International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 15-02-2025, Accepted: 16-03-2025, Published: 31-03-2025
Volume 7, Issue 2, 2025, Page No. 38-42

Effect of different pre-sowing seed treatment on field emergence, plant growth and seed yield parameters of durum wheat (*Triticum durum* desf.) under field conditions

Nisha Ramani[1], Dr. Kalyanrao Patil[1], Kinjalkumar Jashwantlal Suthar[2]
[1] Department of Seed Science and Technology BACA, AAU, Anand, Gujarat, India
[2] Department of Agriculture, Anand Agricultural University, Dhandhuka, Ahmedabad, Gujarat, India

Abstract
The experiment was conducted to study the effect of pre-sowing seed treatments on field emergence, plant growth and seed yield attributes under field condition. Experiment was conducted in field with Factorial RBD design including three wheat varieties GW 1, GW 1346 and GADW 3 primed with T2: KNO_3 (1%), T3: Salicylic Acid (100 ppm), T4: $CaCl_2$ (250 ppm) and T5: H_2O_2 (100 mM); coated with T6: Sodium Lauryl Sulphate, T7: Calcium Peroxide T8: Bacillus subtilis and T9: Bio NPK. T1 was taken as control. The primed seeds were shade dried up to their original moisture content and sown in the field with three replications. The seed yield and its characters were recorded during rabi seasons at Agricultural Research Station, AAU, Dhandhuka during 2023-24. The yield attributing characters showed significant differences among pre-sowing seed treatments, wheat varieties and their interaction. Among the different priming treatments; seeds primed with KNO_3 (1%) recorded significantly highest field emergence (84.89 %), plant height (96.98 cm), number of tillers per plant (8.53), number of effective tillers per plant (8.07), spike length (8.49 cm), number of seeds per spike (36.47), 1000 seed weight (50.68 g), seed yield per plant (14.74 g) and seed yield per plot (1.96 kg). Among the varieties: GW 1 showed positive response to different pre-sowing seed treatments and recorded significantly higher field emergence (86.26 %), 1000 seed weight (51.67 g), number of seeds per spike (35.18), seed yield per plant (13.56 g) and seed yield per plot (1.94 kg) whereas GADW 3 recorded higher plant height (98.21 cm), number of tillers per plant (8.12), number of effective tillers per plant (7.67) and spike length (8.4 cm).
These pre-sowing seed technologies help seeds to overcome abiotic stresses at the time of germination and growth. The variety GW 1 was observed to maintain higher field emergence and yield. Durum wheat variety GADW 3 performed better than GW 1346. Based on the results from the present study, further investigations can be performed in pre-sowing seed technology programs to improve seed quality traits.

Keywords: Pre-sowing seed treatments, priming, coating, KNO_3, seed yield, field emergence, durum wheat, abiotic stress

Introduction

Wheat is a major staple food crop for more than one third of the world population and is the main staple food of Asia. It originated in Southwestern Asia and belonged to the family *Poaceae*. Durum wheat (*Triticum durum* Desf.), is a tetraploid species of wheat. It is called pasta wheat or macaroni wheat. It was developed by artificial selection of the domesticated emmer wheat strains formerly grown in Central Europe and the Near East around 7000 BC. It predominantly grows in the Middle East (Mohammadi and Haghparast, 2022). Durum in Latin means "hard" and these species is the hardest of all wheat.

Durum wheat (*Triticum durum* Desf.) is grown on 8 to 10% of the total wheat-cultivated area. India is one of the prime producers of durum wheat with 1.5 million hectares dedicated to its cultivation each year, accounting for approximately 10% of total wheat production. Madhya Pradesh, Gujarat, Maharashtra, Karnataka and Southern Rajasthan are suitable for durum cultivation. In India during *Rabi* season 2022-23 total cultivated area of wheat was 34.15 million hectares with the production of around 106 million ton. Total wheat growing area in Uttar Pradesh was 10.24 million hectares with total wheat production was 18 million metric tons whereas, durum wheat covered around 1.5-2.0 million hectares, with production of 1.5 million metric ton.

During grain filling stages of late sown wheat, high temperature limits the seed yield (Farooq *et al*., 2011) [4] because soluble starch synthase involved in synthesis and deposition of starch is extremely sensitive to high temperature whose activity decreases when temperature touches the level beyond 20°C which decreases grain weight and shrinks size of the wheat seed. Drought stress during developmental stages in wheat has been considered one of the major factors that affect the grain yield and quality. This is particularly true if stress occurs during the early growth stages, compromising stand establishment and the final crop yield and productivity.

Abiotic stresses such as drought and salinity stress are widespread problems around the world (Soltani *et al*., 2006) [15]. Seed germination and seedling growth of wheat like other crops, were negatively affected by salinity stress. Soil salinity is a major abiotic stress which adversely affects physiological and metabolic processes, leading to diminished growth and yield (Azizpour *et al*., 2010) [1]. Excess amount of salt in the soil adversely affects plant growth and development. Processes such as seed germination, seedling growth and vigour, vegetative growth, flowering and fruit set are adversely affected by high salt concentration.

Pre-sowing treatments of seeds are easy, low risk and potent approach to overcome the environmental stress problems in crop plants. Among various strategies, seed priming and coating has been developed and used extensively to improve seed quality parameters.

Priming is one of the common techniques of controlled hydration of seed which uses principles of pre-soaking seed in water and dried back to storage moisture content to activate the pre-germination activity in seed, it partially hydrates seeds without allowing radicle emergence. Consequently, primed seeds are equipped with advanced germination and exhibit improved germination rate and uniformity. Seed priming as a cost-effective approach is being used for different crops and in different countries to improve yield (Farooq *et al.*, 2019) [5]. Seed priming technique improves the germination, seedling emergence, growth and yield attributes of crop. It decreases the time between sowing and emergence, enhance germination homogeny and seedling growth. Seed coating is considered one of the best methods to promote sustainable agriculture where the physical and physiological properties of seeds can be enhanced to increase seed vigour, seed health and overall germination of seed. To improve vigour, seeds are often exposed to pre-germination treatment. Pre-sowing seed technologies like seed priming and coating can help to overcome the negative effects of drought and salinity on performance of seed and improve the quality of seeds.

A field experiment was conducted during 2023 and 2024 at ARS, AAU Dhandhuka. The experiment was started in the month of November during Rabi seasonThe seeds of durum wheat varieties GW 1, GW 1346 and GADW 3 were obtained from Agricultural Research Station, AAU, Dhandhuka.

Material and methods

Methodology for Seed Priming

Seeds of the varieties were subjected to priming with KNO3, salicylic acid, CaCl2 and H2O2 for 6 hours. For the priming treatment, seeds were soaked in priming solutions having double the volume of seed. It was ensured that seeds remained immersed in the solution, to avoid precocious germination during the treatment period. Priming was given in the flasks at room temperature and dried back to the original moisture content under shade after 6 hours duration (Ghobadi *et al*., 2012) [6].

Methodology for Seed Coating

Wheat seeds were treated with two coating agents' calcium peroxide, sodium lauryl sulphate, *Bacillus subtilis* and Bio NPK. For seed coating, a semi auto Laboratory Seed Treater (Model ML2000, (Model ML2000, SATECH Germany) was used. For seed coating treatment, wheat seeds were introduced from inlet in the coating pan having width, length and height 400 × 600 × 750 mm, respectively, followed by the application of coating agent and binding agent with inert matter. Talcum powder used as inert material and Carboxy Methyl Cellulose (CMC) was used as a binder to attach the coating agent with seeds. After seed coating, the seeds were extracted from the seed coating machine through outlet and were dried.

Field emergence (%)

The number of seeds germinated from the total seeds sown in the experimental plot was counted at 14 DAS and recorded as field emergence in per cent.

Field emergence (%) = Number of seeds germinated × 100 Total number of seed sown

Plant height (cm)

The plant height in the field was measured and recorded from the five randomly tagged plants during maturity stage. Their average was worked out and recorded as plant height for each plot.

Number of tillers per plant

The number of tillers per plant were counted and recorded from the five randomly tagged plants during maturity stage. Their average was worked out and recorded as number of tillers per plant for each treatment.

The number of effective tillers per Number of effective tillers per plant

plant were counted and recorded from the five randomly tagged plants during maturity stage. Their average was worked out and recorded as number of effective tillers per plant for each treatment.

Spike length (cm)

The length of spike was measured and recorded from the five randomly tagged spikes during maturity stage. Their average was worked out and recorded as length of spike for each treatment.

Number of seeds per spike

The number of seeds were counted and recorded from the five randomly tagged spikes during harvesting stage. Their average was worked out and recorded as number of seeds per spike for each treatment.

1000 seed weight (g)

One thousand seeds were randomly counted by using seed counter from composite sample of the produce from the net plot from each treatment and recorded by using electronic weighing balance. Materials and Methods

Seed yield per plant (g)

The seed yield per plant was recorded from five randomly tagged plants. The weight was measured by electronic balance and recorded as seed yield per plant

Seed yield per plot (kg)

The seed yield from individual net plot of each treatment in all the replication was weighted by electronic balance and recorded as seed yield per plot.

Results

The significantly highest field emergence (84.89 %) was recorded by priming treatment with KNO3 (1 %) (T2). Lowest field emergence (71.22 %) was recorded by salicylic priming treatment (T3). The superiority of seed priming technique may be because seeds imbibed more water, which enabled better stand establishment. The wheat varietal differences in response to different priming treatments showed varietal potential for field emergence (%). Potassium nitrate (KNO_3) is the most known chemical for Results and discussion 57 promoting seed germination. The absorbed nitrate (NO_3) is used in the metabolism of the embryo through the enzyme Nitrate Reductase (NR) which resulted in increased activity of total amylase and proteases during germination. The results are in concurrence with the earlier finding of Jabbarpour *et al*., (2014) [8], Yadav *et al*., (2016) [16], Karjule *et al*., (2019) [11], Esatu *et al*., (2022) [2] and Haque (2024) [7] in wheat.

Table 1: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Field Emergence (%)

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	82.00	67.33	75.00	74.78
	T_2	92.00	77.00	85.67	84.89
	T_3	78.67	66.33	68.67	71.22
	T_4	87.67	69.33	76.33	77.78
	T_5	89.33	68.33	80.00	79.22
	T_6	90.67	70.67	83.67	81.67
	T_7	82.67	67.67	75.00	75.11
	T_8	84.00	68.00	79.67	77.22
	T_9	89.33	73.33	80.67	81.11
	Mean	86.26	69.78	78.30	78.11
For comparing the means of		S.Em. ±		CD @ 5 %	
V		0.37		1.05	
T		0.64		1.81	
V × T		1.10		3.14	
CV (%)		2.45			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

Seed priming and coating significantly enhanced the plant height in wheat genotypes. Maximum plant height was recorded with KNO_3 followed by seed coating with sodium lauryl sulphate. The increase in plant height might be due to stimulation of cell division and cell elongation. Difference in plant height among varieties was due to genetic character of varieties. However, various seed pre-sowing treatments tend to ameliorate the negative effects of salt stress. The results are in accordance with previous findings of Kalpana *et al*., (2015) [10] and Yadav *et al*., (2016) [16] in wheat and Javed *et al*., (2021) [9] in rice.

Table 2: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Plant Height (cm)

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	90.17	83.27	95.06	89.50
	T_2	96.67	91.40	102.87	96.98
	T_3	88.23	81.13	94.27	87.88
	T_4	90.19	87.91	97.93	92.01
	T_5	90.87	88.30	99.20	92.79
	T_6	94.44	91.13	100.07	95.21
	T_7	90.31	81.80	97.27	89.79
	T_8	90.47	86.47	97.39	91.44
	T_9	91.27	90.63	99.83	93.91
	Mean	91.40	86.89	98.21	92.17
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.65		1.85	
T		1.13		3.02	
V × T		1.95		NS	
CV (%)		3.67			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

KNO_3 (1 %) priming, sodium lauryl sulphate and Bio NPK seed coating treatment which encouraged deposition of more photo-assimilates in key plant parts which greatly affects the final yield. The enhanced number of tillers with KNO_3 (1 %) priming, sodium lauryl sulphate and Bio NPK seed coating might be due to cell enlargement and increase in normal cell division. Increase in number of tillers may also be attributed to the fact that these treatments activate protein synthesis, RNAs, carbohydrates and free amino acids during germination which found to be advantageous for subsequent phases of growth. The results are in accordance with the studies of Kalpana *et al*., (2015) [10], Karjule *et al*., (2019) [11] and Faisal *et al*., (2023) [3] in wheat. KNO_3 priming treatment showed highest number of effective tillers attributed to early germination and vigourous growth, consequently good crop establishment and highest tillering followed by sodium lauryl sulphate coating may be due to enhanced photosynthetic activity also reported by Kalpana *et al*., (2015) [10], Karjule *et al*., (2019) [11] and Faisal *et al*., (2023) [3] in wheat.

Table 3: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Number of Effective Tillers per Plant

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	7.50	7.07	7.27	7.28
	T_2	8.07	7.77	8.37	8.07
	T_3	7.00	7.03	7.30	7.11
	T_4	7.60	7.13	7.60	7.44
	T_5	7.73	7.30	7.67	7.57
	T_6	7.93	7.40	8.00	7.78
	T_7	7.53	7.13	7.57	7.41
	T_8	7.53	7.13	7.47	7.38
	T_9	7.60	7.33	7.87	7.60
	Mean	7.61	7.26	7.68	7.52
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.06		0.17	
T		0.11		0.30	
V × T		0.18		NS	
CV (%)		4.19			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

Spike length is a character of great significance that contributes to grain yield per unit area considerably in wheat crop. Significant effect in length of spike was due to genetic makeup of genotype of varieties as well as their varied response to pre-sowing seed treatments. Treated seeds emerged earlier with enhanced crop growth rate and net assimilation rate as compared to non-primed seeds. Priming with KNO_3 and coating with sodium lauryl sulphate encourage the deposition of more photo-assimilates in key plant parts which greatly affects the growth and ultimately showed highest spike length. These findings are consistent with Kalpana *et al*., (2015) [10] and Karjule *et al*., (2019) [11] in wheat.

Table 4: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Spike Length (cm)

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	7.63	7.15	8.33	7.71
	T_2	8.62	7.77	9.09	8.49
	T_3	7.57	7.02	7.53	7.37
	T_4	7.86	7.07	8.53	7.82
	T_5	7.89	7.40	8.57	7.95
	T_6	8.59	7.41	8.75	8.25
	T_7	7.65	7.09	8.30	7.68
	T_8	7.68	7.37	8.43	7.83
	T_9	8.33	7.40	8.64	8.12
	Mean	7.98	7.30	8.46	7.91
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.06		0.16	
T		0.10		0.28	
V × T		0.71		NS	
CV (%)		3.74			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

varieties showed significant influence on the number of seeds per spike might be due to their genotypic and phenotypic variation. The results indicated that pre-sowing treatments significantly influenced the number of seeds per spike during plant growth period. KNO_3 priming treatment improves assimilated area which resulted in enhanced growth and showed highest number of seeds per spike. The results are in accordance with previous findings of Karjule *et al*., (2019) [11] and Faisal *et al*., (2023) [3] in wheat.

Table 5: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Number of Seeds per Spike

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	32.58	29.27	32.38	31.41
	T_2	37.88	35.01	36.53	36.47
	T_3	33.70	28.50	32.31	31.50
	T_4	34.33	32.08	33.81	33.41
	T_5	35.60	31.85	35.60	34.35
	T_6	37.73	34.43	36.51	36.22
	T_7	33.95	30.10	32.47	32.17
	T_8	34.21	31.60	33.70	33.17
	T_9	36.60	32.99	36.00	35.20
	Mean	35.18	31.76	34.37	33.77
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.18		0.51	
T		0.31		0.89	
V × T		0.54		NS	
CV (%)		2.78			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

The significantly higher 1000 seed weight (50.68 g) by priming treatment of KNO_3 (1 %) (T_2) followed by sodium lauryl sulphate seed coating this might be due to plants emerged earlier and showed better crop growth rate and highest net assimilation rate that resulted in highest 1000 seed weight as compared to non-primed seeds.

Highest seed yield per plant (14.74 g) was recorded by KNO_3 (1 %) (T_2) this might be due to its stimulated effect on nitrate reductase activity and highest nitrate reductase activity converts more amount of NO_3^- to NO_2^- which further converts to ammonia in plants leaves and roots which led to better partitioning of the nitrogen towards sink side. The results are in accordance with earlier findings of Sarlach *et al*., (2013) [14], Kalpana *et al*., (2015) [10], Kumar *et al*., (2016) [12], Karjule *et al*., (2019) [11] and Esatu *et al*., (2022) [2] in wheat.

Table 6: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on 1000 Seed Weight (g)

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	50.16	40.30	50.19	46.89
	T_2	55.12	43.74	53.18	50.68
	T_3	48.96	39.95	48.05	45.65
	T_4	50.82	41.42	50.25	47.49
	T_5	52.48	40.45	52.32	48.42
	T_6	53.84	41.83	53.07	49.58
	T_7	49.85	40.39	50.11	46.78
	T_8	50.04	40.10	49.85	46.66
	T_9	53.78	41.60	52.70	49.36
	Mean	51.67	41.09	51.08	47.95
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.36		1.01	
T		0.62		1.75	
V × T		1.07		NS	
CV (%)		3.85			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

The probable reason behind the difference of seed yield per plot among the varieties is diverse genetic makeup of wheat cultivars, differential varietal response to pre-sowing seed treatments and seed size which is positively correlated with seedling vigour. The reduction in grain yield under salt stress might have resulted from loss of photosynthetic capacity, salinity effect on leaf development, reduction in pollen viability and stigma receptivity. Highest seed yield per plot by KNO_3 treatment is mainly due to enhanced nitrogen proportion in plants that stimulates faster growth. Similar results are also reported by Kumar *et al*., (2016) [12], Karjule *et al*., (2019) [11], Esatu *et al*., (2022) [2] and Faisal *et al*., (2023) [3].

Table 7: Effect of Different Pre-sowing Seed Treatments and Wheat Varieties on Seed Yield per Plant (g)

Varieties (V)		V_1	V_2	V_3	Mean
Treatments (T)	T_1	12.43	8.11	11.54	10.69
	T_2	17.11	11.47	15.64	14.74
	T_3	10.11	7.53	10.33	9.32
	T_4	12.93	9.18	12.59	11.57
	T_5	14.49	9.51	14.50	12.84
	T_6	15.21	10.76	15.46	13.81
	T_7	12.57	8.68	12.78	11.34
	T_8	12.61	9.00	12.08	11.23
	T_9	14.76	9.96	15.04	13.25
	Mean	13.58	9.36	13.33	12.09
For comparing the means of		S.Em. ±		CD @ 5%	
V		0.11		0.32	
T		0.20		0.56	
V × T		0.34		0.97	
CV (%)		4.86			

V1: GW 1, V2: GW 1346, V3: GADW 3, T1: Control, T2: KNO3 (1%) priming, T3: Salicylic Acid (100 ppm) priming, T4: CaCl2 (250 ppm) priming, T5: H2O2 (100 mM) priming, T6: Sodium Lauryl Sulphate coating, T7: Calcium Peroxide coating, T8: Bacillus subtilis coating, T9: Bio NPK coating

Conclusion

Pre-sowing seed treatments alleviate abiotic stress during germination and seedling growth. Priming with KNO_3 followed by sodium lauryl sulphate coating was observed to enhance seed quality parameters in durum wheat varieties. Hence, pre-sowing seed treatments were found to be effective to curtail the abiotic stress by enhancing the seed quality parameters *viz*., field establishment, 1000 seed weight, number of tillers and seed yield.

Declaration

The authors declare no conflict of interest.

References

1. Azizpour K, Shakiba MR, Khosh KSN, Alyari H, Moghaddam M, Esfandiari E, Pessarakli M. Physiological response of spring durum wheat genotypes to salinity. Journal of Plant Nutrition,2010:33:859-73.
2. Esatu A, Seid H, Kaske K, Debeli G. Priming effect on seed germination, seedling vigour and yield of bread wheat (*Triticum aestivum* L.),2022. Available from: https://doi.org/10.21203/rs.3.rs-2215149/v1
3. Faisal S, Muhammad S, Luqman M, Hasnain M, Rasool A, *et al*. Effects of priming on seed germination, physico-chemistry and yield of late sown wheat crop (*Triticum aestivum* L.). Polish Journal of Environmental Studies,2023:32(2):1113-24.
4. Farooq M, Bramley H, Palta J, Siddique K. Heat stress in wheat during reproductive and grain-filling phases. Critical Reviews in Plant Sciences,2011:30:491-507.
5. Farooq M, Usman M, Nadeem F, Rehman H, Wahid A, Basra SM, *et al*. Seed priming in field crops potential benefits, adoption and challenges. Crop and Pasture Science,2019:70(9):731-71.
6. Ghobadi M, Shafiei Abnavi M, Jalali-Honarmand S, Mohammadi GR, Ghobadi ME. Effects of seed priming with some plant growth regulators (Cytokinin and salicylic acid) on germination parameters in wheat (*Triticum aestivum* L.). Journal of Agricultural Technology,2012:8(7):2157-67.
7. Haque MA. Effect of seed priming on germination behavior and emergence of wheat (*Triticum aestivum* L.). Journal of Agriculture and Ecology Research International,2024:25(2):53-61.
8. Jabbarpour S, Ghassemi-Golezani K, Aghazadeh R. Effects of salt priming on seedling vigour and field establishment of aged winter wheat seeds. International Journal of Biosciences,2014:5(3):67-72.
9. Javed T, Afzal I, Mauro RP. Seed coating in direct seeded rice: An innovative and sustainable approach to enhance grain yield and weed management under submerged conditions. Sustainability,2021:13(4):2190.
10. Kalpana A, Khan H, Singh AK, Maurya KN, Mubeen RK, *et al*. Effect of different seed priming treatments on germination, growth, biochemical changes and yield of wheat varieties under sodic soil. International Journal of Science Research,2015:4(7):306-10.
11. Karjule A, Kalyanrao, Sasidharan N, Patel DA. Effect of different seed priming treatments on yield attributes of wheat (*Triticum aestivum* L.). Indian Journal of Agricultural Sciences,2019:89(10):1649-53.
12. Kumar R, Dhiman KC, Sharma JK, Sharma J. Effect of seed priming on seed yield and yield components of wheat (*Triticum aestivum* L.) under irrigated and rainfed conditions. Himachal Journal of Agricultural Research,2016:42(2):155-61.
13. Ramani N, Patil K, Pandya M. Effect of pre-sowing seed treatments on seed quality parameters of durum wheat (Triticum durum Desf.) under laboratory conditions. Journal of Cereal Research, 2024, 16(2).
14. Sarlach RS, Sharma A, Bains NS. Seed priming in wheat: Effect on seed germination, yield parameters and grain yield. Progress Research,2013:8:109-12.
15. Soltani A, Gholipoor M, Zeinali E. Seed reserve utilization and seedling growth of wheat as affected by drought and salinity. Environmental and Experimental Botany,2006:55(1-2):195-200.
16. Yadav RK, Amitkumar, Pandey, Kewat RN, Ram Gopal. Effect of seed priming on yield and biochemical characteristic of wheat in sodic soil of eastern Uttar Pradesh. International Journal of Bio-Resource and Stress Management,2016:7(4):545-9.