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Short Communication

Impact of pre-storage seed invigoration in ash gourd [*Benincasa hispida* (Thunb.) Cogn.]

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Ash gourd is widely cultivated as a vegetable crop in Kerala. In the state, prolonging seed longevity is a major concern as the prevailing hot humid conditions accelerates deterioration of seeds leading to rapid loss of viability during storage. Seed deterioration due to ageing is indeed inevitable and irreversible phenomenon, the best that can be done is to lower its rate (Coolbear 1995). It is reported that seed priming technology helps in rapid and uniform germination and emergence of seeds and impart a great tolerance to adverse environmental conditions (Heydecker et al. 1973). A study conducted at KAU on the storability of invigorated seeds of ash gourd variety KAU local had revealed that viability of the invigorated seed was maintained above the Indian minimum seed certification standards (IMSCS) for seven months after storage (MAS) under ambient condition (Shobha 2016). Considering all the above, the present study was formulated to elucidate the effect of seed invigoration on viability and quality of seeds stored under ambient and refrigerated environment.

The experiment was conducted at the Department of Seed Science and Technology, College of Horticulture, Kerala Agricultural University (KAU), Thrissur. The seeds of ash gourd variety KAU Local collected immediately after extraction were invigorated with the respective priming agents (Table 1) in the ratio 1:2 on volume basis for the specified period. The invigorated and untreated seeds were shade dried at room temperature to $\leq$ 8 per cent moisture prior to packing. The seed required for the monthly assessment of seed germination in each of the seven treatments (I_1 to I_7) were packed separately in polyethylene bags of 700 gauge. Three replicates each of the seed thus packed in each treatment were stored under two storage conditions *i.e.*, ambient storage and refrigerated condition. The germination test was carried out in sand medium as per standard procedure (ISTA 2010). Four replicates of 100 seeds each were germinated in a germination room maintained at 25±2°C temperature and 90±3% RH. The number of normal seedlings were counted in each replication at the end of germination period *i.e.,* on the 14th day and the per cent of germination was computed Statistical analysis of the data was performed using OPSTAT and MSTAT-C package for completely randomized design with two factors (storage condition and invigoration treatments).

Germination of seeds under the refrigerated storage during the initial period (up to 3 MAS) was lower than that under ambient conditions. Germination in ambient stored seeds was retained above MSCS of 60 per cent up to 5 MAS (68%) whereas in seeds under refrigerated storage it was retained above MSCS for 13 MAS (61%) (Fig 1). Similar reports on the extension of seed viability

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Table 1: Details of treatment

Treatment	Details
I_1	$CaCl_2$ (50 mM for 12 h)
I_2	$CaCl_2$ (50 mM for 24 h)
I_3	Kinetin (Cytokinin) (10 ppm for 12 h)
I_4	Kinetin (Cytokinin) (10 ppm for 24 h)
I_5	KH_2PO_4 (100 mM for 24 h)
I_6	*Pseudomonas fluorescens* ($1x10^6$ cfu.ml^{-1} for 12 h)
I_7	Absolute control (untreated seeds)

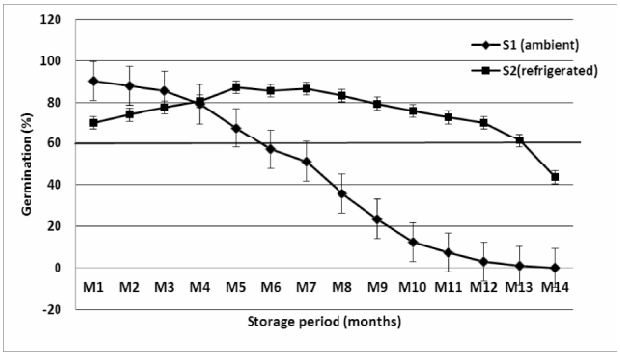

Fig 1: Influence of storage condition on germination (%) in ash gourd

under the cold storage and its advantage over ambient storage were also observed by Dhatt (2016) in pancy, Basavegowda et al. (2016) in pigeon pea, Dhatt et al. (2018) in *Nemesia strumosa.*

Unlike the invigorated seeds which exhibited a germination per cent above 80 after 1 MAS, the germination of the untreated control (I_7) was below the MSCS at 1 MAS and gradually reached a maximum of 84 per cent at 5 MAS. This indicated that priming induced early germination in invigorated seeds (Table 2) and presence of dormancy in untreated control. The finding is in consonance with that of earlier workers (Afzal et al. 2008; Moeinzadeh et al. 2010; Afzal et al. 2012; Shobha 2016). Considering the significant superiority of seeds invigorated with I_1 ($CaCl_2$ 50mM 12 h) and I_2 ($CaCl_2$ 50mM 24 h) with respect to germination in the initial storage period (up to 4 MAS) coupled with retention of germination above MSCS for 8 MAS, priming with $CaCl_2$ 50mM can be advocated.

The interaction between storage condition and invigoration treatment (Table 3) indicated that Bio-primed seeds (*Pf* 1x10^6 cfu.ml^{-1} for 12h; S_2I_6) registered the highest germination (73%) at 13 MAS and was significantly superior to all other treatments. The untreated seeds (S_2I_7) and seeds invigorated with $CaCl_2$ 50mM 12 h (S_2I_1) retained viability above MSCS for 12 MAS only. Under ambient storage, the untreated seeds as well as seeds invigorated with $CaCl_2$ 50mM for 24 h (S_1I_2) had retained viability above MSCS for 7 MAS. The result is in concomitance with that of Meena et al. (2017) and Dorna et al. (2013). The advantage of invigorating seeds of ash gourd with $CaCl_2$ 50mM was also reported by Shobha (2016).

Considering the impact of storage environment and invigoration treatment on seed quality discussed above, it can be concluded that seed invigoration followed by refrigerated storage is advantageous. If only ambient storage condition is feasible, it would be advantageous to invigorate the seeds with $CaCl_2$ 50mM for 12h (I_1) as viability above MSCS is retained for 8 MAS compared to untreated seeds (7 MAS). If provision for refrigerated storage is available, bio-priming with *Pf* 1x10^6 cfu.ml^{-1} for 12 h (S_2I_6) or invigoration with $CaCl_2$ 50mM for 24h (I_2) would be advantageous.

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Table 2: Effect of invigoration treatment on germination (%) during storage in ash gourd

Invigoration treatment (I)	Storage period (months)									
	1 MAS	2 MAS	3 MAS	4MAS	5 MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
I_1	89.00^a (74.48)	89.00^a (72.56)	88.00^a (71.00)	84.00^a (67.00)	86.00^a (70.00)	76.00^a (63.03)	72.00^a (59.00)	70.00^a (57.00)	58.00^b (50.00)	51.00^a (45.00)
I_2	86.00^{ab} (69.26)	88.00^a (70.90)	89.00^a (71.00)	89.00^a (71.00)	87.00^a (70.00)	75.00^{ab} (61.00)	75.00^a (61.00)	60.00^b (51.00)	56.00^b (49.00)	51.00^a (45.00)
I_3	82.00^{bc} (66.27)	79.00^b (63.17)	80.00^b (63.00)	75.00^b (60.00)	70.00^{cd} (60.00)	60.00^c (54.00)	57.00^b (52.00)	51.00^c (45.00)	43.00^c (39.00)	38.00^b (31.00)
I_4	81.00^{bc} (68.65)	77.00^b (62.07)	75.00^c (60.00)	66.40^b (54.00)	64.00^d (53.00)	64.00^{bc} (53.00)	55.00^b (48.00)	54.00^{bc} (48.00)	41.00^c (37.00)	39.00^b (34.00)
I_5	80.00^c (64.00)	81.00^b (64.00)	81.00^b (64.00)	87.00^a (70.00)	76.00^{bc} (62.00)	74.00^{ab} (62.00)	70.00^a (58.00)	53.00^{bc} (47.00)	46.00^c (42.00)	40.00^b (36.00)
I_6	84.00^{abc} (70.00)	85.00^a (70.00)	84.00^{ab} (68.00)	83.00^a (66.00)	71.00^{cd} (58.00)	70.00^{abc} (58.00)	73.00^a (60.00)	56.00^{bc} (50.00)	45.00^c (40.00)	43.00^{ab} (37.00)
I_7	56.00^d (48.00)	65.00^c (54.00)	69.00^d (56.00)	71.00^b (57.00)	84.00^{ab} (66.00)	76.00^a (61.00)	77.00^a (61.00)	70.00^a (57.00)	66.00^a (55.00)	44.00^{ab} (40.00)
SEm ±	1.28	1.028	1.144	2.103	2.123	2.515	2.12	1.628	1.228	1.946
CD (0.05)	3.726	2.994	3.33	6.122	6.183	10.30	6.174	4.741	3.575	5.666

Table 3: Interaction effect of Storage condition and Invigoration treatment on germination (%) during storage in ash gourd

Invigoration treatment (I)	Storage period (months)													
	1 MAS	2 MAS	3 MAS	4MAS	5 MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS	11 MAS	12 MAS	13 MAS	14 MAS
S_1I_1	99.00^{a} (85.00)	97.00^{a} (81.00)	94.00^{a} (77.00)	83.00^{abc} (66.00)	77.00^{cd} (61.00)	68.00^{d} (56.00)	62.00^{b} (52.00)	61.00^{c} (51.00)	41.00^{d} (39.00)	37.00.^{d} (37.00)	32.00^{d} (34.00)	11.00^{e} (19.00)	6.00^{d} (14.00)	0.00^{e}
S_1I_2	93.00^{bc} (75.00)	93.00^{b} (75.00)	92.00^{a} (74.00)	88.00^{abc} (70.00)	82.00^{bcd} (65.00)	62.00^{de} (52.00)	63.00^{b} (53.00)	37.00^{d} (37.00)	33.00^{e} (35.00)	25.00^{e} (30.00)	9.00^{e} (17.00)	6.00^{ef} (14.00)	0.00^{e}	0.00^{e}
S_1I_3	93.00^{bc} (74.00)	82.00^{d} (65.00)	81.00^{bcd} (64.00)	64.00^{gh} (53.00)	44.00^{f} (41.00)	33.00^{g} (35.00)	27.00^{d} (31.00)	24.00^{e} (29.00)	10.00^{fg} (18.00)	0.43^{g} (3.00)	2.00^{ef} (9.00)	0.00^{g}	0.00^{e}	0.00^{e}
S_1I_4	98.00^{ab} (83.00)	86.00^{cd} (67.00)	80.00^{cde} (63.00)	60.00^{h} (51.00)	55.00^{e} (48.00)	48.00^{f} (44.00)	27.00^{d} (31.00)	20.00^{e} (26.00)	6.00^{g} (14.00)	3.00^{g} (8.00)	2.00^{ef} (4.00)	1.00^{fg} (5.00)	0.00^{e}	0.00^{e}
S_1I_5	90.00^{c} (72.00)	89.00^{bc} (70.00)	84.00^{bc} (67.00)	93.00^{a} (75.00)	63.00^{e} (53.00)	55.00^{ef} (47.00)	53.00^{c} (47.00)	22.00^{e} (28.00)	13.00^{f} (21.00)	4.00^{fg} (12.00)	0.00^{f}	0.00^{g}	0.00^{e}	0.00^{e}
S_1I_6	98.00^{ab} (83.00)	98.00^{a} (83.00)	93.00^{a} (75.00)	88.00^{ab} (70.00)	62.00^{e} (52.00)	60.00^{de} (51.00)	53.00^{c} (47.00)	24.00^{e} (29.00)	6.00^{g} (14.00)	1.00^{g} (7.00)	0.00^{f}	0.00^{g}	0.00^{e}	0.00^{e}
S_1I_7	58.00^{g} (50.00)	69.00^{f} (56.00)	70.00^{f} (56.00)	73.00^{def} (59.00)	87.00^{abc} (69.00)	71.00^{cd} (57.00)	70.00^{b} (56.00)	58.00^{c} (50.00)	53.00^{c} (46.00)	12.00^{f} (19.00)	4.00^{ef} (11.00)	1.00^{fg} (4.00)	0.00^{e}	0.00^{e}
S_2I_1	79.00^{d} (63.00)	81.00^{d} (64.)	82.00^{bcd} (64.00)	84.00^{abc} (67.00)	95.00^{a} (71.00)	85.00^{ab} (67.00)	82.00^{a} (65.00)	80.00^{b} (63.00)	75.00^{b} (60.00)	65.00^{c} (53.00))	63.00^{c} (53.00)	62.00^{d} (2.00)	52.00^{c} (46.00)	40.00^{cd} (39.00)
S_2I_2	79.00^{d} (63.00)	84.00^{d} (67.00)	86.00^{b} (68.00)	91.00^{ab} (73.00.)	93.00^{a} (75.00)	88.00^{ab} (70.00)	87.00^{a} (69.00)	82.00^{ab} (65.00)	79.00^{b} (62.00)	76.00^{b} (61.19)	74.00^{b} (59.00)	74.00^{ab} (59.00)	60.00^{b} (50.00)	40.00^{cd} (39.00)
S_2I_3	72.00^{e} (58.00)	76.00^{e} (61.00)	79.00^{cde} (63.00)	85.000^{abc} (68.00)	96.00^{a} (79.00)	88.00^{ab} (72.00)	88.00^{a} (72.00)	77.00^{b} (62.00)	76.00^{b} (60.00)	75.00^{b} (60.00)	73.00^{b} (59.00)	73.00^{bc} (58.00)	64.00^{b} (53.00)	43.^{bc} (41.00)
S_2I_4	65.00^{f} (54.00)	69.00^{f} (56.00)	70.00^{f} (57.00)	72.00^{efg} (58.00)	73.00^{d} (59.00)	80.00^{bc} (63.00)	83.00^{a} (66.00)	88.00^{a} (70.00)	77.00^{b} (61.00)	75.00^{b} (60.00)	70.00^{bc} (56.00)	65.00^{d} (54.00)	61.00^{b} (51.00)	57.00^{a} (49.00)
S_2I_5	70.00^{ef} (56.00)	72.00^{ef} (58.00)	78.00^{de} (62.00)	82.00^{bcd} (65.00)	90.00^{ab} (72.00)	93.88^{a} (76.00)	87.00^{a} (69.00.)	84.00^{ab} (66.00)	80.00^{ab} (63.00)	76.00^{b} (61.00))	73.00^{b} (59.00)	68.00^{cd} (55.00)	62.00^{b} (52.00)	41.00^{cd} (39.00)
S_2I_6	70.00^{ef} (56.00)	72.00^{ef} (58.00)	75.00^{e} (60.00)	78.00^{cde} (62.00)	80.00^{bcd} (64.00)	81.00^{bc} (64.00)	92.00^{a} (73.00)	88.00^{a} (70.00)	85.00^{a} (67.00)	85.00^{a} (67.00)	84.00^{a} (66.00)	79.00^{a} (63.00)	73.00^{a} (59.00)	48.00^{b} (44.00)
S_2I_7	53.00^{h} (47.00)	61.^{g} (51.00)	68.00^{f} (56.00)	69.00^{fgh} (56.00)	81.00^{bcd} (64.00)	82.00^{ab} (67.00)	84.00^{a} (66.00)	81.00^{ab} (64.00)	80.00^{ab} (63.00)	76.00^{b} (61.00))	68.^{bc} (55.89)	67.00^{cd} (55.00)	54.00^{c} (47.00)	35.00^{d} (36.00)
SEM ±	1.81	1.454	1.617	2.973	3.003	3.56	2.999	2.302	1.736	2.752	2.719	1.935	1.816	1.962
CD (0.05)	5.2 69	4.234	4.709	8.658	8.744	10.358	8.731	6.704	5.055	8.012	7.917	5.634	5.287	5.682

*Values in parentheses are Arc sine transformed values

**Means in each column with atleast one letter in common are not significantly different at 5% level of probability

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