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EFFECT OF HALO-PRIMING ON SEED QUALITY PARAMETERS OF OAT (*AVENA SATIVA*)

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SUMMARY

The study was conducted on fresh and one year old seed lot of two varieties of oat *viz.,* OS 6 and HFO 611 in the laboratory of Seed Science and Technology, CCS Haryana Agricultural University during 2022-23. The seeds of both the lots of these varieties were haloprimed with solutions of different concentrations (0.5, 1.0 and 1.5%) of various salts *viz*., NaCl, $CaCl_2$ and KNO_3 for 14 h and 24 h at 20°C temperature and dried back to original moisture content. The results revealed that all of the halo-priming treatments demonstrated an improvement in seed germination and vigour indices for both varieties. The extent of improvement was more in the old seed lot as compared to the fresh seed lot. Among the treatments, maximum enhancement in fresh seed lot was observed in seeds primed with $CaCl_2$ @ 1.5%, which was at par with NaCl @ 1.0%. However, for the old seed lot, $CaCl_2$ @1.0% gave better results. Halo priming for a duration of 24 hours resulted in more enhancements in seed quality as compared to 14 hour halo priming duration. No significant difference was observed with a 14-hour priming duration in the fresh seed lots of both varieties. Halo-priming the seeds with $CaCl_2$ @ 1.5% for 24 hours resulted in a 4.87% enhancement in seed germination as compared to the control for the fresh seed lot of variety HFO 611, whereas enhancement was 7.45% for OS 6 variety. Negative effect was observed on seed quality parameters when seeds were halo-primed for 14 h at higher concentrations (1.0 and 1.5%) of NaCl in old seed lots of both the varieties. In old seed lot of HFO 611 variety, germination reduced from 83.67% to 80.00% while in case of OS 6 variety it reduced from 77.33% to 74.00% when seeds were halo-primed with NaCl @ 1.5% for 14 h. It is concluded from the study that halo-priming is a beneficial technique for seed quality enhancement. Halo-priming of oat seeds with $CaCl_2$ @ 1.5% at 20°C for 24 hours should be used to enhance the seed quality.

Keywords: Halo-Priming, Seed Quality, *Avena sativa,* seed lots

Oat (*Avena sativa*), a cereal grain belonging to the Poaceae family, is widely cultivated for its versatile and nutritious seeds. With its high fiber content and numerous health benefits, oats are consumed in various forms such as rolled oats, oatmeal, and oat flour, making them a versatile ingredient in breakfast cereals, baked goods, and granola bars. Oats are also valued as animal feed and are frequently grown as a cover crop to enhance soil health. Their adaptability and nutritional value have made oats a staple crop across the globe. Major oat-producing nations, including Russia, Canada, the United States, Australia, and Poland, benefit from favorable climates and effective agricultural practices for oat cultivation. Despite the growing demand for oat grain among consumers, the cultivation area and production of oats have steadily decreased over the past few decades in the majority of countries (Stewart and McDougall, 2014, Achleitner *et al.,* 2008). This suggests a significant disparity between the supply and demand of oat grain, which could be attributed to the potential health advantages and nutritional value of whole grains **(**Cristina and Peñas, 2017). Inadequate vigor and viability, often exacerbated by unfavorable environmental conditions, lead to insufficient crop establishment and ultimately result in reduced yield. Occasionally, when fresh seeds are unavailable, the necessity to resort to carryover/revalidated seeds can further contribute to subpar yield outcomes. Several methods of seed priming are commonly used to improve germination rates which include hydro-priming (soaking seeds in water), halo-priming (soaking seeds in an inorganic salt solution), osmo-priming (soaking seeds in a solution with low water potential), solid matrix priming (treating seeds with solid materials possessing specific chemical and

physical characteristics), thermo-priming (subjecting seeds to high or low temperatures), and biopriming (hydrating seeds using microorganisms or their biological compounds) (Ashraf and Foolad, 2005). These priming techniques can be influenced by factors such as the volume of the priming solution, duration of soaking, temperature, priming method, and drying of seeds. Controlling these factors is crucial to optimize the priming treatment and enhance its effectiveness. Adequate volume of the solution ensures proper water uptake, while the duration of soaking should achieve desired physiological changes without causing harm. Optimal temperature selection promotes metabolic reactions and seed hydration. The choice of priming method depends on desired outcomes and seed characteristics. According to Bhuker *et al.* (2022), soaking oat seeds in one and a half times their volume of water at ambient conditions (20±2°C) for 14 hours through hydro-priming is the most effective method for improving seed quality. However, if the volume of water is reduced to half or equal to the seed volume, the soaking duration should be extended to 26 and 24 hours, respectively, to achieve similar results. Numerous studies have demonstrated that pre-sowing treatments involving substances like $CaCl_2$, KCl, and NaCl can effectively improve the speed and uniformity of seed emergence, thereby promoting early vigour even in stressful conditions. (Iqbal *et al.*, 2006 and Taghvaei *et al.,* 2012). Halo priming is a seed treatment technique aimed at enhancing seed quality and promoting better germination and seedling development. It involves subjecting seeds to a short soaking period in a solution containing specific substances or chemicals known to improve seed performance. The primary aim of halo priming is to improve seed germination, seedling vigor, and overall plant performance. The treatment triggers physiological changes within the seeds, such as the activation of metabolic processes and the enhancement of enzyme activities, which contribute to improved seed quality. Halo priming can improve germination rates by breaking seed dormancy and promoting faster and more uniform germination. Treated seeds often exhibit stronger and more vigorous seedlings, enabling better establishment and early growth. Halo priming can enhance seedlings' ability to withstand various stresses, such as drought, salinity, or temperature fluctuations, leading to improved crop performance under adverse conditions. By promoting synchronized germination and seedling development, halo priming can contribute to more uniform plant stands and improved crop uniformity. Halopriming has the potential to enhance salinity tolerance during the germination stage, enabling the establishment of plants in saline environments (Taghvaei *et al.,* 2022). The application of halo-priming treatments, specifically the 4000 ppm NaCl concentration, resulted in improved consistency and speed of germination, higher germination percentage, and germination index. Additionally, it led to the production of more robust seedlings with increased dry weight compared to untreated seeds. When planted under field conditions, plants derived from halo-primed seeds, particularly those treated with 4000 ppm NaCl, exhibited higher grain yield and water use efficiency compared to untreated seeds, especially when subjected to water scarcity during irrigation. The enduring stress memory induced by seed halo-priming, particularly at the 4000 ppm NaCl level, facilitated the establishment of maize seedlings, enhanced grain yield, and improved WUE, thereby mitigating the detrimental effects of drought stress (El-Sanatawy *et al.,* 2021). Under stressful conditions, it is anticipated that halo primed seeds exhibit faster, vigorous and more synchronized germination. Hence, the study was planned to standardize concentration of salt solution for enhancing planting value of oat seeds.

MATERIALS AND METHODS

The fresh and one year old seed lot of two varieties of oat *viz.,* OS 6 and HFO 611 were procured from Forage section, Department of Genetics and Plant Breeding and study was conducted in laboratory of Seed Science and Technology, CCS Haryana Agricultural University during 2022-23. Both the lots of these varieties were soaked in solutions of different concentrations (0.5, 1.0 and 1.5%) of salts viz., Nacl, $CaCl_2$ and KNO_3 for 14 h and 24 h at 20°C temperature and dried back to original moisture content. The initial moisture content of unprimed seeds and halo-primed seeds were determined using the standard hot air oven method. After drying the primed seeds back to their original moisture content, they were evaluated for germination percentage and vigor indices by using three replications of 100 seeds as per guidelines of International Seed Testing Association (ISTA, 2019). The seeds were placed between adequately moistened germination papers and kept at a temperature of 20°C in a seed germinator. The final count was taken on the eighth day, considering only normal seedlings for calculating the percentage germination. Ten random

TABLE 1
Effect of halo-priming on germination (%) of fresh and old seed of oat

Treatments (T) →	HFO 611						OS 6					
	Fresh lot (2022-23)			Old lot (2021-22)			Fresh lot (2022-23)			Old lot (2021-22)		
Duration (D) ↓	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean
T_1: Control (untreated)	89.00	89.00	89.00	83.67	83.67	83.67	85.00	85.00	85.00	77.33	73.33	75.33
T_2: Hydro-priming	89.67	90.00	89.84	84.00	89.33	86.67	85.67	88.33	87.00	73.33	78.67	76.00
T_3: NaCl 0.5%	89.33	91.33	90.33	84.00	90.00	87.00	85.67	88.33	87.00	73.67	74.00	73.84
T_4: NaCl 1.0%	90.00	95.00	92.50	80.67	89.33	85.00	86.00	88.67	87.34	74.33	78.67	76.50
T_5: NaCl 1.5%	91.00	89.33	90.17	80.00	89.33	84.67	86.67	89.00	87.84	74.00	78.33	76.17
T_6: CaCl2 0.5%	89.33	93.33	91.33	85.67	91.33	88.50	86.00	90.33	88.17	69.00	82.00	75.50
T_7: CaCl2 1.0%	89.67	91.33	90.50	84.00	94.00	89.00	86.33	91.00	88.67	78.00	79.67	78.84
T_8: CaCl2 1.5%	91.67	93.33	92.50	82.00	90.00	86.00	87.33	91.33	89.33	79.00	77.33	78.17
T_9: KNO3 0.5%	89.33	89.33	89.33	76.00	93.00	84.50	86.00	88.33	87.17	79.33	83.33	81.33
T_{10}: KNO3 1.0%	89.67	93.67	91.67	76.67	89.00	82.84	86.67	89.00	87.84	77.33	79.00	78.17
T_{11}: KNO3 1.5%	91.33	91.33	91.33	79.33	89.33	84.33	87.33	89.67	88.50	77.67	77.33	77.50
C. D. (P=0.05)	T= 0.90, D= 2.1, TxD=N.S.			T= 1.11, D= 2.60, TxD=3.67			T= 0.81, D= 1.91, TxD=N.S.			T= 1.09, D= 2.55, TxD=3.61		
S. Em±	T= 0.31, D= 0.74, TxD=1.04			T= 0.39, D= 0.91, TxD=1.28			T= 0.28, D= 0.67, TxD=0.94			T= 0.38, D= 0.89, TxD=1.26		

normal seedlings from each replication of both seed lots of the two varieties were selected during the final count of the germination test, and their average seedling length was measured in centimeters. These ten seedlings from each replication were then dried in a hot air oven at 80°C for 48 hours, and the average seedling dry weight was calculated in milligrams. The seedling vigor indices were calculated using the method provided by Abdul-Baki and Anderson (1973), where Vigor index-I was determined as the product of germination percentage and average seedling length, and Vigor index-II was calculated as the product of germination percentage and average seedling dry weight. The experiment was carried out using a factorial completely randomized design, following the standard method suggested by Panse and Sukhatme (1985). The data was analyzed using the online statistical tool (OPSTAT) developed by Sheoran (2010), and mean values were compared at a significance level of p=0.05.

RESULTS AND DISCUSSION

All of the halo-priming treatments demonstrated an improvement in seed germination and vigour indices for both varieties. The extent of improvement was greater in the old seed lot compared to the fresh seed lot. Among the treatments, maximum enhancement was observed in seeds primed with $CaCl_2$ at a concentration of 1.5%, which was at par with NaCl at 1.0% for the fresh seed lot. However, for the old seed lot, $CaCl_2$ at 1.0% gave better results. Priming for a duration of 24 hours resulted in greater enhancements in seed quality compared to a 14 hour priming duration. No significant difference was observed with a 14-hour priming duration in the fresh seed lots of both varieties. Halo-priming the seeds with $CaCl_2$ at 1.5% for 24 hours resulted in a 4.87% increase in seed germination compared to the control for the fresh seed lot of variety HFO 611, whereas it was 7.45% for OS 6 variety. The disparity in the effectiveness of halopriming on germination enhancement between OS variety and HFO 611 variety may be attributed to the genetic variations present in these respective varieties. The improved performance observed in haloprimed seeds could potentially be attributed to reduced electrical conductivity in the leachates of the seeds, higher levels of total and reducing sugars, and an increase in ?-amylase activity (Nawaz *et al.,* 2011). In the case of the old seed lot, a 12.35% increase in germination was recorded for HFO 611 and 11.8% for OS 6. Fujikura *et al.* (1993) also supported the results and reported that hydropriming demonstrated advantageous impacts on both aged fresh cauliflower seeds, specifically in terms of germination rate and the percentage of normal seedlings. The findings of Damalas *et al.* in 2019 and Eskandari and Kazemi in 2011 further corroborated previous reports that highlighted the effectiveness of halo-priming as a valuable technique in enhancing the

TABLE 2
Effect of halo-priming on vigour index -I of fresh and old seed of oat

Treatments (T) →	HFO 611						OS 6					
	Fresh lot (2022-23)			Old lot (2021-22)			Fresh lot (2022-23)			Old lot (2021-22)		
Duration (D) ↓	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean
T_1: Control (untreated)	2723	2723	2723	2171	2171	2171	2295	2295	2295	2096	2096	2096
T_2: Hydro-priming	2349	3234	2792	2118	2619	2369	2719	2879	2799	2264	2323	2294
T_3: NaCl 0.5%	2077	2549	2313	1710	2310	2010	2352	2809	2581	2018	2188	2103
T_4: NaCl 1.0%	2422	2945	2684	1951	2309	2130	2390	2890	2640	2021	2336	2179
T_5: NaCl 1.5%	2074	3291	2683	1920	2606	2263	2418	2999	2709	1856	2427	2142
T_6: CaCl2 0.5%	2251	2712	2482	1711	2449	2080	2666	2926	2796	2417	2452	2435
T_7: CaCl2 1.0%	2094	2874	2484	2123	2894	2509	2801	3070	2936	2556	2395	2476
T_8: CaCl2 1.5%	2625	3676	3151	2137	2866	2502	2843	3247	3045	2569	2515	2542
T_9: KNO3 0.5%	2316	2644	2480	1852	2548	2200	2541	2574	2558	2266	2163	2215
T_{10}: KNO3 1.0%	2354	3180	2767	1902	2630	2266	2574	2862	2718	2283	2235	2259
T_{11}: KNO3 1.5%	2575	3175	2875	2066	2831	2449	2768	3143	2956	2347	2451	2399
C. D. (P=0.05)	T= 65.22, D= 152.96, TxD=216.31			T= 67.70, D= 158.78, TxD=224.54			T= 45.68, D= 107.13, TxD=151.50			T= 47.01, D= 110.24, TxD=155.90		
S. Em±	T= 22.81, D= 53.49, TxD=75.63			T= 23.67, D= 55.52, TxD=78.52			T= 15.97, D= 37.46, TxD=52.98			T= 16.44, D= 38.55, TxD=54.52		

vigor and successful establishment of seedlings in fababean and cowpea crops, respectively. The findings related to the fresh and dry weights of roots and shoots are consistent with the results reported by Ashraf and Rauf (2001). Their study revealed that seedlings originating from haloprimed seeds exhibited significantly greater fresh and dry weights compared to untreated seeds. Negative effect was observed among seed quality parameters when seeds were halo-primed for 14 h at higher concentrations (1.0 and 1.5%) of NaCl in old seed lots of both the varieties. In old seed lot of HFO 611 variety, germination reduced from 83.67% to 80.00% while in case of OS 6 variety it reduced from 77.33% to 74.00% when seeds were halo-primed with NaCl @ 1.5% for 14 h. Findings of Bewley and Black, (1982) also supports the results who reported that halopriming during seed germination have indicated that this stage is highly sensitive to the concentration of NaCl. Halopriming with NaCl can potentially lead to toxicity issues as ions accumulate within the tissues, as observed in multiple vegetable species (Brocklehurst and Dearman, 1984). The

TABLE 3
Effect of halo-priming on vigour index -II of fresh and old seed of oat

Treatments (T) →	HFO 611						OS 6					
	Fresh lot (2022-23)			Old lot (2021-22)			Fresh lot (2022-23)			Old lot (2021-22)		
Duration (D) ↓	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean	14hr	24hr	Mean
T_1: Control (untreated)	11.57	11.57	11.57	10.54	10.54	10.54	10.54	10.54	10.54	8.36	8.36	8.36
T_2: Hydro-priming	11.88	12.60	12.24	10.96	11.61	11.29	10.40	11.17	10.79	8.26	8.38	8.32
T_3: NaCl 0.5%	11.74	12.00	11.87	10.79	11.82	11.31	9.73	11.09	10.41	8.12	8.40	8.26
T_4: NaCl 1.0%	12.10	12.92	12.51	9.36	11.79	10.58	10.41	11.71	11.06	8.26	8.30	8.28
T_5: NaCl 1.5%	11.69	12.28	11.99	9.40	11.53	10.47	10.05	11.88	10.97	7.87	8.78	8.33
T6:CaCl2 0.5%	11.97	12.18	12.08	9.64	11.32	10.48	11.09	11.74	11.42	9.31	9.72	9.52
T_7: CaCl2 1.0%	11.73	11.78	11.76	9.79	13.12	11.46	9.80	12.60	11.20	9.46	9.72	9.59
T_8: CaCl2 1.5%	12.15	12.60	12.38	10.70	12.02	11.36	11.01	12.97	11.99	8.79	8.51	8.65
T_9: KNO3 0.5%	11.08	11.08	11.08	9.88	10.09	9.99	9.72	11.35	10.54	8.78	9.04	8.91
T_{10}: KNO3 1.0%	11.84	12.18	12.01	9.96	10.81	10.39	10.58	11.88	11.23	9.16	9.20	9.18
T_{11}: KNO3 1.5%	11.43	11.51	11.47	10.39	11.93	11.16	11.09	12.24	11.67	8.63	8.78	8.71
C. D. (P=0.05)	T= 0.20, D= 0.46, TxD=N.S.			T= 0.22, D= 0.51, TxD=0.72			T= 0.24, D= 0.55, TxD=0.78			T= 0.19, D= 0.44, TxD=N.S.		
S. Em±	T= 07, D= 0.16, TxD=0.23			T= 0.08, D= 0.18, TxD=0.25			T= 0.08, D= 0.19, TxD=0.27			T= 0.07, D= 0.16, TxD=0.22		

decrease in seed emergence percentage when exposed to NaCl is attributed to the accumulation of salts in the tissues, resulting in toxicity (Smith and Cobb, 1991).

CONCLUSION

It is concluded from the study that halo-priming with $CaCl_2$ @ 1.5% at 20°C for 24 hours is very effective in enhancing the seed quality parameters of oat, hence this pre-sowing practice can be used to enhance the germination/vigour of marginal/old seeds lots.

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