0.164	0.159	3008.39	3102.85	3055.62
T ₆	90.95	29.11	91.05	29.11	29.76	29.44	0.149	0.162	0.156	2648.24	2713.08	2680.66
T ₇	90.25	30.46	90.36	30.46	30.70	30.58	0.132	0.149	0.141	2748.83	2776.81	2762.82
T ₈	93.52	30.56	93.85	30.56	31.12	30.84	0.151	0.158	0.155	2857.13	2930.49	2893.81
T ₉	96.09	32.34	96.30	32.34	33.41	32.88	0.162	0.167	0.165	3107.38	3224.48	3165.93
T ₁₀	90.52	30.50	91.16	30.50	30.57	30.53	0.148	0.155	0.152	2760.60	2806.18	2783.39
T ₁₁	95.15	31.39	95.33	31.39	31.99	31.69	0.147	0.157	0.152	2986.75	3054.13	3020.43
T ₁₂	90.83	29.33	90.99	29.33	29.63	29.48	0.148	0.150	0.149	2664.53	2700.10	2682.31
Mean	91.74	29.43	91.94	29.43	30.22	29.82	0.143	0.150	0.147	2703.52	2788.29	2745.90
SE(m) ±	0.81	0.98	0.54	0.98	0.56	0.64	0.006	0.005	0.004	93.68	58.46	63.69
C.D. at 5%	2.37	2.88	1.60	2.88	1.64	1.88	0.016	0.015	0.011	275.07	171.65	187.01
CV (%)	1.52	5.78	1.02	5.78	3.20	3.71	6.78	5.74	4.42	6.00	3.63	4.02

Table 2: Effect of different seed priming treatments on seed quality parameters of wheat

Treatment	Seed vigour-II				Seed viability	
	2023	2023	2024	Pooled	2024	Pooled
T ₁	10.37	87.67	87.00	87.33	10.68	10.53
T ₂	12.24	88.00	88.33	88.17	12.64	12.44
T ₃	11.73	88.67	89.33	89.00	11.92	11.82
T ₄	12.67	89.00	90.00	89.50	13.40	13.03
T ₅	14.60	93.00	92.67	92.83	15.68	15.14
T ₆	13.54	91.67	91.00	91.33	14.80	14.17
T ₇	11.94	88.00	89.00	88.50	13.48	12.71
T ₈	14.13	89.67	89.33	89.50	14.84	14.49
T ₉	15.53	94.00	93.33	93.67	16.15	15.84
T ₁₀	13.36	91.67	91.67	91.67	14.26	13.81
T ₁₁	13.99	90.33	90.33	90.33	14.98	14.49
T ₁₂	13.46	92.00	93.00	92.50	13.70	13.58
Mean	13.13	90.31	90.42	90.36	13.88	13.50
SE(m) ±	0.54	0.67	0.59	0.39	0.47	0.34
C.D. at 5%	1.58	1.96	1.72	1.13	1.37	1.00
CV (%)	7.08	1.28	1.12	0.74	5.83	4.37

T₁. Control (Untreated), T₂. Hydro-priming- Soaking in water for 8h at 25 °C and air drying at 25 °C for 48h, T₃ Halopriming-Soaking in Salicylic acid(@75 ppm) solution and drying T₄ Halopriming-Soaking in GA₃(@100 ppm) solution and drying T₅. Halopriming-Soaking in ZnSo₄(@0.3%) solution and drying T₆. Halopriming-Soaking in NaCl(@0.5%) solution and drying T₇. Halopriming-Soaking in CaCl₂(@0.5%) solution and drying, T₈ Halopriming-Soaking in FeSo₄(@0.5%) solution and drying, T₉, Halopriming-Soaking in KNO₃(@0.3%) solution and drying T₁₀. Halo priming-Soaking in KCl(@0.3%) solution and drying, T₁₁. Halopriming CaSo₄ (@0.5%) solution and drying, T₁₂. Halopriming-Soaking in NaNO₃(@0.5%) solution and drying

Conclusion

The present study that adverse field conditions often inhibit seed germination and early seedling growth, thereby reducing the planting value and crop establishment. Seed priming proved to be an effective technique to overcome these limitations by enhancing germination and seedling vigor. Among the treatments evaluated, halo-priming with KNO₃ (0.3%) followed by drying significantly improved germination percentage, seedling vigor, and early seedling growth. The treatment promoted faster and more uniform emergence, resulting in better stand establishment under variable environmental conditions. Therefore, halo-priming with KNO₃ 0.3% can be recommended as a simple, economical, and effective pre-sowing seed

treatment for improving seed performance and ensuring better crop establishment in field conditions.

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