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Priming impacts the germination and biochemical parameters of seeds in bitter gourd (*Momordica charantia* L.)

Thabsheer P.[1], Rose Mary Francies[2]*, Dijee Bastian[1], Beena C.[3], Deepu Mathew[4] and Anju Asokan[2]

[1]*Department of Seed Science and Technology, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur 680 656, Kerala, India*
[2]*Agricultural Research Station, Kerala Agricultural University, Mannuthy P.O., Thrissur 680 651, Kerala, India*
[3]*AICRP on Medicinal, Aromatic Plants & Betel vine, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur 680656, Kerala, India*
[4]*Department of Plant Biotechnology, Centre for Plant Biotechnology and Molecular Biology, Kerala Agricultural University, Vellanikkara, Thrissur 680 656, Kerala, India*

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Abstract

Seeds of bitter gourd variety Preethi stored under ambient environment were subjected to various priming treatments after six months of storage aiming to improve germination.The eleven priming treatments employed were T_1: KNO_3 0.3 % for 2 h, T_2: KNO_3 0.015 % for 3 h, T_3: KH_2P0_4 0.01 M for 24 h, T_4: PEG 6000 -1.5 MPa for 24 h, T_5: GA_3 100 ppm for 24 h, T_6: Solid matrix priming with Perlite for 48 h, T_7: Solid matrix priming with Cocopeat for 48 h, T_8: *Psuedomonas fluorescens* $1x10^6$ cfu.ml^{-1} for 24 h, T_9: Hydration hot water at 50° C for 4 h, T_{10}: Hydration with cold water at 28° C for 24 h and T_{11}:Absolute control.The results indicated that solid matrix priming with perlite for 48 hours significantly enhanced germination parameters and seed biochemical indices in bitter gourd (*Momordica charantia*) seeds. Solid matrix priming with cocopeat for 48 hours and seed treatment with *Pseudomonas fluorescens* (1×10^6 cfu.ml^{-1}) were also effective, though to a slightly lesser extent in a few instances than perlite-based priming. Osmopriming with PEG 6000 (-1.5 MPa for 24 h) was found to be detrimental and found to be inferior to untreated control.

Keywords: Cocopeat, Osmopriming, Perlite, Priming, *Psuedomonas fluorescens*

Introduction

Bitter gourd (*Momordica charantia* L.) is a commonly cultivated vegetable known for its edible fruit and medicinal benefits. Although seeds are widely used for propagation, they have a shorter lifespan compared to other orthodox seeds (Peter et al.,1998). Cryo-storage at -196°C and cold storage are effective *ex-situ* conservation methods to ensure long-term seed storage. Despite being classified as an orthodox seed, the bitter gourd seed is sensitive to low temperatures. Research indicates significant declines in germination when the seeds are stored at low or sub-zero temperatures for more than six months (Sharmila et al., 2019). Furthermore, the thick seed coat surrounding the embryo affects germination by creating mechanical barriers that restrict the growth of the embryo.

Several methods to address the issue of poor or slow seed germination have been advocated, and one of them is seed priming (Pandita and Nagarajan, 2004). In gourds, seeds subjected to priming with PEG 6000 -1.5 MPa (Shukla et al., 2018), 150 ppm KNO_3 *i.e.*, 0.015 per cent (KAU, 2016), KH_2PO_4 10^{-2} M (Kaur et al., 2019), solid matrix priming with perlite and cocopeat (Kanwar and Mehta, 2017), hormonal priming with 100 ppm GA_3 (Kumar and Singh, 2013) and plant growth regulators, have been reported to foster high vigour resulting in improved crop growth and increased yield.

During the priming, seeds are partially hydrated leading to initiation of pre-germinative metabolic processes, ensuring that radical emergence is avoided (Pill, 1986). Primed seeds have been found to withstand biotic and abiotic stressors better (Sivasubramaniam et al., 2011). Priming helps minimize oxidative damage caused by sub-optimal temperatures and improves seed performance in various crop species (Chen and Sung, 2001).

Enzyme activation, seed coat softening, and seed dormancy break are all advantages of priming. Priming also helps in reducing the germination time (Nawaz et al., 2013). The

* Author for Correspondences: Phone : 9447792341; Email: rose.mary@kau.in

repair mechanisms triggered by priming treatments could involve several physiological processes, such as enhanced protein and RNA synthesis (Khan et al., 1992), embryo development (Hegarty, 1970) and DNA replication (Jain and van Staden, 2007).

Based on the above-mentioned factors, the study aimed to assess the germination rate and biochemical parameters, such as total soluble sugar, total protein, total dehydrogenase activity, amylase activity, and catalase activity, of bitter gourd seeds subjected to different priming treatments after six months of storage under ambient conditions. The specific goal of the study was to delineate the most effective seed priming method to improve both germination and biochemical characteristics of bitter gourd seeds.

Materials and Methods

The study was carried out in the laboratory of the Department of Seed Science and Technology at the College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala. It was designed as a Completely Randomized Design with three replications and eleven priming treatments. Seeds of the high-yielding bitter gourd variety Preethi were sourced within two weeks after harvest and dried to 6.84 per cent moisture content. Dry seeds of bitter gourd variety Preethi were packed in moisture proof bags (700-gauge polyethylene bags), sealed airtight, and stored for a period of six month from 20 Nov, 2021 to 21 May, 2022. Following storage, the seeds were subjected to priming treatments as detailed inTable 1.

Table 1. Details of priming treatments

Sl. No.	Treatment	Dosage	Solute per litre distilled water	Duration (h)
T_1	KNO_3	0.3 %	3 g	2
T_2	KNO_3	0.015 %	0.15 g	3
T_3	KH_2PO_4	0.01 M	1.36 g	24
T_4	PEG 6000	-1.5 MPa	367.67 g	24
T_5	GA_3	100 ppm	10 mg	24
T_6	Solid matrix priming with Perlite			48
T_7	Solid matrix priming with Cocopeat			48
T_8	*Psuedomonas fluorescens* ($1x10^6$ cfu.ml^{-1})	2.5 ml/ kg seed		24
T_9	Hydration (hot water)	50°C		4
T_{10}	Hydration (cold water)	28°C		24
T_{11}	Absolute control	Untreated		

The required dosage of priming solutions of KNO_3 (T_1 and T_2), KH_2PO_4 (T_3), PEG 6000 (T_4) and GA_3 (T_5) were prepared by dissolving the appropriate quantity of the chemical is distilled water. In order to bio-prime the seeds (T_8), liquid formulation of *P. fluorescens* ($1x10^6$ cfu.ml^{-1}) was used @ 2.5 ml/kg seed. During hydropriming with hot water (T_9), seeds were soaked in hot water maintained at 50± 1°C for 4 h with the help of a water bath (Grant, LSB12), while during hydration with cold water (T_{10}), the seeds were soaked in cold water (28°C) for 24 h. After the designated priming period in each case, the excess solution was poured off, and the seeds were placed on two layers of fresh blotting paper to absorb the remaining moisture. The seeds were then transferred to fresh blotter paper and shade-dried for two weeks.

For solid matrix priming with perlite (T_6), two parts of perlite with a neutral pH, a specific gravity ranging from 2.2 to 2.4, and a moisture content of less than 1.0 per cent was carefully mixed with one part of water on weight-by-weight basis. The seeds were kept as a layer in between two layers of moist perlite in a tray and watered daily while ensuring drainage of excess water. The seeds were then removed, spread on two layers of fresh blotting paper and shade-dried for a period of two weeks. Similarly, in case of solid matrix priming with cocopeat (T_7), two parts of cocopeat with a pH of 5.0, electrical conductivity of 0.6 dSm^{-1}, bulk density of 0.11 and moisture content less than 18 per cent was combined with one part of water on weight-by-weight basis and used to prime the seeds as in solid matrix priming with perlite (T_6).

Germination and biochemical parameters of the primed seeds were assessed before and after priming following standard procedures. Germination (%) was assessed in sand medium (ISTA, 2010). Four replicates of 100 seeds were germinated from each treatment, in trays containing fine sand (sieve size 0.80 mm) maintained in a germination room (25±2 °C and RH 90±3 per cent). The sand was moistened to 50 per cent of its water holding capacity. The seeds were planted on the levelled layer of moist sand at a depth of 2.50 to 3.00 cm and covered with 10-20 mm of uncompressed sand. Germination was recorded on the 4th and 14th days of the test. Germination (%) was calculated using the following formula:

Germination (%) =

(No. of germinated normal seedlings /Total seeds) x 100

In order to assess the biochemical parameters, two replicates from each three replications of a priming treatment were used. Total soluble sugar (%) was determined through anthrone method (Trevelyan and Harrison, 1952). Total protein content (%) was calculated by the method developed by Lowry et al. (1951). The activity of the dehydrogenase enzyme was measured using the procedure described by Kittock and Law (1968) and represented as an OD value.α-Amylase activity (µmol min^{-1}) was quantified using the

dinitrosalicylic acid (DNS) reagent method as described by Fossum and Whitaker (1974). Catalase activity (µmol min.$^{-1}$ g^{-1}) was determined by measuring the absorbance of H_2O_2 at 240 nm in the UV range (Aebi, 1984).

Statistical analysis of the data on various seed quality parameters was performed using GRAPES 1.0.0 (Gopinath et al., 2020) developed by Department of Agricultural Statistics, College of Agriculture, Kerala Agricultural University, Vellayani.

Results and Discussion

Germination per cent of seed lot recorded before priming treatments (Table 2) was 80.71 per cent. The total soluble sugar and total protein content in the seeds prior to priming were 5.78 and 6.22 per cent respectively. The estimated total dehydrogenase activity in the seed before priming was 0.291 OD, while the activity of enzymes α–Amylase and catalase activity in seeds before priming was 7.81 µmol min.$^{-1}$ and 22.39 µmol min.$^{-1}$ g^{-1} respectively.

It was evident that the priming treatments significantly influenced germination (%) and other biochemical indices of seeds of bitter gourd. T_6 (Perlite for 48 h) with 95.08 per cent registered the highest germination, while germination in T_4 (PEG 6000 -1.5 MPa for 24 h: 59.47 %) was the least. Germination in all treatments, except T_4, T_2 (KNO_3 0.015 % for 3 h: 88.38 %), T_{11} (Absolute control: 80.38 %) and T_3 (KH_2PO_4 0.01 M for 24 h: 89.49 %) were on par with treatment T_6. Improved germination was observed in nine out of ten priming treatments and compared to the untreated seeds, while it tended to decrease by 26.32 per cent on osmopriming with PEG 6000 (T_4). Conversely, it became evident that priming with PEG 6000 -1.5 MPa for 24 h was detrimental in bitter gourd. Solid matrix priming with perlite or cocopeat, biopriming with *P. fluorescens,* hormonal priming, hydropriming with either hot water or cold water resulted in significant enhancement of germination over untreated seeds. Several reports point out that during early phases of germination, seed priming promotes the production of enzymes that are necessary for quick radicle protrusion and hypocotyl elongation which resulted quick germination (Bensen et al., 1990; Maske et al., 1997).

Significantly higher total soluble sugar was observed in the solid matrix priming treatment T_6 (Perlite for 48 h: 7.70 %) followed by T_8 (*P. fluorescens* 1x10^6 cfu.ml^{-1} for 24 h; 6.85 %), T_7 (Cocopeat for 48 h: 6.67 %) and T_{10} (Hydration with cold water for 24 h: 6.58 %). It was evident that the treatments other than T_6, T_8 and T_7were significantly inferior in total soluble sugar content. Solid matrix priming with Perlite (T_6-Perlite for 48 h: 7.70 %) and bio-priming ($T_{8:}$ *P. fluorescens* 1x10^6 cfu.ml^{-1} for 24 h; 7.58 %) resulted in significantly higher total protein content of seeds followed by T_7 (Cocopeat for 48 h: 7.37 %) and T_5 (GA_3 100 ppm for 24 h: 7.25%). T_4 (PEG 6000 -1.5 MPa for 24 h: 6.27 %) had registered the least total protein content in seeds and was found to be on par with T_2 (KNO_3 0.015 % for 3 h: 6.62 %), T_3 (KH_2P0_4 0.01M for 24 h: 6.28%), T_9 (Hydration with hot water at 50°C for 4 h:6.46 %) and T_{10} (Hydration with cold water for 24 h: 6.41 %).

The dehydrogenase activity in the seed lots primed was found to be significantly superior in treatments T_6 (Perlite for 48 h: 0.409 OD) and T_7 (Cocopeat for 48 h: 0.379 OD) and T_8 (*P. fluorescens* 1x10^6 cfu.ml^{-1} for 24 h; 0.364 OD). Meanwhile, the enzyme activity in all the other treatments

Table 2. Variation in germination and biochemical parameters on priming in bitter gourd

Status of priming	Treatment	Germination (%)		Total soluble sugar (%)		Total protein (%)		Total dehydrogenase (OD)		α–Amylase activity (µmol min.$^{-1}$)		Catalase activity (µmol min.$^{-1}$g^{-1})	
Before priming		80.71	*Per cent change	5.78	*Per cent change	6.22	*Per cent change	0.291	*Per cent change	7.81	*Per cent change	22.39	*Per cent change
After priming	T_1	91.16^{abc}	12.95	6.02^{c}	4.15	7.04^{cd}	13.18	0.327^{c}	12.37	8.47^{abcd}	8.45	23.53^{bc}	5.09
	T_2	88.38^{cd}	9.50	5.85^{cd}	1.21	6.62^{de}	6.43	0.282^{bc}	-3.09	7.67^{de}	-1.79	19.73^{f}	-11.88
	T_3	89.49^{bcd}	10.88	5.69^{cd}	-1.56	6.28^{e}	0.96	0.263^{c}	-9.62	8.21^{abcd}	5.12	20.57^{ef}	-8.13
	T_4	59.47^{e}	-26.32	5.84^{cd}	1.04	6.27^{e}	0.80	0.274^{c}	-5.84	6.15^{f}	-21.25	19.49^{f}	-12.95
	T_5	93.93^{ab}	16.38	5.94^{cd}	2.77	7.25^{bc}	16.56	0.246^{c}	-15.46	9.21^{a}	17.93	25.28^{a}	12.91
	T_6	95.08^{a}	17.80	7.70^{a}	33.22	7.88^{a}	26.69	0.409^{a}	40.55	8.73^{abc}	11.78	25.13^{a}	12.24
	T_7	94.75^{a}	17.40	6.67^{b}	15.40	7.37^{bc}	18.49	0.379^{a}	30.24	8.30^{abcd}	6.27	24.32^{ab}	8.62
	T_8	95.05^{a}	17.77	6.85^{b}	18.51	7.58^{ab}	21.86	0.364^{ab}	25.09	8.86^{ab}	13.44	25.06^{a}	11.92
	T_9	90.60^{abc}	12.25	5.82^{cd}	0.69	6.46^{e}	3.86	0.279^{c}	-4.12	7.11^{ef}	-8.96	20.03^{f}	-10.54
	T_{10}	91.16^{abc}	12.95	6.58^{b}	13.84	6.41^{e}	3.05	0.274^{c}	-5.84	7.94^{bcde}	1.66	21.62^{de}	-3.44
	T_{11}	80.38^{d}	-0.41	5.67^{cd}	-1.90	6.29^{e}	1.13	0.290^{bc}	-0.34	7.82^{cde}	0.13	22.23^{cd}	-0.71
	CD (0.05)	4.896		0.461		0.472		0.083		1.003		1.387	

T_1: KNO_3 (0.3% for 2 h)
T_2: KNO_3 (0.015 % for 3 h)
T_3: KH_2P0_4 (0.01 M for 24 h)
T_4: PEG 6000 (-1.5 MPa for 24 h)
T_5: GA_3 (100 ppm for 24 h)
T_6: Solid matrix priming with Perlite (for 48 h)
T_7: Solid matrix priming with cocopeat (for 48 h)
T_8: *Psuedomonas fluorescens* (1x10^6 cfu.ml^{-1} for 24 h)
T_9: Hydration (hot water at 50°C for 4 h)
T_{10}: Hydration (cold water soaking for 24 h)
T_{11}: Absolute control
*Per cent change: Per cent change in parameter after priming *vs* before priming

was significantly lower.The highest α–amylase activity was observed in the treatment T_5 (GA_3 100 ppm for 24 h: 9.21 µmol $min.^{-1}$) followed by T_8 (*P. fluorescens* 1x106 $cfu.ml^{-1}$ for 24 h; 8.86 µmol $min.^{-1}$), T_6 (Perlite for 48 h: 8.73 µmol $min.^{-1}$) and T_7 (Cocopeat for 48 h: 8.30 µmol $min.^{-1}$) and T_3 (KH_2PO_4 0.01 M for 24 h: 8.21 µmol $min.^{-1}$). The activity of α–Amylase enzyme was found to be significantly higher in these treatments. Significantly high activity of enzyme catalase was observed in the treatments T_5 (GA_3 100 ppm for 24 h: 25.28 µmol $min.^{-1}$ g^{-1}), T_6 (Perlite for 48 h: 25.13 µmol $min.^{-1}$ g^{-1}), T_8 (*P. fluorescens* $1x10^6$ $cfu.ml^{-1}$ for 24 h; 25.06 µmol $min.^{-1}$ g^{-1}) and T_7 (Cocopeat for 48 h: 24.32 µmol $min.^{-1}$ g^{-1}), while the activity of the enzyme was found to be significantly lower in other treatments.

The results indicated that seeds subjected to solid matrix priming with perlite (T_6) or cocopeat (T_7), as well as biopriming with *Pseudomonas fluorescens* (T_8), exhibited significantly higher germination percentages, total soluble sugar and protein contents, and enzymatic activities of total dehydrogenase, α-amylase, and catalase, compared to untreated seeds. The percentage increases in these parameters were also of a higher magnitude in the aforementioned priming treatments (T_6, T_7, and T_8), whereas the improvements observed in treatments T_4 (PEG 6000 at -1.5 MPa for 24 h), T_2 (KNO_3 at 0.015 % for 3 h), and T_3 (KH_2PO_4 at 0.01 M for 24 h) were extremely low.

Amylases are essential enzymes involved in breaking down the starch reserve in seeds, providing sugars to support the developing embryo. On the other hand, dehydrogenases, which belong to the oxidoreductase family, catalyses the removal of hydrogen from the substrate being oxidized. They affect a large number of processes, including seed germination. The activities of total dehydrogenase and malate dehydrogenase were higher in primed seed compared to the non-primed control (Pandita et al., 2010). Basra et al. (2005) suggested that increased α-amylase activity in primed seeds leads to faster starch breakdown, quicker embryo growth, and more synchronized germination. It provides energy to the sprouting radicle of primed seeds. As a result, primed seeds germinated and grew faster than unprimed seeds (Afzal et al., 2006).

Seed priming induces metabolic changes in seeds before germination by regulating hydration but ensures that the moisture level does not induce radicle emergence. Enzymes such as dehydrogenases, peroxidase, and catalases play a crucial role in seedling emergence and germination. Following priming treatments, the activities of these enzymes were reported to be significantly higher compared to controls (Saha et al., 2022). Kibinza et al. (2011) noted that priming enhanced catalase production, which aids in seed recovery during priming. This boost in enzyme activity may be linked to increased respiration, energy production, and nutrient delivery to the developing seeds. Similar findings of enhanced respiration, energy generation, and nutrient supply to germinating seeds were reported by Verma et al. (2003) in mustard and Pallavi et al. (2003) in sunflower.

Based on the overall results, solid matrix priming of bitter gourd seeds with perlite for 48 hours resulted in a significantly high enhancement of germination and biochemical parameters compared to untreated seeds. Solid matrix priming with cocopeat (48 h) and biopriming with *Pseudomonas fluorescens* ($1x10^6$ $cfu.ml^{-1}$ for 24 h) were very effective, though slightly less so than perlite - based priming.

References

Aebi, H. 1984. Catalase *in vitro*. *Methods Enzymol*. 105: 121-126. https://doi: 10.1016/s0076-6879(84)05016-3. PMID: 6727660.

Afzal, I., Basra, S.M.A., Hameed, A., and Farooq, M. 2006. Physiological enhancements for alleviation of salt tolerance in spring wheat. *Pak. J. Bot*. 38: 1649-1659.

Basra, S.M., Farooq, A.M., and Tabassum, R. 2005. Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice (*Oryza sativa* L.). *Seed Sci. Technol*. 33: 623-628.

Bensen, R.J., Beall, F.D., Mullet, J.E., and Morgan, P.W. 1990. Detection of endogenous gibberellins and their relationship to hypocotyl elongation in soybean seedlings. *Plant Physiol.* 94:77-84.

Chen, C.C. and Sung, J.M. 2001. Priming bitter gourd seeds with selenium solution enhances germinability and antioxidative responses under sub-optimal temperature. *Physiol. Plant.* 111: 9-16.

Fossum, K. and Whitaker, J.R. 1974. Simple method for detecting amylase inhibitors in biological materials. *J. Nutri.* 104(7): 930-936.

Gopinath, P.P., Parsad, R., Joseph, B., and Adarsh, V.S. 2020. GRAPES: General R-shiny based analysis platform empowered by statistics, version 1.0.0. KAU Grapes, https://doi.org/10.5281/zenodo.4923220.

Hegarty, T.W. 1970. The possibility of increasing field establishment by seed hardening. *Hortic. Res.* 10: 59-64.

ISTA [International Seed Testing Association]. 2010. International rules for seed testing. *Seed Sci. Technol*. 139: 23-31.

Jain, N. and van Staden, J. 2007. The potential of the smoke-derived compound 3-methyl-2H-furo [2, 3-c] pyran-2-one as a priming agent for tomato seeds. *Seed Sci. Res.* 17(3): 175-181.

Kanwar, R. and Mehta, D.K. 2017. Studies on solid matrix priming of seeds in bitter gourd (*Momordica charantia* L.). *J. Appl. Nat. Sci*. 9 (1): 395-401.

KAU [Kerala Agricultural University]. 2016. *Package of Practices Recommendations: Crops* (15th Ed.). Kerala Agricultural University, Thrissur, 393p.

Kaur, B., Rajinder Singh, R., and Singh, D. 2019. Invigoration of

T_1 watermelon tetraploid seeds. *Agri. Res. J*. 56(2): 213-219.

Kumar, R. and Singh, R. 2013. Effect of seed priming on emergence and vigour of bitter gourd (*Momordica charantia* L.). *J. Res*. 50(3-4): 114-118.

Khan, A.A., Maguire, J.D., Abawi, G. S., and Ilyas, S. 1992. Matriconditioning of vegetable seeds to improve stand establishment in early field plantings. *J. Am. Society Hortic. Sci*. 117(1): 41-47.

Kibinza, S., Bazin, J, Bailly, C., Farrant, J.M., Corbineau, F., and El-Maarouf-Bouteau, H. 2011. Catalase is a key enzyme in seed recovery from ageing during priming. *Plant Sci.* 181(3): 309-315. https://doi: 10.1016/j.plantsci.2011.06.003.

Kittock, D.L. and Law, A.G. 1968. Relationship of seedling vigor to respiration and tetrazolium chloride reduction by germinating wheat seeds. *Agron. J.* 60(3): 286-288.

Lowry, O., Rosebrough, N., Farr, A.L., and Randall, R. 1951. Protein measurement with the Folin phenol reagent. *J. Biochem*. 193(1): 265-275.

Maske, V.G, Dotale, R.D, Sorte P.N, Tale, B.D., and Chore C.N. 1997. Germination, root and shoot studies in soybean as influenced by GA_3 and NAA. *J. Soils Crops* 7:147-149.

Nawaz, J., Hussain, M., Jabbar, A., Nadeem, G.A., Sajid, M., Subtain, M.U., and Shabbir, I. 2013. Seed priming a technique. *Intl. J. Agric. Crop Sci.*6(20): 1373 -1381

Pallavi, M.S., Kumar, S., Dangi, K.S., and Reddy, A.V. 2003. Effect of seed ageing on physiological, biochemical and yield attributes in sunflower (*Helianthus annuus* L.) cv. Morden. *Seed Res.* 31(2): 161-168.

Pandita, V.K. and Nagarajan, S. 2004. Effect of pre-sowing treatments in improving emergence of bitter gourd seedlings. *Ind. J. Hortic.* 61(3): 280-281.

Pandita, V.K., Anand, A., Nagarajan, S., Seth, R., and Sinha, S.N., 2010. Solid matrix priming improves seed emergence and crop performance in okra. *Seed Sci. Technol.* 38(3): 665-674.

Peter, K.V., Sadhu, M.K., Raj, M., and Prasanna, K.P. 1998. Improvement and cultivation: Bitter gourd, snake gourd, pointed gourd and ivy gourd. In: N.M. Nayar and T.A. More (eds.), Cucurbits. Oxford and IBH Publishing House Pvt. Ltd., New Delhi. pp. 187-195.

Pill, W.G. 1986. Parsley emergence and seedling growth from raw, osmo-conditioned and pre-germinated seeds. *Hortic. Sci*. 21: 1134-1136.

Saha, D., Choyal, P., Mishra, U.N., Dey, P., Bose, B., Prathibha, M.D., and Singhal, R.K. 2022. Drought stress responses and inducing tolerance by seed priming approach in plants. *Plant Stress* 4: 100066.

Sharmila, M., Ram, S.G., Thiruvengadam, V., and Swarnapriya, R. 2019. Effect of cryo-storage on the germinability of bitter gourd (*Momordica charantia* L.) seeds. *Electron. J. Plant Br.* 10(2): 944-948.

Shukla, Y.R., Raturi, H.C., and Sharma, R. 2018. Effect of seed priming treatments on quality and storage life of cucumber cv K-75 seeds under temperature-stress conditions. *Intl. J. Farm Sci.* 8(4): 137-143.

Sivasubramaniam, K., Geetha, R., Sujatha, K., Raja, K., Sripunitha, A., and Selvarani, R.2011. Seed priming: triumphs and tribulations. *Madras Agric. J.* 98(7-9): 197-209.

Trevelyan, W.E. and Harrison, J.S. 1952. Studies on yeast metabolism. 1. Fractionation and micro determination of cell carbohydrates. *Biochem. J.* 50(3): 298

Verma, S.S., Tomer, R.P.S., and Verma, U. 2003. Loss of viability and vigour in Indian mustard seeds stored under ambient conditions. *Seed Res.* 31: 98-101.