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Germination performance of chilli (*Capsicum annuum* L.) and coriander (*Coriandrum sativum* L.) as affected by seed priming treatments

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Abstract
Seeds of chilli cv. Pusa Jwala and coriander cv. Akash Ganga primed with water (hydro priming), GA_3 (50, 100 & 150 ppm), PEG 6000 (-1.1 & -1.5 MPa) for 12, 24 and 36 hours at 25°C and keeping unprimed seeds as control were tested to study the priming effects on germination and seedling growth traits. Significant variation for germination percent, fresh ungerminated seeds, mean germination time, germination index, seed vigour index, root and shoot length, seedling fresh and dry weight, and seedling emergence were observed among the treatments. For both the crops, GA_3 and PEG priming were found the most effective. Twelve hours of hydro-priming and 24 hours of GA_3 and PEG priming were found to be the best duration. GA_3 @ 50 ppm and PEG 6000 @ -1.1 MPa were the best for enhancement of germination and seedling growth traits in both the crops.

Keywords: chilli, coriander, priming concentration, priming duration, priming media

Introduction
Vegetables like chilli and coriander are important constituents of Indian agriculture due to short duration, nutritional richness and economic viability. They also possess high medicinal value and are good sources of carbohydrates, proteins, vitamins and minerals.
Chilli is used as a universal spice. It contains capsaicin, the main compound for pungency and capsanthin and capsorubin, the main colouring compound. Germination in chilli is prolonged and non-uniform, leading to poor emergence which affects crop stand establishment particularly under stress conditions like salinity and high temperatures that delays germination, emergence and seedling growth (Demir and Okcu, 2004) [3]. Coriander is used as an aromatic and medicinal plant. It is cultivated for the seeds as well as the leaves. The staggered flowering behaviour of coriander results in variable fruit formation leading to slow and uneven germination of coriander seeds (Rubatzky *et al*., 1999) [12]. In these crops, uniform and faster germination can be achieved through seed priming. In priming, seeds are partially hydrated and then dried back to the original moisture level thus activating the pre-germination metabolic activities, but preventing radicle emergence (McDonald, 1999) [10]. It enhances the rate and uniformity of germination, improves seedling stand, crop establishment and yield thereby providing a simple and cheap technology to the farmers for better crop production. To achieve maximum benefit of priming, the safe limits of priming duration and concentration should be known. Hence, the present research work was conducted in order to study the effect of hydro-priming, GA_3 and PEG 6000 priming at different concentrations and durations on germination and seedling growth traits of both chilli and coriander.

Materials and Methods
The present investigation was carried out in the laboratory of the Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat during 2016 and 2017 in completely randomized designs (CRD) with three replications. A year old seeds of chilli cv. Pusa Jwala and coriander cv. Akash Ganga was used for the experiments. At first, seeds were surface sterilized by dipping in 0.1% Mercuric Chloride solution for two minutes, then rinsed thrice in distilled water and dried on filter papers. These seeds were then primed with distilled water (hydro-priming), GA_3 @ 50, 100 and 150 ppm and PEG 6000 @ -1.1 and -1.5 MPa solutions for 12, 24 and 36 hrs. at 25°C constituting 19 treatments viz., hydro-priming for 12, 24 and 36 hrs.; GA_3 @ 50 ppm for 12, 24, 36 hrs.; GA_3 @100 ppm for 12, 24, 36 hrs.; GA_3 @ 150 ppm for 12, 24, 36 hrs.; PEG 6000 @ -1.1 MPa for 12, 24, 36 hrs.; PEG 6000 @ -1.5 MPa for 12, 24, 36 hrs. Following the priming treatments, seeds were washed thoroughly with distilled water and dried back to their original moisture content by forced air under the shade

on filter papers. Unprimed seeds served as control. Fifty seeds per replication were used for germination test as per ISTA procedure (ISTA, 1985) in each treatment. Observations were taken for germination percentage (GP), fresh ungerminated seed (FUS), seed vigour index (SVI) computed by multiplying GP and seedling length (SL+RL), root length (RL), shoot length (SL), seedling fresh weight (SFW) and dry weight (SDW). Radicle emergence (2 mm) was recorded daily for 14 and 21 consecutive days in chilli and coriander, respectively to calculate the mean germination time (MGT) and germination index (GI) as follows: MGT (days) $= \frac{\sum fx}{\sum x}$

Where,

f = Number of days from the beginning of the germination test

x = Number of seeds newly germinated on that day

$$\text{GI} = \frac{\text{Number of seeds germinated}}{\text{Days of 1st count}} + \cdots + \frac{\text{Number of seeds germinated}}{\text{Days of the final count}}$$

For seedling emergence (SE), about 2-3 cm thick layer of sterilized soil was placed in plastic trays where germination test was carried out. Data were analyzed as per factorial CRD design in MS Excel 2007.

Results and Discussion

Irrespective of the media, concentrations or durations, the priming treatments significantly enhanced germination and seedling growth traits of both chilli (Table 1) and coriander (Table 2) over their respective control indicating the beneficial effect of priming. Germination was increased by 26.2 and 23.7% for hydro-priming, 76.6 and 47% for GA_3 and 77.4 and 57.7% for PEG in chilli and coriander, respectively. It is already known that priming leads to completion of first two germination phases during the priming process itself and hence after sowing, primed seeds enter immediately into the third phase of germination - radicle emergence once rehydrated (Varier *et al*., 2010) [17]. This could be the reason for achieving higher germination, emergence and GI with low fresh ungerminated seeds and MGT in the present study. Primed seeds also showed high SVI, shoot and root length, seedling fresh and dry weight as priming also leaches growth inhibitors, and enhances the activity of different enzymes like malate synthase, iso-citrate lyase, malate dehydrogenase (Lin and Sung, 2001) [9], increases antioxidative response, decreases lipid peroxidation (Islam *et al.*, 2012) [7], repairs membranes and organelles, and mobilizes stored materials (Sarika *et al*., 2013) [15], thus facilitating faster and uniform germination and growth. Poor performance by unprimed seeds might be attributed to excessive leakage of electrolytes from seeds due to membrane damage during imbibitions (Divya and Nirmala, 2015) [5].

In our investigation, the interaction between priming media, concentrations and durations played a vital and significant role in the germination and seedling growth performance of chilli and coriander.

Effect of priming media

In chilli (Table 3), PEG enhanced maximum germination (66.22%), seedling emergence (47.66%), GI (2.05), SVI (530.19) and seedling root length (4.34 cm) and reduction in fresh ungerminated seeds (33.78%) which were closely followed by GA_3 for germination (65.93%), seedling root length (3.86 cm) and fresh ungerminated seed (34.07%). However, the highest seedling shoot length (3.93 cm), fresh weight (80.89 mg) and dry weight (52.56 mg) were observed in GA_3 with PEG being at par for seedling shoot length (3.61cm). Hydro-priming was the best for MGT (6.25).

For coriander (Table 4), PEG registered maximum enhancement for germination (54.67%), emergence (48.0%), GI (1.2) and SVI (1173.44) and reduction in fresh ungerminated seeds (45.34%). GA_3 was at par with PEG for GI (1.12) and induced maximum seedling shoot length (11.07cm) and root length (11.81cm), fresh (581.14 mg) and dry weight (155.67 mg). The fastest germination was observed in hydro-priming (9.56) followed by GA_3 (9.97). Singh (1984) [16] was of the opinion that PEG priming improved germination, not only due to hydration but also due to an increase in protein, sugar and RNA synthesis; also PEG unlike other salts, is less toxic as it is an inert compound with high molecular weight and cannot enter seeds due to its large molecular size. Growth parameters like seedling root and shoot length, fresh and dry weight were enhanced maximum by GA_3. GA_3 is a very potent hormone which occurs naturally in plants and has effects on cell growth and elongation and has a great impact on germination, vigour and nutrient uptake. Islam *et al*. (2012) [7] attributed this to an extensive accumulation of nucleic acid in GA_3 primed seed resulting in germination acceleration. The present results were in tune with the findings of Yogananda *et al.* (2004) [18] and Amjad *et al.* (2007) [1].

Effect of duration

Twelve hours of hydropriming and 24 hours of GA_3 and PEG priming was found to be the most effective for enhancing the germination and seedling growth traits both in chilli (Table 3) and coriander (Table 4) but for MGT, 36 hours was the best for all the priming agents except in coriander where 12 hours of PEG priming gave the best result. Muhammad *et al*. (2014) [11] also reported potentiality of 12 hours water soaking to improve germination and seedling growth in bitter gourd. Soaking duration is of utmost importance as soaking for too short duration may not complete metabolic repair processes or stimulate the enzyme activities proving ineffective in enhancing seed germination or vigour (Saini *et al*., 2017) [14]; and too long duration may promote radicle emergence even after drying (Harris, 1996) [6] and once radicle emerges seed becomes desiccation sensitive. A longer time taken in PEG priming to achieve results similar to hydro-priming may be due to a low osmotic potential of the solution (Dezfuli *et al.*, 2008) [4] and hence slower water uptake results in less progressed metabolic processes (Badeck *et al*., 2006) [2]. It is in conformity with the findings of Kaur *et al.* (2015) [8] who reported 24 hours of PEG priming increased biochemical components like crude protein, total minerals, dry matter, and iodine phosphorous in okra.

Effect of concentration

For both chilli (Table 3) and coriander (Table 4), 50 ppm of GA_3 and -1.1 MPa of PEG were the most effective in improving all the germination and seedling growth traits except for MGT, for which 150 ppm of GA_3 and -1.5 of MPa PEG were found to be the best concentration. Further, lower concentrations were found to be more effective than higher concentrations since the imbibition rate is faster in lower concentrations enabling the seeds attaining the phase two of germination faster than higher concentrations (Ruttanaruangboworn *et al*., 2017) [13].

Table 1: Mean performance for germination parameters of chilli as influenced by different priming treatments

Treatment	Hour	Germination (%)	Fresh ungerminated seeds (%)	Mean germination time (days)	Germination index	Seed vigour index	Root length (cm)	Shoot length (cm)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Seedling emergence (%)
Hydro-priming	12	54.67 fg	45.33 fg	6.80 c	2.20bc	424.79 efg	4.10 c	3.67 defg	69.00 e	35.33 f	51.33 abc
	24	45.33 hi	54.67 hi	6.06 b	1.67 efg	302.35 hi	3.50 efg	3.17 ghi	64.00 f	32.33 f	43.33 def
	36	41.33 i	58.67 i	5.90 b	1.63fg	242.61 i	3.17 g	2.70 i	56.00 g	27.00 g	34.67 gh
GA_3 @ 50 ppm	12	72.00 bc	28.00 bc	8.23 efg	1.96 cde	585.36 bcd	3.97 cd	4.16 abcd	106.67 a	88.67 a	37.33 fg
	24	81.33 a	18.67 a	8.70 gh	2.90 a	769.38 a	5.03 ab	4.43 ab	106.00 a	83.33 b	54.67 a
	36	60.00 efg	40.00 efg	7.80 de	1.50 fg	455.40 ef	3.63 def	3.96 bcde	92.00 b	61.33 c	52.00 ab
GA_3 @ 100 ppm	12	70.67 bcd	29.33 bcd	7.96 ef	2.30 b	518.01bcde	3.40 fg	3.93 bcde	83.67 c	55.00 d	49.33 abcd
	24	74.67 ab	25.33 ab	8.56 fgh	2.03 bcd	586.91 bc	3.86 cde	4.00 abcde	63.33 f	34.33 f	44.00 de
	36	54.67 fg	45.33 fg	7.73 de	1.53 fg	407.84 fg	3.83 cdef	3.63 defg	65.67 ef	46.00 e	45.33 cde
GA_3 @ 150 ppm	12	62.67 def	37.33 def	8.20 efg	2.33 b	469.40 e	3.93 cde	3.56 efgh	53.67 gh	24.00 g	49.33abcd
	24	65.33 cde	34.67 cde	7.20 cd	1.67 efg	531.13bcde	3.60 defg	4.53 a	82.33 c	57.00 cd	42.67 ef
	36	52.00 gh	48.00 gh	7.10 cd	1.67 efg	346.32 gh	3.53 defg	3.13 ghi	74.67 d	34.67 f	29.33 h
PEG 6000 @ -1.1 MPa	12	61.33 ef	38.67 ef	9.13 hi	2.23bc	447.71 ef	4.10 c	3.20 ghi	54.67 g	25.67 g	46.67 bcde
	24	74.67 ab	25.33 ab	9.13 hi	2.23bc	726.54 a	5.46 a	4.27abc	77.00 d	46.67 e	55.33 a
	36	70.67 bcd	29.33 bcd	8.73 cd	2.20 bc	614.12 b	4.83 b	3.86 cdef	85.67 c	53.67 d	52.00 ab
PEG 6000 @ -1.5 MPa	12	64.00 cde	36.00 cde	7.80 de	2.20 bc	432.64 ef	3.70 cdef	3.06 hi	53.67 gh	24.67 g	41.33 ef
	24	61.33 ef	38.67 ef	9.27 hi	1.70 ef	464.27 ef	4.10 c	3.47 efgh	76.00 d	36.67 f	51.33 abc
	36	65.33 cde	34.67 cde	4.70 a	1.73def	495.85 cde	3.83 cdef	3.76 cdef	49.33 h	16.33 h	49.33 abcd
Control	-	37.33 i	62.67 i	9.83 i	1.37 g	243.76 i	3.17 g	3.36 fgh	43.67 i	14.33 h	32.00 gh
Range		81.33-37.33	62.67-18.67	9.83-4.70	2.90-1.37	770.13-243.33	5.46-3.17	4.53-2.70	106.67-43.67	88.67-14.33	55.33-29.33
SE(d) ±		2.85	4.03	0.25	0.10	37.28	0.15	0.19	2.39	1.64	2.20
CD, 5%		8.16	8.16	0.72	0.31	106.73	0.45	0.56	4.85	4.70	6.29

Means followed by the same letters are not significantly different

Table 2: Mean performance for germination parameters of coriander as influenced by different priming treatments

Treatment	Hour	Germination (%)	Fresh ungerminated seeds (%)	Mean germination time (days)	Germination index	Seed vigour index	Root length (cm)	Shoot length (cm)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Seedling emergence (%)
Hydro-priming	12	46.67 ghi	53.33 ghi	10.10 ef	1.07 ef	978.20 j	10.00 gh	10.96cdef	488.67 defg	74.33 hi	44.00 cde
	24	42.67ij	57.33 ij	9.36 bcd	0.81 g	777.87 lnopq	9.20 hi	9.03 hi	514.00 cdef	63.00 ij	38.67 efgh
	36	38.67 jk	61.33 j	9.23 bc	0.73 g	654.30 q	8.76 i	8.16 i	377.00 hi	54.67 jk	36.00 gh
GA_3 @ 50 ppm	12	56.00 abcd	44.00 abcd	10.13 efg	1.36 ab	1396.08 ab	12.33 ab	12.60 a	540.33 bcde	189.00 ab	37.33 fgh
	24	58.67 abc	41.33 abc	11.50 ij	1.30 abc	1448.56 a	12.93 a	11.76 abc	667.67 a	203.00 a	56.67 a
	36	54.67bcde	45.33 bcde	9.83 cdef	1.21 bcde	1244.29 bcdef	11.96 bc	10.80 cdefg	664.00 a	201.33 a	52.00 ab
GA_3 @ 100 ppm	12	53.33 cdef	46.67 cdef	10.00 def	1.02 f	1245.79 bcde	12.30 abc	11.06 bcde	603.00 ab	121.67 d	49.33bc
	24	54.67 bcde	45.33 bcde	10.10 ef	1.45 a	1302.79 abcd	11.73 bcd	12.10 ab	547.33 bcde	177.67 b	44.00 cde
	36	44.00 hij	56.00 hij	10.46 ef	1.09 ef	924.0 jklmn	10.90 def	10.10 efgh	505.67 def	110.67 de	43.33cdef

GA_3 @ 150 ppm	12	45.33 hi	54.67 hi	9.80 fgh	0.83 g	944.22 jklm	10.90 def	9.93 fgh	572.00 bcd	151.00 c	49.33 bc
	24	49.33 efgh	50.67 efgh	9.20 cdef	1.12 def	1142.48 defghi	12.36 ab	10.80 cdefg	602.67 ab	108.00 def	42.67def
	36	42.67 ij	57.33 ij	8.80 ab	0.79 g	912.71 jklmno	10.86 ef	10.53 defg	431.33 fgh	102.67 ef	33.33 hi
PEG 6000 @ -1.1 MPa	12	49.33 efgh	50.67 efgh	11.70 j	1.26 bcd	948.62 jkl	9.40 hi	9.83 gh	461.00 efgh	85.67 gh	46.67bcd
	24	60.00 ab	40.00 ab	11.16 hij	1.35 ab	1365.60 abc	11.46 cde	11.30 bcd	538.33 bcde	95.00 fg	52.67 ab
	36	57.33 gh	42.67 abcd	10.43 fgh	1.13def	1199.34 defgh	10.46 fg	10.46 defg	498.33 defg	86.67 gh	51.33 ab
PEG 6000 @-1.5 MPa	12	52.00 defg	48.00 defg	8.10 a	1.15 cdef	949.52 jk	10.30 fg	7.96 i	417.67 gh	51.67 jk	40.00efg
	24	61.33 a	38.67 a	10.26 ij	1.25bcd	1234.57 cdefg	9.67 gh	10.46 defg	592.67 fg	80.00 h	48.00 bcd
	36	48.00 fghi	52.00 fgh	10.86 fgh	1.05 f	882.72 jklmnop	9.36 hi	9.03 hi	391.33 hi	83.33 gh	49.33bc
Control	-	34.67 k	68.00 k	10.40 ef	0.83 g	481.91 r	7.10 j	6.80 j	327.67 i	46.33 k	29.33 i
Range		61.33-34.67	68.00-38.67	11.70-8.10	1.45-0.79	1448.56-481.91	12.93-7.10	12.60-6.80	667.67-327.67	203.00-46.33	56.67-29.33
SE(d) ±		2.16	2.21	0.25	0.05	56.86	0.29	0.39	30.39	5.08	2.17
CD, 5%		6.19	6.31	0.73	0.151	162.79	0.84	1.12	87.01	14.56	6.23

Means followed by the same letters are not significantly different

Table 3: Effect of priming treatments on germination and seedling growth traits of chilli

Traits	GP	FUS	MGT	GI	SVI	RL	SL	SFW	SDW	SE
Best priming agent	PEG (66.22), GA_3 (65.93)	PEG (33.78), GA_3 (34.07)	HP (6.25)	PEG (2.05)	PEG (530.19)	PEG (4.34), GA_3 (3.86)	GA_3 (3.93), PEG (3.61)	GA_3 (80.89)	GA_3 (52.56)	PEG (47.66)
Best duration										
Hydro priming (HP)	12 hr (54.67)	12 hr (45.33)	36 hr (5.90)	12 hr (2.20)	12 hr (424.79)	12 hr (4.10)	12 hr (3.67)	12 hr (69.00)	12 hr (35.33)	12 hr (51.33)
GA_3 priming (GA_3)	24 hr (73.78)	24 hr (26.22)	36 hr (7.54)	24 hr (2.20)	24 hr (629.14)	24 hr (4.17)	24 hr (4.32)	24 hr (83.89)	24 hr (58.22)	24 hr (47.11)
PEG priming (PEG)	24 hr/36 hr (68.00)	24 hr (32.00)	36 hr (6.71)	24 hr (2.21)	24 hr (595.40)	24 hr (4.78)	24 hr (3.87)	24 hr (76.50)	24 hr (41.67)	24 hr (51.67)
Best concentration										
GA_3 priming	50 ppm (71.11)	50 ppm (28.89)	150 ppm (7.50)	50 ppm (2.30)	50 ppm (603.38)	50 ppm (4.21)	50 ppm (4.19)	50 ppm (101.56)	50 ppm (77.78)	50 ppm (48.00)
PEG priming	-1.1 MPa (68.89)	-1.1 MPa (31.11)	-1.5 MPa (7.26)	-1.1 MPa (2.22)	-1.1 MPa (596.12)	-1.1 MPa (4.80)	-1.1 MPa (3.78)	-1.1 MPa (72.45)	-1.1 MPa (42.00)	-1.1 MPa (51.33)

Table 4: Effect of priming treatments on germination and seedling growth traits of coriander

Traits	GP	FUS	MGT	GI	SVI	RL	SL	SFW	SDW	SE
Best priming agent	PEG (54.67)	PEG (45.34)	HP (9.56), GA_3 (9.97)	PEG (1.2), GA_3 (1.12)	GA_3 (1173.44)	GA_3 (11.81)	GA_3 (11.07)	GA_3 (581.14)	GA_3 (155.67)	PEG (48.00)
Best duration										
Hydro priming (HP)	12 hr (46.67)	12 hr(53.33)	36 hr(9.23)	12 hr(1.07)	12 hr(933.86)	12 hr(10.00)	12 hr(10.97)	12 hr(488.67)	12 hr(74.33)	12 hr(44.00)
GA_3 priming (GA_3)	24 hr(54.22)	24 hr(45.33)	36 hr(9.69)	24 hr(1.28)	24 hr(1297.94)	24 hr(12.34)	24 hr(11.56)	24 hr(605.88)	24 hr(162.89)	24 hr(47.78)
PEG priming (PEG)	24 hr(60.67)	24 hr(39.34)	12 hr(9.90)	24 hr(1.30)	24 hr(1300.09)	24 hr(10.56)	24 hr(10.88)	24 hr(565.50)	24 hr(87.50)	24 hr(50.34)
Best concentration										
GA_3 priming	50 ppm (56.45)	50 ppm(43.55)	150 ppm(9.26)	50 ppm(1.90)	50 ppm(1362.98)	50 ppm(12.41)	50 ppm(11.72)	50 ppm(656.10)	50 ppm(197.78)	50 ppm(48.67)
PEG priming	-1.1 MPa (55.55)	-1.1 MPa (44.45)	-1.5 MPa (9.74)	-1.1 MPa (1.25)	-1.1 MPa (1171.19)	-1.1 MPa (10.42)	-1.1 MPa (10.53)	-1.1 MPa (499.22)	-1.1 MPa (89.11)	-1.1 MPa (50.22)

GP=Germination (%), FUS=Fresh ungerminated seeds, MGT=Mean germination time, GI=Germination index, SVI=Seed vigour index, RL=Root length, SL=Shoot length, SFW=Seedling fresh weight, SDW=Seedling dry weight, SE=Seedling emergence (%)

Conclusion

Priming treatments exhibited marked influence on seed germination and seedling growth of chilli and coriander. The seed germination and seedling growth parameters showed variation in their performance with respect to different priming media, concentrations and durations irrespective of the crops studied. Twelve hours of hydro-priming and 24 hours of 50 ppm GA_3 and -1.1 MPa PEG priming were observed to be best priming treatments for both the crops.

References

1. Amjad M, Khurram Z, Qumer I, Iftikhar A, Riaz AM, Zulfiqar AS. Effect of seed priming on seed vigour and salt tolerance in hot pepper. Pak. J Agri. Sci. 2007; 44:408-16.
2. Badeck B, Van Duijn B, Grzesik M. Effects of water supply methods and seed moisture content on germination of China aster (*Callistephus chinensis*) and tomato (*Lycopersicon esculentum* Mill.). Seeds Europ. J Agron. 2006; 24:45-51.
3. Demir I, Okcu G. Accelerated hydration treatment for improving germination and seedling growth in aubergine (Solanum melongena) and pepper (*Capsicum annuum*). Ann. Appl. Biol. 2004; 144:121-123.
4. Dezfuli PM, Sharif-zadeh F, Janmohammadi M. Influence of priming techniques on seed germination behaviour of maize inbred lines (*Zea mays* L.). J Agri. Bio. Sci. 2008; 3:22-25.
5. Divya P, Devi SN. Priming and storage for enhancement of seed quality in Chilli. J of the Andaman Science Association, 2015; 20:141-144.
6. Harris D. Effects of manure, genotype, seed priming, depth and date of sowing on the emergence and early growth of *Sorghum bicolour* (L.). Soil Tillage Res. 1996; 40:73-88.
7. Islam MS, Abdul MBM, Hossain T, Ahmed JU, Khan HI. Priming on embryo emergence and seedling vigour of small-fruited bitter gourd (*Momordica charantia* L.) under sub-optimal temperature. Inter. J of Agri. Sci. Res. 2012; 2:1-10.
8. Kaur H, Chawla N, Bassi G, Pathak M. Effect of different seed priming treatments on germination of Okra (*Abelmoschus esculentus* L.). Int. J Current Sci. 2015; 15:51-58.
9. Lin JM, Sung JM. Pre-sowing treatments for improving emergence of bitter gourd seedlings under optimal and sub-optimal temperatures. Seed Sci. Tech. 2001; 29:39-50.
10. McDonald MB. Seed deterioration: physiology, repair and assessment. Seed Science & Technology, 1999; 27:177-237.
11. Muhammad SS, Muhammad S, Ahmed Z, Muhammad S. Effect of seed soaking on seed germination and growth of bitter gourd cultivars. IOSR J of Agri. and Veterinary Sci. 2014; 6:07-11.
12. Rubatzky VE, Quiros CF, Simon PW. Carrots and Related Vegetable Umbelliferae. CABI, UK, 1999, 294.
13. Ruttanaruangboworn A, Chanprasert W, Tobunluepop P, Onwimol D. Effect of seed priming with different concentrations of potassium nitrate on the pattern of seed imbibition and germination of rice (*Oryza sativa* L.). J of Integrative Agriculture, 2017; 16(3):605-613.
14. Saini R, Rai PK, Bara BM, Sahu P, Anjer T, Kumar R. Effect of different seed priming treatments and its duration on seedling characters of Bitter gourd (*Momordica charantia* L.). Journal of Pharmacognosy and Phytochemistry, 2017; 6(5):848-850.
15. Sarika G, Basavaraju GV, Bhanuprakash K, Chaanakeshava V, Paramesh R, Radha BN. Investigation on seed viability and vigour of aged seed by priming in French bean. Vegetable Science, 2013; 40:169-73.
16. Singh G. Physiological studies in some vegetable crops. Ph. D. Thesis, Gujarat University, Ahmedabad, 1984, 1-217.
17. Varier A, Vari KA, Dadlani M. The subcellular basis of seed priming. Current Science, 2010; 99(4):450-456.
18. Yogananda DK, Vyakarnahal BS, Shekhargouda M. Effect of seed invigoration with growth regulations and micronutrients on germination and seedling vigour of bell pepper cv. California Wonder. Karnataka J Agri. Sci. 2004; 17(4):811-813.