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Pre-storage seed invigoration treatments and foliar application of micronutrients on seed germinability, vigor and field performance of wheat (*Triticum aestivum* L.) cv. UP 262

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Abstract
An experiment was carried out in the D-Block Farm, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani (22º96′ North latitude and 88º42′ East longitude) from 2016 to 2018 during the Rabi season of 2016 to 2017. To verify the positive impact of pre-storage treatments on wheat crop yield and field performance during the Rabi season, field experiments were conducted using a Randomised Block Design (RBD) with three replications per treatment. These were the pre-storage procedures: i) Control (untreated), ii) Pure neem leaf (2 g/kg), iv) 50 mg/kg of aspirin; v) 2 g/kg of bleaching powder; vi) moist sand conditioning and drying; and vii) soaking and drying. The study was conducted using wheat (Triticum aestivum L.). Cv. UP 262. The results indicate that pre-storage dry seed treatments with red chilli powder (@ 1g/kg of seed), aspirin (@ 50 mg/kg of seed) and bleaching powder (@ 2g/kg of seed) may be suggested to extend storability and improve field performance and productivity of stored wheat seed. In addition, foliar application of Boron (@0.5 %) at the time of flowering on the standing crop raised from red chilli powder-treated seeds is advocated to improve field performance and productivity.

Keywords: Pre-storage seed treatments, germinability, foliar micro- nutrients, grain yield

Introduction
Wheat (*Triticum aestivum* L.) is the most extensively grown cereal in terms of both area and output, with an estimated 112.74 million metric tons produced in 2023. Its adaptability to a wide range of agroclimatic conditions is another factor that makes it the most popular crop (GOI, DA &FW, 2023). It is among the most significant cereal crops that provide sustenance for people worldwide. It is the second most important staple crop in India, behind rice. China, India, the United States, Australia, and others are the main wheat-growing nations. Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Gujarat, and West Bengal are the states that produce the maximum wheat grain. In 2010–2011, West Bengal produced 874.4 thousand tons of wheat with a yield of 2760 kg per hectare, cultivated on 316.8 thousand hectares of land. With an average yearly rainfall of 50–100 cm, cold winters and rather hot summers are the ideal agroclimatic conditions for wheat. Throughout the nation, cultivars like PBW 343, UP 262, Sonalika, and Kalyansona are extensively grown.

Numerous studies have demonstrated that various environmental conditions, including high wetness, high temperature, and oxygen, affect how quickly seeds age. The two most significant environmental parameters influencing the viability of sound seeds are seed moisture and temperature. The life of a seed is likewise cut in half with every 1% increase in seed moisture and for every 5°C increase in temperature, according to Harrington, J.F. (1973) [8]. Viability nomographs developed by Roberts, E.H. (1972) [12], based on the viability equations with temperature and seed moisture as the extrinsic factors can be used to estimate the storage life of many agricultural seeds. Any post-harvest treatment that improves germinability, storability, and field performance over the comparable untreated control seed is referred to as "seed invigoration" (Basu, R.N., 1990) [13]. Fundamentally, an invigorating treatment is physiological in nature and ought to boost seed performance for a considerable amount of time following the treatment. Finding an appropriate, low-cost dry treatment that improves the post-storage germinability and field performance of many wheat cultivars, such as cv. UP 262, using finely dry plant preparations and popular less-toxic treatments like aspirin.

Materials and Methods
An experiment was conducted in Field experiment was conducted during *rabi* season of 2016 to 2017 at the D-Block Farm, Bidhan Chandra Krishi Vishwavidyalaya, Kalyani (22º96′ North latitude and 88º42′ East Longitude) during the period from 2016 to 2018. The investigation was carried out with UP 262 cultivars of wheat (*Triticum aestivum* L.) crops. Field experiments were carried out to confirm the beneficial effect of the pre-storage treatments on the field performance and productivity of the wheat crops during the Rabi season, with three replications for each treatment. The pre-storage treatments were as follows: i) Untreated control, ii) Neem leaf powder (2 g/kg), iii) Red chilli powder (1 g/kg), iv) Aspirin (50 mg/kg), v) Bleaching powder (2 g/kg), vi) Moist sand conditioning-drying and vii) Soaking-drying. The basal dose of N: P_2O_5: K_2O at the rate of 100: 60: 40 kg/hectare was added. Half of the total nitrogen, phosphate, and potassium were injected during the last stages of land preparation. Two separate dosages of the remaining nitrogen were given: one at the peak tillering stage and another at the panicle emergence stage. 100 kg of wheat seeds per hectare were planted, with a 25 cm gap between each row. On the same day, a post-sowing irrigation was performed. In addition to the post-sowing irrigation, the crop received four additional irrigations: one at the dough stage, one at the blooming stage, one at the tillering stage, and one at the crown root initiation (C.R.I.)

stage. The suggested process was followed in the creation of the other cultural practices, such as weddings and pesticide application. Both wheat cultivars (cv. UP 262) were grown using the identical techniques, including land preparation, fertilizer inputs, seed rate, irrigation, and pesticide management. Seed samples were taken from various containers at monthly intervals to conduct germination experiments using the Punjabi and Basu methods.

Statistical analysis: To assess the impact of treatment on viability maintenance, the data from laboratory germination tests, field studies, and biochemical tests were statistically analyzed using Fisher, R.A.'s variance methodology (1948) [14]. Before statistical analysis, germination (%) data were converted to the appropriate arc-sin angle, and seedling length data were examined accordingly. The germination percentage was multiplied by the length of each seedling to determine the vigor index.

Results and Discussion

1. Efficacy of pre-storage seed invigoration treatments for improved storability and field performance of wheat

When crop varieties are not adequately maintained, they lose their distinctiveness and health. The main causes of contamination and degradation are diseases transferred by seeds, genetic drift, outcrossing, volunteer plants, mutation, and environmental stresses. Careful seed management during seed multiplication can prevent this degradation (Patra, 2025) [16]. The process of seed multiplication is typically exclusively used to certify high-yielding hybrid varieties and other types that are notified by the Seed Act of 1966 (Patra, 2023) [21]. Numerous studies have shown that temperature, humidity, draught, soil salinity, soil acidity, and other factors have a major influence on seed germination, vigor, viability, and ultimately seed output (Patra, 2022) [23].

By activating metabolic pathways, seed priming breaks dormancy, stops seeds from deteriorating, and increases resistance to biotic and abiotic stresses (Garai, U., & Patra, S.,2024) [24]. In this study, two-month-old wheat seeds (cv. UP 262) that had just been harvested were cleaned and dried before receiving invigoration treatments. Details of the treatment are provided in the section on materials and methods. Following accelerated ageing at 98% relative humidity and 400°C for 12 days and 100% relative humidity and 40°C for 7 days, most of the treated seeds showed a notable increase in germination percentage and seedling Length as determined by root and shoot length compared to the untreated control (Tables 1, 2, 3, 4, and 5). Aspirin and soaking-drying have outperformed the control in terms of increasing germinability among the treatments. When treated and untreated seeds were allowed to age naturally for four months under ambient circumstances for a total of twelve months, similar trends in results were also seen. The majority of the treated seeds had greater vigor indices than the control, which is determined by multiplying the germination percentage by seedling length. The outcomes of seed invigoration treatments in preserving vigor and viability over the corresponding untreated control were essentially the same for both cultivars. Consequently, it might be argued that cultivar variation has no bearing on the effects of therapy on germinability.

Most of the treated seeds significantly outperformed the corresponding untreated control in terms of yield per unit area in the crop grown from the treated and untreated seeds (cv. UP 262) (Table 7). Aspirin and bleaching powder have outperformed the other treatments in terms of enhancing field productivity and performance. Regarding the effectiveness of treatments in enhancing field performance, both cultivars displayed essentially comparable results. The results of the therapy are not affected by cultivar variety. It has been discovered that pre-storage dry seed invigoration treatments involving aspirin, bleaching powder, and red chilli powder are highly successful in preventing seed degeneration during future storage. Seed degradation was also successfully controlled by dry dressing with crude plant material and some pharmaceutical compounds (Pal and Basu, 1993, 1994; Mandal *et al*., 1999, 2000; Rathinavel and Dharmalingam, 2001; 2002) [3, 4, 10, 11]. It has been discovered that pre-storage (harvest-fresh) dry physiological treatments using chemicals, medicinal formulations, and crude plant components in high-medium vigor wheat seeds are highly successful in reducing seed deterioration and enhancing the crop's performance in the field. The vigor, viability, and productivity of wheat were shown to be significantly improved by the majority of dry physiological seed treatments, particularly aspirin, bleaching powder, and red chilli powder. These findings are consistent with earlier observations made in the present laboratory studies on how well dry treatments maintain the productivity, viability, and vigor of several other horticultural and agricultural crop seeds ((De *et al*., 2003; Mandal *et al*., 1999, 2000; 2011[2, 3, 4, 15]; Guha *et al*., 2012; Guha and Mandal, 2013; Saha and Mandal, 2014, Patra., 2017a & 2017b; Patra, S., & Burman, D., 2017) [17, 19].

Table 1: Effect of pre-storage seed treatments on the germinability of 2-month-old wheat (cv. UP 262) immediately after treatment (before ageing)

Treatments	Germination		Mean root length (mm)	Mean shoot length (mm)	Mean total seedling length (mm)	Vigour Index
	(%)	Arc-sin value				
Control (untreated)	98	88.2	213	53	266	26068
Neem leaf powder	100	90.0	255	60	315	31500
Red chilli powder	98	88.2	269	57	326	31948
Bleaching powder	100	90.0	251	60	311	31100
Aspirin	100	90.0	292	60	352	35200
MSC-D	98	88.2	210	53	263	25774
S-D	99	89.1	236	55	299	28809
L.S.D. at 0.05 P	-	NS	NS	NS	-	-
L.S.D. at 0.01 P	-	NS	NS	NS	-	-

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

Table 2: Effect of pre-storage seed treatment on the germinability of wheat (cv. UP 262) after accelerated ageing at 98% RH and 40ºC for 12 days

Treatments	Germination		Mean root length (mm)	Mean shoot length (mm)	Mean total seedling length (mm)	Vigour Index
	(%)	Arc-sin value				
Control (untreated)	75	59.7	198	44	242	18150
Neem leaf powder	82	64.9	252	47	299	24518
Red chilli powder	80	63.4	243	52	295	23600
Bleaching powder	85	67.6	250	52	302	25670
Aspirin	90	71.6	272	58	330	29700
MSC-D	83	66	255	55	311	25813
S-D	82	65.2	269	53	322	26404
L.S.D. at 0.05 P	-	2.8	10.0	3.7	-	-
L.S.D. at 0.01 P	-	3.9	14.6	4.8	-	-

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

Table 3: Effect of pre-storage seed treatments on the germinability of wheat (cv. UP 262) after accelerated ageing at 100% RH and 40ºC for 7 days

Treatments	Germination		Mean root length (mm)	Mean shoot length (mm)	Mean total seedling length (mm)	VigourIndex
	(%)	Arc-sin value				
Control (untreated)	55	4378	143	35	178	9790
Neem leaf powder	63	50.14	155	40	195	12285
Red chilli powder	55	43.78	160	40	200	11000
Bleaching powder	58	46.16	154	38	192	11136
Aspirin	63	50.14	151	33	184	11592
MSC-D	62	52.25	161	32	193	11966
S-D	80	63.4	160	35	195	15600
L.S.D. at 0.05 P	-	NS	4.7	3.3	-	-

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

Table 4: Effect of pre-storage seed treatments on the germinability of wheat (cv. UP 262) after natural ageing under ambient conditions for 4 months

Treatments	Germination		Mean root length (mm)	Mean shoot length (mm)	Mean total seedling length (mm)	Vigour Index
	(%)	Arc-sin value				
Control (untreated)	80	63.68	170	30	200	16000
Neem leaf powder	85	67.66	189	38	227	19295
Red chilli powder	83	67.2	185	40	225	18675
Bleaching powder	92	73.23	195	38	233	21436
Aspirin	94	74.82	205	39	244	22936
MSC-D	91	72.43	194	41	235	21385
S-D	90	73.6	192	38	230	20700
L.S.D. at 0.05 P	-	2.7	8.1	2.7	-	-
L.S.D. at 0.01 P	-	3.6	10.4	3.9	-	-

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

Table 5: Effect of pre-storage seed treatments on the germinability of wheat (cv. UP 262) after storage in unsealed glass bottle for 12 months

Treatments	Germination		Mean root length (mm)	Mean shoot length (mm)	Mean total seedling length (mm)	Vigour Index
	(%)	Arc-sin value				
Control (untreated)	84	66.4	148	35	183	15372
Neem leaf powder	90	71.6	174	42	216	19440
Red chilli powder	93	74.7	175	40	215	19995
Bleaching powder	96	78.4	167	41	208	19968
Aspirin	94	72.43	190	45	235	22090
MSC-D	90	71.6	201	36	237	21330
S-D	88	70.04	210	40	250	22000
L.S.D. at 0.05 P	-	5.1	18.5	2.8	-	-
L.S.D. at 0.01 P	-	6.9	25.7	3.9	-	-

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

2. Compatibility of pre-storage seed invigoration treatments with foliar application of micronutrients for improved yield and seed performances of wheat (cv. UP 262)

Fresh wheat seed (cv. UP 262) that was two months old was harvested using pre-storage seed invigoration procedures. The current study examined how certain wheat genotypes responded to boron, zinc, and molybdenum in late-planted conditions for grain yield and its yield components, taking into account that wheat is grown in the state under late-planted conditions and boron deficiency constraints. During the flowering stage, the crop was sprayed with a solution of boron (0.5%), zinc (0.5%), and molybdenum (0.2%) at a rate of 1 litre per square meter on a sunny morning. The crop produced from pre-storage treated and untreated wheat seeds (cv. UP 262) demonstrated that the dry and wet treated seeds considerably increased yield compared to the control (Table 6). The treatments that improved field performance and productivity the most were aspirin, bleaching powder, soaking-drying, and wet sand conditioning-drying.

In order to assess the effectiveness of micronutrients in conjunction with seed invigoration therapy for boosting wheat yield and yield qualities, a diluted solution of the micronutrients boron, zinc, and molybdenum was sprayed over the standing crop grown from treated and untreated seed at the flowering stage. The findings show that the output of all micronutrients was considerably higher than that of the control and other dry treatments (Table 6). Compared to dry treatments and control, only water spray demonstrated a slight improvement in field performance and productivity. When it comes to boosting yield, boron has outperformed the other micronutrients. In several instances, the combination of micronutrients and dry treatments improved field production and performance in a statistically meaningful way. The foliar spray with Boron and Zinc showed substantial increase in yield when applied on the crop raised from red chilli powder treated seed (Table 6). The result clearly indicates that foliar spray of micronutrients employing Boron, Zinc and Molybdenum improved field performance and productivity. The interaction effects between Boron and Zinc with red chilli powder treatments significantly enhance the yield of wheat. This suggests that the Boron has a direct effect on fertilization especially on grain filling of wheat. It can reduce pollen abortion which is one of the most significant problems in wheat seed production.

Patra (2025) [16] reported that the hardening of seeds improved the initial establishment of plant significantly increased seed yield and seed quality compared to normal sowing. Basavarajeswari *et al*., (2008) [1] reported that application of boric acid @ 100 ppm resulted in maximum number of primary branches, yield per plant and fruit yield of tomato. They have also found that best treatment was the mixture of micronutrients (Bo, Zn, Mn, Fe and Mo) in increasing fruit yield over the control. Gnenis *et al*., (2003) and Soleimani (2006) [22] reported marked increase in number of grains per spike of wheat for foliar application of boron and zinc. Torun *et al*., (2001) and Grewal *et al*. (1997) [25, 27] reported an increase in wheat production with the application of zinc and boron over control. Similar type results were obtained by IssaPiri (2012) in increasing grain yield of Sorghum with the foliar application of micronutrient. Improvement in growth characters by the application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity, which leads to an increase in various plant metabolites responsible for cell division and elongation, as opined by Hatwar *et al*., (2003). Basavarajeswari *et al*., (2008) [1, 9] found that boron application was pronounced, showing an increase of 35 percent in the yield of tomato fruit over the control. Kumbhar and Deshmukh (1993) and Bose and Tripathi (1996) reported that the increase in dry matter production may be attributed to greater accumulation of photosynthates by vegetative parts and fruits in tomato. Habib (2009) reported that foliar application of Zn and Fe increased seed yield of wheat and its quality compared to the control. In conformity, the present studies also revealed that foliar application of Boron (@ 0.5%) on the standing crop raised from the invigorated seed with red chilli powder or alone (crop grown from untreated seed) improved yield and other yield attributes over the untreated control.

Table 6: Effect of seed invigoration treatments wheat (cv. UP 262) followed by foliar spray with micronutrients on grain yield (g)/m^2

Dry Treatment	Micronutrients (foliar applications)					Mean
	Control	Water	Boron	Zinc	Molybdenum	
Control	180	188.8	237.6	235.8	237.5	215.9
Neem leaf powder	192	196.5	248.8	245.6	241.9	224.9
Red chilli powder	202.5	210.3	265.7	263.8	242.8	237
Asprin	215	217.5	250.6	245.8	240.3	233.8
Bleaching powder	210.5	216.8	250.4	250	246	234.7
MSC-D	205.8	214	255.3	254.8	250	265.9
S-D	210.6	212.5	250.6	252.2	246.8	234.5
Mean	202.3	208	251.2	249.7	243.6	

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

L.S.D Values for mean effects	Probability level	
	0.05P	0.01P
Physiological treatment	12.2	16.4
Micronutrient	8.1	10.4
Interaction	20.3	23.2

Table 7: Effect of pre-storage seed treatments on field performance and productivity of stored wheat (cv. UP 262)

Treatments	Plant population/m^2	Plant height (cm)	Number of shoots/m^2	Length of panicle (cm)	Grain/Panicle	Grain yield/m^2 (g)	1000-grain weight(g)
Control(untreated)	156	74.2	252	8.2	34.2	198.8	33.8
Neem leaf powder	159	71.5	265	8.5	36.7	212.5	33.7
Red chilli powder	168	72.3	263	9.1	38.4	220.8	35
Bleaching Powder	156	74.6	270	9.3	42.8	235.3	34.7
Aspirin	160	72.3	274	9.2	41.3	238.2	35
MSC-D	168	73.5	266	9.0	40.8	232.5	34.8
S-D	160	70.8	260	9.1	41.5	232.0	34.5
L.S.D. at 0.05P	1.3	0.9	-	NS	0.9	-	NS
L.S.D. at 0.01P	1.8	1.2	-	NS	1.4	-	NS

NS: Not significant, MSC-D: Moist Sand Conditioning –drying, S-D: Soaking- drying

Conclusion
The study concludes that pre-storage dry seed treatments with aspirin (50 mg/kg of seed) and bleaching powder (2 g/kg of seed) may be recommended to extend storability and enhance field performance and production of stored wheat seed (*cv*. UP 262). Additionally, for improved field performance and productivity, foliar application of boron (at 0.5%) during flowering is recommended for the standing crop grown from seeds treated with red chilli powder.

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Conflict of Interest
Authors have declared that no conflict of interest.

References

1. Basavarajeswari CP, Hosamni RM, Ajjappalavara PS, Naik BH, Smitha RP, Ukkund. Effect of foliar application of micronutrients on growth, yield components of Tomato (*Lycopersicon esculentum* Mill). Karnataka Journal of Agriculture Science,2008:21(3):428-430.
2. De BK, Mandal AK, Basu RN. Seed invigoration treatments on different seed sizes of wheat (*Triticum aestivum* L.) for improved storability and field performance. Seed Sci. and Technol,2003:31:379-388.
3. Mandal AK, De BK, Basu RN. Dry-seed treatment for improved germinability and productivity of wheat (*Triticum aestivum* L.). Indian J. of Agric. Sci,1999:69:627-630.
4. Mandal AK, De BK, Saha R, Basu RN. Seed invigoration treatments for improved storability, field emergence and productivity of soybean (*Glycine max* [L.] Merrill). Seed Sci. and Technol,2000:28:201-207.
5. Guenis A, Alpaslan M, Unal A. Effects of boron fertilization on the yield and some yield components of bread and durum wheat. Turk J. Agric,2003:27:329-335.
6. GOI DA FW. Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture & Farmers Welfare, 2023.
7. Annual Report. Directorate of Wheat Research, Indian Council of Agriculture Research, 2007.
8. Harrington JF. Problems of seed storage. Seed Ecology, (ed. Heydecker, W.) Butterworths, Lond, 1973, 251-253.
9. Hatwar GP, Gondane SK, Urkude SM, Ghaukar OV. Effect of foliar application of micronutrients on growth and yield of okra (*Abelmoschus esculentus* L.). Progressive Horticulture,2003:19:219-22.
10. Rathinavel K, Dharmalingam C. Efficacy of seed treatment on storability of cotton seeds and seedling vigour. Journal of Tropical Agriculture,2001:39(2):128-133.
11. Rathinavel K, Dharmalingam C. Effect of chlorination treatment on the control of seed deterioration in cotton (*Gossypium* sp.). Indian Journal of Agricultural Research,2002:36(1):17-23.
12. Roberts EH. Viability of seed (ed. Roberts, E.H, Chapman and Hall, London), 1972, 14-58.
13. Basu RN. Seed invigoration for extended storability. Proceedings of the International Conference on Seed Sci. and Technol, New Delhi, 1990.
14. Fisher RA. Statistical methods for research workers. Oliver and Boyd. Edinburgh, 1948.
15. Mandal AK, Patra S, Mallick RB, Mahata A, Biswas J. Efficacy of seed treatment in rice (cv. Swarna masuri) for improved germinability and comparative study on field performance by conventional and system of rice intensification (SRI) technology. CROP Research,2011:41(1-3):227-232.
16. Patra S. Review Study on the Maintenance of Improved Crop Varieties for Protecting Their Popularity in Seed Multiplication Systems. Journal of Stress Physiology & Biochemistry, 2025, 21(2).
17. Patra S. Effect of pre-storage seed invigoration treatment in onion (*Allium cepa* L, cv. Agrifound Dark Red) for improved germinability and field performance. International Journal of Current Microbiology and Applied Sciences,2017:6(6):478–482. https://doi.org/10.20546/ijcmas.2017.606.055
18. Patra S. Response of various seed invigoration treatments in high and medium vigour rice (*Oryza sativa* L. cv. IET-4094) seeds for improved germinability. Crop Research,2017:52(1–3):1–3.
19. Patra S, Burman D. Maintenance of storability and enhancing productivity of rice crop by seed invigoration treatments in coastal region of Sundarbans. Vegetos,2017:30(1):15–32. https://doi.org/10.5958/2229-4473.2017.00015.1
20. Patra S. A review on management of seed borne diseases through seed multiplication strategies. In Biological Forum–An International Journal,2023:15(1):377-382.
21. Patra S. Seed Multiplication of Traditional Varieties of Paddy (*Oryza sativa* L) for their Protection in Sustainable Agriculture. Biological Forum – An International Journal,2023:15(1):592-600.
22. Suleimani R. The effects of integrated application of micronutrient on wheat in low organic carbon conditions of alkaline soils of Western Iran. Proc. 18th World Congress of Soil Sci, July 9-15, Philadelphia, USA, 2006.
23. Patra S. Overview of the influence of environmental factors on seed performance. GAU Research Journal,2022:47(2):82-88.
24. Garai U, Patra S. Review of the effects of seed priming for improving seed germination, seedling establishment and yield on several pulse crops. Journal of Stress Physiology & Biochemistry,2024:20(4):63-79.
25. Grewal HS, Zhonggu L, Graham RD. Influence of subsoil zinc on dry matter production, seed yield and distribution of zinc in oilseed rape genotypes differing in zinc efficiency. Plant and Soil,1997:192(2):181-189.
26. Patra S. Role of seed hardening techniques in crops. AgriGate Magazine, 2025, 5(2).
27. Torun A, G.Ã. ltekin I, Kalayci M, Yilmaz A, Eker S, Cakmak I. Effects of zinc fertilization on grain yield and shoot concentrations of zinc, boron, and phosphorus of 25 wheat cultivars grown on a zinc-deficient and boron-toxic soil. J. Plant Nutr,2001:24(11):1817-1829.
28. Fisher RA. Statistical Methods for Research Workers. Oliver and Boyd, Edinburgh, 1948.