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Effect of priming on enhancing storability of high and low vigour brinjal (*Solanum melongena* L.) seeds

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Abstract

The present study was on brinjal (*Solanum melongena* L.) seeds var. Punjab Nagina. The quality of brinjal seeds in terms of vigour and viability severely declines due to natural ageing during storage between harvesting and the next sowing season. The objective of this study was to evaluate the effect of various priming treatments on the quality and storability of brinjal seeds. The freshly harvested seed was divided into two lots. One of these seed lots was subjected to accelerated ageing to obtain low-vigour seed and the other lot was considered to be high vigour. The high and low-vigour seeds were primed with KNO_3 (1%), GA_3 (100ppm), KH_2PO_4 (0.1M), PEG 6000 (30%) and H_2O, respectively, for 12 hours at 25°C. Thereafter, the seeds were stored in moisture-impervious bags for 12 months in a refrigerator (4°C). The objective was to observe whether the priming treatments improve the seed vigour and retain the advantages obtained during storage. The seeds were drawn at three monthly intervals, *viz.*, zero, three, six, nine and twelve months of storage for studying germination percentage, speed of germination, mean days to germination, seedling length, root length, shoot length, seedling dry weight and seedling vigour index. With an increase in storage duration, a decline in the physiological aspect of seed quality was observed in both high and low-vigour seeds. All the priming treatments improved the germination-related parameters in both high and low-vigour seeds over control, but the extent of improvement varied. Seed priming with GA_3 (100ppm) and KNO_3 (1%) were the best treatments for both high and low-vigour seeds, even after storage for 12 months.

Key words: Brinjal, seeds, priming, germination, GA_3, storage, vigour, KNO_3, biochemical, PEG, *Solanum melongena*, viability, seedling vigour index

Introduction

Seed viability and storability depend on seed moisture, relative humidity and temperature. High seed moisture and high temperature would hasten the process of seed deterioration, resulting in loss of seed viability. Pre-harvest factors and storage environment generally determine seed longevity. Successful seed germination is one of the crucial phases in the plant's life cycle (Shoab *et al.,* 2012). Seeds are frequently required to be stored till the next growing season. But then, during prolonged storage, seed quality in terms of vigour and viability severely declines due to the degenerative process of natural physiological ageing (Shaban, 2013). Seed storage under appropriate conditions and priming techniques helps reduce the rate of seed deterioration and reverse its detrimental effects to some extent (Ghassemi-Golezani *et al.,* 2012).

Seed priming allows for regulated hydration and water absorption; physiological changes associated with germination are initiated with priming, although radical protrusion through the seed coat does not occur (McDonald, 2000; Yuan *et al.,* 2010). Because primed seeds are physiologically near to germination, they exhibit increased germination rate, early and uniform germination, superior growth traits, quicker emergence, and better crop stand establishment (Farooq *et al.,* 2007). It increases the mean performance of the seed lot by minimizing variance owing to staggered emergence within a seed lot.

Various seed priming techniques such as halo-priming, hydro-priming, osmo-priming, thermo-priming and solid matrix priming are employed for improving seed germination and seedling vigour (Venkatasubramanian and Umarani, 2007). Although priming is commended as a useful technique to improve the seed vigour is primed and stored seeds (Parera and Cantliffe, 2010; Venkatasubramanian and Umarani, 2010). However, it is also reported to cause deleterious effects on the storage life of seeds (Wang *et al.,* 2018).

There are limitations in the production of brinjal (*Solanum melongena* L.) seeds such as short-term seed viability and further decline in seed viability and vigour during storage. In brinjal, very little work has been reported on improving seed storability through priming. In the present study, high and low-vigour seeds were subjected to various priming treatments and after that stored for various durations. The objectives were to study the efficacy of seed priming on improving germinability and seedling vigour of both high and low-vigour seeds and whether the priming effects are retained after seed storage.

Materials and methods

The freshly harvested seeds had a germination percent of >80% (high-vigour seeds). A portion of these seeds was subjected to accelerated ageing to obtain low-vigour seeds (Germination percent < 65%).

For germination studies, the seeds were surface sterilized with mercuric chloride 0.1% solution for 30 seconds to avoid fungal invasions, followed by rinsing with distilled water. Then, the

seeds were surface-dried with filter paper. Germination tests were carried out both in Petri-dishes and by rolled paper towel method. Petri dishes were lined with moistened germination paper. Ten undamaged seeds were placed in each Petri dish using forceps. The Petri-dishes were kept in a seed germinator in the dark at 25±2ºC for 14 days and counts of germinating seeds were recorded each day. A seed was considered to have germinated when its radical was about 1mm long.

The seeds were also kept for germination using the rolled paper method. The selected seeds (30 per roll) were placed between two layers of wet germination paper towels. The paper towels were rolled and placed in the upright position in a germinator at 25±2ºC and 70% RH for 14 days (ISTA 1985). The number of seedlings was counted on the 14^{th} day and expressed as germination percentage.

Accelerated ageing: It was carried out in desiccators. Relative humidity of 90% was achieved by placing a supersaturated solution of NaCl in the base of the desiccators (Wexler and Hasegawa, 1954). A wire mesh was placed above the solution. The seeds were weighed and then spread in a single layer in an open Petri dish and this Petri dish was placed above the wire mesh. The lid of the desiccator was sealed with the grease and placed at 45ºC for 7 days in an incubator to obtain low-vigour seeds. The seed weight was recorded again after the ageing period. The aged seeds were dried in shade for two days to regain the original weight (Delouche and Baskin, 1973). Low and high-vigour brinjal seeds were primed in solutions of KNO_3 (1%), KH_2PO_4 (0.1M), PEG 6000 (30%), GA_3 (100 ppm) and distilled water. Petri dishes (14.0 cm) were lined with two layers of germination paper and moistened with a priming solution to drench the germination paper thoroughly. The seeds were placed on these for 12 hours for controlled imbibition of the priming solution.

At the end of the priming treatment, the seeds were rinsed in water to remove any adhering salts, blotted dry and weighed. These were then spread out in a thin layer for drying under shade for three days to regain their original moisture content. Afterwards, primed high and low-vigour seeds were packed in moisture-impervious aluminum pouches separately and stored at 4ºC in a refrigerator. The seeds were then drawn at tri-monthly intervals and placed for germination at 25 ºC. The number of seeds germinated each day was counted every 24 hours for 14 days. Germination percentage, mean days to germination, and germination speed were calculated (Ranal and de Santana, 2006).

Mean days to germination $= \frac{\sum nt}{\sum n}$ (n is the number of seeds that were germinated on day t, and t is the number of days counted from the beginning of the germination test).

Speed of germination $= \frac{X1}{Y1} + \frac{(X2-X1)}{Y2} + \frac{Xn-(Xn-1)}{Yn}$; Xn – Number of seeds germinated at n^{th} count, Yn – Number of days from sowing to n^{th} count

At the end of 14 days, ten seedlings were selected at random. The seedling length was measured from the tip of the shoot till the tip of the root with a centimeter scale. Root length (from root tip to root base) and shoot length (from shoot tip to shoot base) were also recorded separately. Ten seedlings from each replication were placed in separate bags for dry weight determination and dried for 24 hours in a hot air oven maintained at 70ºC. The dried seedlings were allowed to cool and weighed using an electronic balance. The mean weight per seedling was expressed in milligrams. Seedling Vigour index (SVI) was calculated as per Bewly and Black (1994):

(SVI) = Germination% x seedling dry weight (mg).

Results and discussion

Germination percentage differed significantly between the high-vigour and low-vigour seeds. In general, the germination % decreased with an increase in the storage period. High-vigour seeds recorded 80% germination soon after harvesting and 76.11% after 12 months of storage. In low-vigour seed germination of 64.44% was recorded, which reduced to 51.11% after 12 months of storage (Table 1). The priming treatments given before storage resulted in an increase in germination percentage over unprimed seeds. The extent of the increase depended upon the priming treatment given. In high-vigour seeds, priming with GA_3 increased germination by 23.6% and 13.14% in seeds stored for zero and 12 months, respectively, over their respective controls. Likewise, in low-vigour seeds, priming with GA_3 led to a 34.43% and 56.53% increase over their respective controls stored for zero and 12 months, respectively. Priming with GA_3 improved the percentage germination in low-vigour seeds stored for up to 12 months, at par or more than that of untreated high-vigour seeds stored for the same durations (Table 1). The possible reason could be that the enhancement of seed germination percentage by GA_3 was probably because of the activation of some enzymes that digested reserve food material in the endosperm more rapidly to provide sufficient energy for embryo growth, as stated by Abu-Muriefah (2017). Similar results of improved seed germination through priming with GA_3 were reported in eggplant seeds (Neto *et al.,* 2017) and tomato (Jyoti *et al.,* 2016). Also, Priming maize seeds with 100ppm GA_3 increased the germination percentage and improved seed vigour (Kumari *et al.,* 2017).

Speed of germination differed significantly between high and low-vigour seeds. In general, in both high and low-vigour seeds, a decline in the speed of germination was observed with the storage period (Table 2). Higher germination speed was observed in primed seeds compared to unprimed seeds. In seeds primed with GA_3 an enhancement of 187.72% and 236.84% over unprimed controls in high and low-vigour seeds, respectively, was observed. Also, after 12 months of storage, GA_3 primed high and low-vigour seeds showed an enhancement of 314.61% and 367.5% over unprimed control in high and low-vigour seeds, respectively. The enhancement of germination speed in primed seeds even after 12 months of storage indicates that the positive effect of priming is retained even after 12 months of storage. Maximum speed of germination was attained with GA_3 priming. The possible reason is that applying GA_3 accelerates the pre-germinative metabolic processes, giving the primed seed a head start over the unprimed seed for radical protrusion (Varier *et al.,* 2010). Similar findings of the improved speed of germination with priming treatments were reported in seeds of bell pepper (Yogananda *et al.,* 2004), French bean (Sarika *et al.,* 2013), Okra (Singh *et al.,* 2004) and onion seeds (Yarnia and Tabrizi, 2012). A head starts germinating because priming leads to reduced time taken for germination.

Both high and low-vigour seeds had the least mean days to germination upon harvesting (zero-month storage) and maximum

after 12 months of storage. A lower value of mean days to germination implies a faster germination rate. With different priming treatments, mean days to germination decreased as compared to control in both high and low-vigour seeds. Within each storage duration, mean days to germinate the low-vigour seeds primed with GA_3 stored for zero and twelve months were either significantly less or at par with the control of high-vigour seeds (Table 3). By priming with KNO_3 and KH_2PO_4 mean days to germination were at par with those of high-vigour seeds (control) within each storage duration. A reduction in mean days to germination was observed in osmoprimed Soybean (Sadeghi *et al.,* 2011), okra (Kaur *et al.,* 2015) and hydroprimed tomato and brinjal (Patel *et al.,* 2017) seeds. Similarly, priming in GA_3 reduced mean days to germination in pea (Tsegay and Andargie, 2018) and French bean (Sarika *et al.,* 2013) seeds. GA_3 priming induces enzymes, which reduce mechanical restrains to the embryo.

Table 1. Effect of various priming treatments on the germination percentage of high and low vigour seeds of *Solanum melongena* L. stored for various durations

Treatments	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High Vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	94.40	81.10	87.75	90.54	80.55	85.55	86.66	77.78	82.22	83.89	77.22	80.55	81.11	76.66	78.89
0.1M KH_2PO_4	86.66	79.99	83.32	84.44	76.66	80.55	82.78	75.55	79.16	80.00	74.45	77.22	77.22	73.33	75.28
30%PEG6000	85.55	75.55	80.55	82.78	75.55	79.16	82.22	73.33	77.77	80.28	71.94	76.11	78.33	70.55	74.44
$GA_3$100ppm	98.87	86.63	92.75	94.44	83.33	88.88	90.00	81.66	85.83	88.06	80.83	84.44	86.11	80.00	83.05
H_2O	86.66	76.66	81.66	85.00	73.89	79.44	81.67	71.11	76.39	79.72	69.44	74.58	77.78	67.77	72.77
Control	80.00	64.44	72.22	80.00	62.04	72.13	80.00	57.78	68.89	78.06	54.45	66.25	76.11	51.11	63.61
MEAN	88.69	77.39		86.20	75.34		83.89	72.87		81.67	71.39		79.44	69.90	
CD (P=0.05) (V)		3.26			0.88			0.97			0.73			1.13	
CD (P=0.05) (T)		5.65			1.52			1.68			1.27			1.96	
CD(P=0.05)(VXT)		NS			2.15			2.37			1.80			2.78	

Table 2. Effect of various priming treatments on the speed of germination of high and low vigour seeds of *Solanum melongena* L. stored for stored various durations

Treatment	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	3.83	1.88	2.85	2.70	1.87	2.29	2.42	1.69	2.05	2.13	1.47	1.80	1.84	1.25	1.55
0.1M KH_2PO_4	2.85	1.64	2.20	2.55	1.28	1.92	2.42	1.15	1.78	2.14	0.98	1.56	1.79	0.82	1.31
30%PEG6000	2.82	1.71	2.27	2.50	1.59	2.04	2.00	1.37	1.68	1.72	1.11	1.42	1.45	0.86	1.15
$GA_3$100ppm	4.92	2.56	3.74	4.87	2.41	3.64	4.48	2.20	3.34	4.09	2.03	3.06	3.69	1.87	2.78
H_2O	1.96	1.01	1.48	1.83	0.90	1.37	1.50	0.78	1.14	1.29	0.67	0.98	1.08	0.55	0.81
Control	1.71	0.76	1.24	1.61	0.70	1.16	1.33	0.62	0.97	1.11	0.51	0.81	0.89	0.40	0.64
MEAN	3.01	1.58		2.68	1.46		2.36	1.30		2.08	1.13		1.79	0.96	
CD (P=0.05) (V)		0.21			0.14			0.13			0.12			0.10	
CD (P=0.05) (T)		0.35			0.25			0.22			0.21			0.18	
CD(P=0.05) (VxT)		0.50			0.35			0.32			0.29			0.25	

Table 3. Effect of various priming treatments on the mean days to germination (MDG) of high and low vigour seeds of *Solanum melongena* L. stored for various durations

Treatment	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean
1% KNO_3	2.64	4.47	3.55	4.10	5.21	4.65	4.48	5.03	4.75	4.87	5.36	5.11	5.26	5.68	5.47
0.1M KH_2PO_4	3.93	4.84	4.39	4.23	5.03	4.63	4.78	5.17	4.97	5.19	5.30	5.25	5.60	5.54	5.57
30%PEG6000	4.02	5.00	4.51	4.23	5.57	4.90	4.83	5.89	5.36	4.98	6.04	5.51	5.13	6.18	5.65
$GA_3$100ppm	2.38	3.98	3.18	2.77	4.64	3.71	3.55	4.84	4.19	3.79	4.91	4.35	4.03	4.97	4.50
H_2O	4.12	5.16	4.64	4.40	5.52	4.96	4.93	5.88	5.41	5.15	6.04	5.59	5.36	6.18	5.77
Control	4.48	6.53	5.50	4.85	6.96	5.90	5.34	7.25	6.29	5.50	7.35	6.42	5.65	7.45	6.55
Mean	3.59	5.00		4.10	5.49		4.65	5.68		4.91	5.83		5.17	6.00	
CD (P=0.05) (V)		0.18			0.35			0.12			0.09			0.11	
CD(P=0.05) (T)		0.31			0.61			0.21			0.16			0.18	
CD(P=0.05)(VxT)		0.45			NS			0.30			0.23			0.26	

Storage significantly affected seedling length in both high and low-vigour seeds. In general, a decrease in seedling length was recorded in stored seeds. Within storage duration, priming treatments increased the seedling length over control (un-stored seeds). In GA_3 primed high-vigour seeds, an increase of 69.25 and 73.31% in seedling length immediately after priming (zero months of storage) and after 12 months of storage was observed over their respective controls. Likewise, in GA_3 primed low-vigour seeds, 47.55% and 56.34% increase in seedling length immediately after priming (zero months of storage) and after 12 months of storage, respectively, over their respective controls (Table 4). An increased seedling length after priming is attributed to increased metabolic activity, leading to better mobilization efficiency of stored food during the early stages of germination (Bailly *et al.,* 2002). Also, the exogenous application of GA_3 increases the internodal length of the shoot due to cell elongation, cell division and increased meristematic growth. Increase in seedling length after priming has been reported in many species, *e.g.*, okra seeds by GA_3 priming (Singh *et al.,* 2014), in hot pepper by KNO_3 priming (Pandita *et al.,* 2007), in tomato by hydropriming (Anese *et al.,* 2011) and PEG priming (Mirabi and Hasanabadi, 2012) in tomato. Similar results were observed by GA_3 priming in pea seeds (Tsegay and Andargie, 2018) and French bean (Sarika *et al.,* 2013) seeds by GA_3.

A significant difference in the seedling dry weight (mg) of high and low-vigour seeds was observed among seeds stored for different storage periods. In general, a decrease in the seedling dry weight was observed with storage. Priming treatments enhanced the seedling dry weight in both high and low-vigour seeds. High-vigour GA_3 primed seeds had 96.17% more seedling dry weight than unprimed seeds in freshly harvested seeds and 81.80% more than unprimed seeds stored for 12 months. Likewise, in low-vigour seeds, GA_3 primed seeds had 101.69% more seedling dry weight than unprimed seeds stored for zero months and 124.26% more than unprimed seed at the end of 12 months of storage (Table 5). In Soybean seeds, seed priming with KNO_3 increased seedling dry weight (Ahmadvand *et al.,* 2012). An increase in SVI-II was observed in seeds of many crops primed with GA3 *e.g.*, pea (Tsegay and Andargie, 2018) and French bean seeds (Sarika *et al.*, 2013).

In both high and low-vigour seeds, maximum SVI was observed before storage and minimum was recorded after 12 months of storage (Table 6). Primed seeds had a significantly higher value of SVI than control within each storage period. The highest SVI-II was observed in high-vigour seeds treated with GA_3 100ppm before storage. Similarly, the highest SVI was recorded in seeds before storage for low-vigour seeds. At the end of storage duration, GA_3 primed seeds had SVI more than the control (high-vigour seeds stored for zero months) (Table 7).

The present investigation concluded that high-vigour seeds maintained higher quality parameters for longer durations than high and low-vigour seeds. Seed priming with GA_3 (100ppm) followed by priming with KNO_3 (1%) were the best treatments

Table 4. Effect of various priming treatments on the seedling length (cm) of high and low vigour brinjal seeds stored for various durationsand subjected to germination test in rolled paper towels under laboratory conditions at 25 ºC.

Treatment	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	16.08	11.36	13.72	14.64	10.82	12.73	13.08	10.14	11.61	12.44	9.84	11.14	11.79	9.53	10.66
0.1M KH_2PO_4	14.10	10.72	12.41	14.01	10.23	12.12	13.11	8.80	10.96	12.49	7.99	10.24	11.86	7.16	9.51
30%PEG6000	14.53	11.04	12.79	13.94	10.12	12.03	12.38	9.86	11.12	11.77	9.43	10.60	11.15	8.99	10.07
$GA_3$100ppm	17.67	13.84	15.75	16.91	12.52	14.72	15.42	11.98	13.70	14.76	10.99	12.87	14.09	9.99	12.04
H_2O	12.66	9.88	11.27	11.92	9.12	10.52	10.99	8.88	9.94	10.50	8.61	9.55	10.00	8.33	9.17
Control	10.44	9.38	9.91	9.85	8.52	9.18	9.55	7.40	8.47	8.87	6.94	7.91	8.13	6.39	7.26
Mean	14.25	11.04		13.54	10.22		12.42	9.51		11.80	8.97		11.17	8.40	
CD (*P*=0.05) (V)		0.27			0.41			0.39			0.26			0.24	
CD (*P*=0.05) (T)		0.47			0.71			0.67			0.44			0.42	
CD(*P*=0.05)(VxT)		0.67			1.01			0.95			0.62			0.59	

Table 5. Effect of various priming treatments on the Seedling dry weight (mg) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25 ºC.

Treatment	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	12.03	9.07	10.55	11.54	8.47	10.01	10.35	8.17	9.26	9.65	7.72	8.69	8.95	7.28	8.11
0.1M KH_2PO_4	11.46	9.57	10.51	11.23	8.57	9.90	10.10	7.97	9.03	9.48	7.59	8.53	8.85	7.20	8.03
30%PEG6000	11.07	8.80	9.93	10.97	8.67	9.82	10.73	8.35	9.54	10.22	7.53	8.88	9.70	6.72	8.21
$GA_3$100ppm	14.85	11.90	13.38	14.03	11.33	12.68	13.50	10.32	11.91	12.96	9.74	11.35	11.09	9.15	10.12
H_2O	10.00	8.23	9.12	8.90	7.30	8.10	8.80	7.12	7.96	8.44	6.66	7.55	8.08	6.19	7.14
Control	7.57	5.90	6.73	6.83	5.33	6.08	6.62	4.78	5.79	6.45	4.43	5.44	6.10	4.08	5.09
Mean	11.16	8.91		10.59	8.28		10.02	7.78		9.53	7.28		8.80	6.77	
CD (*P*=0.05) (V)		0.36			0.33			0.22			0.14			0.14	
CD (*P*=0.05) (T)		0.63			0.58			0.39			0.25			0.25	
CD(*P*=0.05)(VXT)		NS			0.81			0.55			0.35			0.35	

Table 6. Effect of various priming treatments on the Seedling Vigour Index-I (SVI-I) of high and low vigour brinjal seeds stored for variousdurations and subjected to germination test in rolled paper towels under laboratory conditions at 25 ºC

Treatment	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	1518	920	1219	1327	872	1100	1135	791	963	1045	760	903	959	730	844
0.1M KH_2PO_4	1222	857	1039	1183	786	984	1085	666	876	1000	595	797	917	526	721
30%PEG6000	1241	832	1036	1155	766	960	1019	727	873	946	681	813	875	637	756
$GA_3$100ppm	1747	1197	1472	1601	1046	1324	1390	983	1186	1302	892	1097	1215	803	1009
H_2O	1097	758	927	1013	674	844	898	632	765	837	598	718	779	565	672
Control	836	604	720	788	530	659	764	428	576	693	380	536	621	327	474
Mean	1277	861		1178	779		1049	704		970	651		894	598	
CD (*P*=0.05) (V)		35			38			34			22			21	
CD (*P*=0.05) (T)		61			67			59			38			37	
CD(*P*=0.05)(VXT)		86			94			NS			54			53	

Table 7. Effect of various priming treatments on the Seedling Vigour Index-II (SVI-II) of high and low vigour brinjal seeds stored forvarious durations and subjected to germination test in rolled paper towels under laboratory conditions at 25 ºC

Treatment	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO_3	1136	734	935	1047	683	865	899	636	768	813	597	705	727	558	643
0.1M KH_2PO_4	993	765	879	952	659	805	837	603	720	762	566	664	687	528	607
30%PEG6000	949	665	807	910	656	782	886	613	749	824	544	684	762	475	619
$GA_3$100ppm	1468	1031	1250	1325	946	1135	1215	843	1029	1143	788	965	956	732	844
H_2O	866	631	748	757	541	649	719	506	613	674	463	569	629	420	525
Control	604	381	493	547	332	439	530	277	403	505	243	374	465	208	337
Mean	1003	701		923	636		850	580		787	533		704	487	
CD (*P*=0.05) (V)		42			31			19			13			14	
CD (*P*=0.05) (T)		72			53			33			22			23	
CD(*P*=0.05)(VXT)		102			75			47			31			33	

for both high and low-vigour seeds. A decline in germination percentage in primed and unprimed seeds was observed after storage, but primed seeds maintained the priming effect even after storage for 12 months. The priming with GA_3 brought the performance of low-vigour seeds at par with that of high-vigour control (no storage) seeds. Although priming treatments improved the seed germination of both high and low-vigour seeds, the improvement in low-vigour seeds in terms of percentage increase over control was higher than in high-vigour seeds.

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