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Research Paper

Physiological potential of seed germination and seedling vigour of okra and parsley as influenced by seed priming treatments

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ABSTRACT

The experiment was conducted at the division of Basic Sciences and Humanities, SKUAST-Kashmir to improve the germination potential and seedling vigour of parsley and okra seeds during the year 2017 and 2018. Current season's seeds of parsley (curly type) and okra (Pusa sawani) were primed with distilled water, vermiwash (4, 6 and 8x), PEG600 (-0.5, -1.0 and -1.5MPa) and KH_2PO_4 (0.5, 1.0 and 1.5%) at 25±2°C. Hydropriming improved germination potential and seedling vigour attributes, in that 18 and 24 hours of priming were proved as the best priming durations for okra and parsley, respectively. Seed priming of okra with 6x vermiwash (vermi-priming) and 1.0% aqueous solution of KH_2PO_4 (nutri-priming) for 18 hours resulted in best GP (92.4 and 91.0), MGT (1.32 and 2.02) and SVI (3.87 and 3.69) while as seed priming with PEG-6000, -1.5MPa (osmo-priming) for 24 hours was proved as the best priming treatment with GP, MGT and SVI values of 88.1, 2.81 and 3.47, respectively. However, unlike okra, 8x vermi-priming and 1.0% nutri-priming for 24 hours were established as the best priming treatments in parsley with superior values of GP (82.5 and 73.7), MGT (5.9 and 8.0) and SVI (0.30 and 0.23), respectively. Osmo-priming (-1.5MPa) with PEG-6000 again took more priming duration (48 hours) than other priming treatments to produce significantly finer GP (77.8), MGT (7.0) and SVI (0.24). Overall, 8x and 6x vermi-priming for 18 and 24 hours duration were proved as the best treatment for seed enhancement in okra and parsley, respectively.

Key words: Okra, parsley, seed germination, seed priming, seedling vigour

Vegetables are rich sources of vitamins and other essential nutrients, and play an important role in human diet. They also gave more farm income than other crops. However, uniformity and rapidity of seed germination and emergence are essential to increase quality and profitable yield which can be achieved by using improved seed quality. Okra (*Abelmoschus esculentus*) is a nutritious and popular vegetable but suffers from poor and uneven seed germination and emergence (Pandita *et al*., 2010; Khan *et al*., 2017a). Parsley (*Petroselinum crispum*), on the other hand, is a versatile herb that provides a concentrated source of nutrients, particularly rich in vitamins A, C, and K. It can be used as a garnish and flavouring and as a vegetable parsley can be used in almost any savoury dish. But, unfortunately its seeds have shorter viable life and also take longer time for seeds to germinate, especially under unfavorable environmental conditions (Dursun A and Ekinci M. 2010; Khan *et al*., 2017a). Seed priming is known to improve the seed vigour with quick and uniform germination, especially under adverse conditions (Khan *et al*., 2016a; Khan *et al*., 2017b). It is a technique of controlled hydration process which involves exposing the seeds to low water potentials that restrict germination but permit pregerminative physiological and biochemical changes to occur. The conventional way of priming seeds has been to immerse them in an aerated solution of an osmotic material, usually polyethylene glycol (PEG). Nowadays different alternative methods of seed priming together with hydropriming, nutripriming, matrix priming have been used for the purpose of seed invigoration. Likewise, vermi-priming involves the immersion of seeds into the diluted solutions of verminwash for a certain periods of time and drying the seeds again up to its original weight (Khan *et al*., 2015; Khan *et al*., 2016b). However, literatures are scanty regarding the seed priming techniques in okra and parsley. Therefore, the present investigation was planned to improve the seed germination attributes and seedling growth using seed priming techniques.

MATERIALS AND METHODS

The experiment was conducted at the division of Basic Sciences and Humanities, SKUAST-Kashmir during the year 2017 and 2018. Current season's seeds of okra (Pusa sawani) and parsley (curly type) obtained from the division of Vegetable Science (SKUAST-Kashmir) were cleaned brought to a moisture content of 10.0 and 9.0 percent, respectively. Okra seeds was primed with distilled water, vermiwash (4, 6 and 8x), PEG600 (-0.5, -1.0 and -1.5MpPa) and KH_2PO_4 (0.5, 1.0 and 1.5%) at 25±2°C for 12, 18 and 24 hours of priming durations, while as parsley seeds were primed with same priming treatments for 24, 48 and 72 hours duration making two separate set of experiments for okra and parsley.

Four replicates of 50 seeds were placed in 140 mm diameter Petri dishes on ten layers of Whatman No.1 filter paper moistened with 40 ml of distilled water. The Petri dishes were placed in incubator at 25±2ºC for recording of various germination parameters. Germination was observed daily according to the Association of Official Seed Analysis of method (AOSA, 1990) until a constant count was achieved. A seed was considered as germinated when the radicle emerged out of seed coat. Germination percentage (GP) was calculated based on equation-I (Ashraf and Abu-Shakra, 1978). Germination energy, EG (the percentage of germinated seeds at n^{th} day of sowing) of okra and parsley was measured at 4^{th} and 7^{th} day of sowing, respectively following the method of (Bam *et al*., 2006). Germination index (GI) was calculated according to equation-II (Bench *et al*., 1991). The time to reach 50% germination (T_{50}) was calculated according to equation-III (Farooq *et al*., 2005). Mean Germination Time (MGT) was calculated using equation IV (Ellis and Roberts, 1981). Explained as equation IV. Seedling vigour index was calculated using equation V (Abdul-Baki and Anderson, 1973).

$$\text{Final germination percent GP} = \frac{\text{Total germinated seed after 12 days}}{\text{Total number of seeds}} \times 100 \quad \text{......... I}$$

$$\text{Germination index (GI)} = (10\times n1) + (9\times n2) + (8\times n3) + (7\times n4) + (6\times n5) + (5\times n6) + (4\times n7) + (3\times n8) + (2\times n9) + (1\times n1) \quad \text{...... II}$$

Where, n1, n2, n3,……,n10 are the number of germinated seeds on the 1^{st}, 2^{nd} and subsequent days until the 10^{th} day.

$$\text{Time to reach 50\% germination } (T_{50}) = ti + \frac{(N / 2 - ni)(ti - tj)}{ni - nj} \quad \text{....... III}$$

Where, N is the final number of emergence and ni, nj cumulative number of seeds germinated by adjacent counts at times ti and tj, respectively when ni < N / 2 < nj.

$$\text{Mean Germination Time (MGT)} = \frac{\Sigma Dn}{\Sigma n} \quad \text{......... IV}$$

Where, n is the number of seeds, which were germinated on day D, and D is the number of days counted from the beginning of germination.

$$\text{Seedling vigour index} = \text{Germination (\%)} \times \text{Seedling dry weight (g)} \quad \text{......... V}$$

Experimental data was subjected to the statistical analysis for detecting significance of differences among different treatments (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Data generated with regard to hydropriming of okra and parsley seeds (Fig. 1) revealed that different seed germination attributes varied significantly with priming duration wherein optimum priming duration also varied with vegetable crop. A priming duration of 18 hours was proved as best in okra seeds for producing highest germination percent (85.7) with greater energy of germination (66.5), germination index (36.7), and seedling dry biomass (29.1mg) whereas, a priming duration of 24 hours was proved as best for parsley seeds that resulted in highest germination percent (78.7) with highest energy of germination (48.7) germination index (12.8), and seedling dry biomass (3.13mg) as compared to the poorest values of germination percent, energy of germination, germination index, and seedling dry biomass either in control of 24 and 72 hours of priming durations, respectively in okra and parsley. These two priming durations in two crops also produced vigorous seedlings (2.49 and 0.25) with minimum T50 (2.75 and 7.2) and MGT (2.38 and 6.5) values, respectively. Previous studies also suggests that priming durations play important role in improvement of seed germination and seed germination potential of vegetable crops varied with priming durations (Khan *et al*., 2017a; Stephen *et al*., 2018). The improvement in seed germination attributes due to hydropriming treatments may be attributed to build-up of germination-promoting metabolites (Kamithi *et al*., 2016) as well as change in water relation properties (osmotic adjustment) of the seed (Hussain *et al*., 2016). Seed priming synchronizes the metabolism germinating embryo in G2 phase of the cell cycle for uniform development of the seedling. It also triggers β-tubulin production that has key role in spindle formation during cell division (Varier *et al*., 2010).

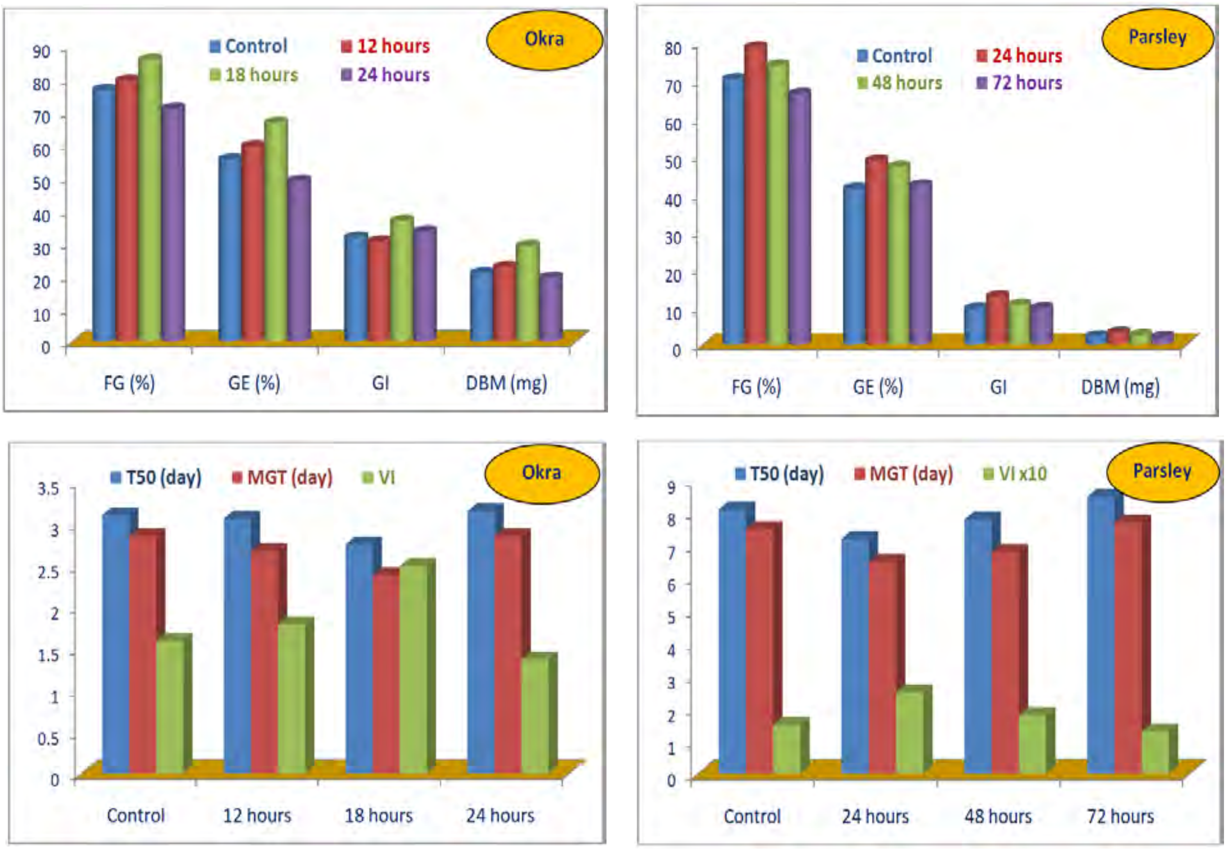

Fig. 1: Effect of hydropriming durations on seed germination attributes of okra and parsley

Data with regard to vermi-priming (table 1) of okra seeds indicate that seed priming in 6x diluted vermiwash and 18 hours priming duration individually, resulted in highest seed germination (88.7 and 90.0%), energy of germination (73.0 and 77.3%), germination index (40.6 and 42.9), seedling dry biomass (31.0 and 30.7mg) and seedling vigour (2.78 and 2.82) with minimum time taken to 50 percent seed germination (2.19 and 2.09day) as well as mean germination time (1.64 and 1.56day). Interaction of vermiwash concentration and priming duration (C × D) also suggested that 6x dilution of vermiwash with 18 hours of priming duration ($C_2 \times D_2$) produced highest germination (92.4%), energy of germination (85.0%), germination index (46.5), seedling dry biomass (41.9mg) and seedling vigour (3.87) with minimum time taken to 50 percent seed germination (1.80day) as well as mean germination time (1.32day).

Data with regard to vermi-priming (table 2) of parsley seeds showed that 8x dilution of vermiwash resulted in maximum germination (76.0%), energy of germination (49.8%), germination index (12.9) and seedling dry biomass (2.71) with least value of T50 (7.2day), MGT (6.7) and most vigorous seedling (0.21). Similarly, priming duration of 24 hours period resulted in highest seed germination (76.8%), energy of germination (56.7%), germination index (12.7), seedling dry biomass (3.44mg) and seedling vigour (0.19) with least value of T50 (7.0day) and MGT (6.6day). Interaction of vermiwash dilution and priming duration (C × D) also validated that 8x dilution with 24 hours priming duration ($C_1 \times D_1$) created maximum germination (82.5%), energy of germination (56.7%), germination index (14.2), seedling dry biomass (3.67mg) and seedling vigour (0.30) with minimum level T50 (6.2day) M GT(5.9day). Comparable research has also been conducted with chilli (Stephen *et al*., 2018) wherein seed priming of chilli with 8x dilution of vermiwash for 30 hours resulted in best germination attributes. Significantly higher germination percent with improved T50, GE and CV has also been reported due seed priming with vermiwash of 8x dilution for 24 hours (Khan *et al*., 2016b). An animated improvement in FGP as well as speed of germination due to vermi-priming may be attributed to the presence of water-soluble macro- and micronutrients, growth promoting hormones, beneficial micro-organisms (Patil *et al*., 2007; Manyuchi *et al*., 2013), etc. which might have also caused a buildup of germination-promoting metabolites, metabolic repair during imbibition and osmotic regulations within the seed.

Table 1: Effect of vermiwash concentration (C) and priming duration (T) on seed germination attribute in okra

Treatments	FG (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
Individual effects							
C_1	78.5	3.04	50.7	2.24	29.6	10.0	0.79
C_2	88.7	2.19	73.0	1.64	40.6	31.0	2.78
C_3	87.4	2.36	70.1	1.74	39.1	24.1	2.16
CD (p≤0.05)	**7.1**	**0.41**	**1.7**	**0.07**	**6.3**	**5.7**	**0.60**
D_1	83.9	2.61	62.6	1.93	35.2	21.4	1.84
D_2	90.0	2.09	77.3	1.56	42.9	30.7	2.82
D_3	80.8	2.89	53.9	2.13	31.2	13.1	1.07
CD (p≤0.05)	**5.3**	**0.34**	**3.7**	**0.03**	**3.1**	**4.9**	**0.04**
Interaction effects							
C_1D_1	77.5	3.10	49.1	2.33	28.3	8.7	0.67
C_1D_2	83.8	2.54	60.3	2.00	34.5	12.4	1.04
C_1D_3	74.3	3.47	42.8	2.40	26.1	9.0	0.67
C_2D_1	88.1	2.35	70.7	1.72	39.1	31.8	2.80
C_2D_2	92.4	1.80	85.0	1.32	46.5	41.9	3.87
C_2D_3	85.6	2.43	63.2	1.87	36.3	19.4	1.66
C_3D_1	86.0	2.38	67.9	1.73	38.3	23.8	2.04
C_3D_2	93.7	1.94	86.5	1.37	47.8	37.8	3.54
C_3D_3	82.5	2.76	55.8	2.13	31.3	10.8	0.89
CD (p≤0.05)	**3.7**	**0.35**	**3.8**	**0.05**	**3.7**	**5.1**	**0.07**

C – Concentration, C_1 = 8x, C_2 = 6x, C_3 = 4x; D – Time duration, D_1= 12 h, D_2 = 18h, D_3 = 24 h

Effect of PEG6000 concentration and priming duration (table 3) on germination attributes of okra, individually as well as in combination, had marked influence on seed germination attributes. PEG6000 with -1.5 MPa (C_3) showed significantly highest level of germination (84.2%), energy of germination (69.0%), germination index (37.2), seedling dry biomass (28.4mg) and seedling vigor (2.39). However, the minimum values of T50 (2.93day) and MGT (2.02day) were recorded with -0.5MPa solution of PEG (C_1). Similarly, highest seed germination (85.5%), energy of germination (66.8%), germination index (36.5), seedling dry biomass (29.2mg) and seedling vigor (2.5) were recorded with 24 hours of priming duration (D_3) while as 12 hours of priming duration (D_1) was able to give minimum levels of T50 (2.5day) and MGT (1.72day). Corresponding to the individual treatments, interaction ($C_3 \times D_3$) data also ratified the top rank of germination (88.1%), energy of germination (78.7%), germination index (42.5), seedling dry biomass (39.4mg) and seedling vigor (3.47). Accordingly, interaction of $C_1 \times D_1$ produced the smallest amount T50 (2.15) and MGT (1.54) values.

Table 2: Effect of vermiwash concentration (C) and priming duration (T) on seed germination attribute in parsley (common curly type)

Treatments	FG (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
			Individual effects				
C_1	76.0	7.2	49.8	6.7	12.9	2.71	0.21
C_2	67.7	8.2	42.9	6.9	10.7	2.63	0.18
C_3	68.2	8.7	40.7	7.1	10.5	2.76	0.19
CD ($p \leq 0.05$)	**2.78**	**0.31**	**3.17**	**0.17**	**0.36**	**NS**	**0.01**
D_1	76.8	7.0	56.7	6.6	12.7	3.44	0.19
D_2	71.5	8.2	43.3	7.0	11.2	2.60	0.13
D_3	63.5	8.9	39.4	7.1	10.1	2.06	0.19
CD ($p \leq 0.05$)	**3.77**	**0.30**	**2.18**	**0.22**	**0.54**	**0.47**	**0.02**
			Interaction effects				
C_1D_1	82.5	6.2	56.7	5.9	14.2	3.67	0.30
C_1D_2	74.0	6.8	51.5	7.1	12.3	2.52	0.19
C_1D_3	71.5	8.5	41.2	7.1	12.1	1.94	0.14
C_2D_1	71.5	7.2	48.6	6.9	11.8	3.25	0.23
C_2D_2	71.5	8.8	39.8	6.8	10.9	2.51	0.18
C_2D_3	60.0	8.7	40.2	6.9	9.4	2.14	0.13
C_3D_1	76.5	7.5	46.7	7.0	12.0	3.41	0.26
C_3D_2	69.0	9.1	38.5	7.1	10.5	2.77	0.19
C_3D_3	59.0	9.5	36.8	7.2	8.9	2.10	0.12
CD ($p \leq 0.05$)	**4.04**	**0.6**	**3.2**	**0.17**	**0.52**	**0.45**	**0.04**

C – Concentration, C_1 = 8x, C_2 = 6x, C_3 = 4x; D – Time duration, D_1= 24 h, D_2 = 48h , D_3 = 72 h

Table3: Effect of PEG-6000 concentration (C) and priming duration (T) on seed germination attribute in okra

Treatments	F G (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
			Individual effects				
C_1	78.7	2.93	52.8	2.02	29.9	16.3	1.28
C_2	78.1	2.95	54.6	2.04	30.2	16.7	1.30
C_3	84.2	3.63	69.0	2.52	37.2	28.4	2.39
CD ($p \leq 0.05$)	**2.5**	**0.22**	**6.4**	**0.28**	**3.5**	**4.7**	**0.30**
D_1	73.4	2.5	44.8	1.72	25.4	9.0	0.66
D_2	82.2	3.5	64.7	2.36	35.4	23.2	1.90
D_3	85.5	3.6	66.8	2.50	36.5	29.2	2.5
CD ($p \leq 0.05$)	**1.7**	**0.20**	**5.4**	**0.25**	**3.7**	**4.8**	**0.27**
			Interaction effects				
C_1D_1	69.8	2.15	39.0	1.54	23.3	8.2	0.57
C_1D_2	80.8	3.40	61.8	2.34	34.1	22.4	1.81
C_1D_3	80.5	3.25	57.5	2.19	32.3	18.2	1.47
C_2D_1	72.8	2.31	44.7	1.60	25.2	8.5	0.62
C_2D_2	78.8	3.12	54.9	2.02	30.7	11.7	0.92
C_2D_3	82.8	3.42	64.3	2.49	34.8	30.0	2.48
C_3D_1	77.6	2.90	50.8	2.01	27.8	10.2	0.79
C_3D_2	86.9	3.85	77.4	2.73	41.4	35.5	3.09
C_3D_3	88.1	4.15	78.7	2.81	42.5	39.4	3.47
CD ($p \leq 0.05$)	**4.8**	**0.22**	**3.7**	**0.18**	**2.5**	**2.5**	**0.23**

C – Concentration, C_1 = 0.50MPa, C_2 = 1.0MPa, C_3 = 1.50MPa; D – Time duration, D_1= 12 h, D_2 = 18h, D_3 = 24 h

Like okra, osmo-priming concentration and duration (table 4) also affected germination attributes in parsley and PEG6000 of -1.5 MPa (C_3) resulted in peak levels of germination (81.0%), energy of germination (48.4%), germination index (11.3), seedling dry biomass (3.07mg) and seedling vigor (0.25) corresponded with minimum values of T50 (7.7day) and MGT (7.1day). Similarly, highest seed germination (77.5%), energy of germination (45.0%), germination index (10.3), seedling dry biomass (2.67mg) and seedling vigor (0.21) were recorded with 24 hours of priming duration (D_3) while no significant differences were observed for T50 and MGT. Interaction effects of $C_3 \times D_3$ also approved the individual effects and showed maximum germination (84.1%), energy of germination (49.8%), germination index (11.5), seedling dry biomass (3.05mg) and seedling vigor (0.27).

Table 4: Effect of PEG-6000 concentration (C) and priming duration (T) on seed germination attribute in parsley

Treatments	FG (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
			Individual effects				
C_1	65.6	8.7	42.2	8.3	9.7	2.24	0.15
C_2	77.8	8.4	43.8	7.6	9.6	2.67	0.20
C_3	81.0	7.7	48.4	7.1	11.3	3.07	0.25
CD ($p\leq0.05$)	**3.1**	**0.3**	**3.1**	**0.4**	**1.1**	**0.09**	**0.03**
D_1	71.2	8.2	45.1	7.5	9.8	2.64	0.19
D_2	75.8	8.4	44.2	7.6	10.5	2.67	0.20
D_3	77.5	8.3	45.0	7.8	10.3	2.67	0.21
CD ($p\leq0.05$)	**1.35**	**NS**	**NS**	**NS**	**0.86**	**NS**	**NS**
			Interaction effects				
C_1D_1	62.5	8.4	43.3	8.0	9.8	2.11	0.13
C_1D_2	67.5	8.8	41.5	8.3	9.7	2.28	0.15
C_1D_3	66.9	8.9	41.7	8.5	9.5	2.33	0.16
C_2D_1	73.3	8.2	44.5	7.4	9.0	2.65	0.19
C_2D_2	78.6	8.6	43.2	7.5	10.1	2.72	0.21
C_2D_3	81.5	8.5	43.6	7.8	9.8	2.63	0.21
C_3D_1	77.8	7.9	47.5	7.0	10.6	3.15	0.24
C_3D_2	81.2	7.8	47.9	7.1	11.8	3.00	0.24
C_3D_3	84.1	7.5	49.8	7.2	11.5	3.05	0.27
CD ($p\leq0.05$)	**2.11**	**0.2**	**1.8**	**0.3**	**1.4**	**0.11**	**0.06**

C – Concentration, C_1 = 0.5MPa, C_2 = 1.0MPa, C_3 = 1.5MPa; D – Time duration, D_1= 24 h, D_2 = 48h , D_3 = 72 h

The finding that osmo-priming improved percent germination is in line with earlier reports (Khan *et al.*, 2016b; Saima *et al.*, 2019). The possible reason for improved germination through priming may be synthesis of proteins and leaching of growth inhibitors (Bray *et al.*, 1989), repair of deteriorative DNA in seeds (Girolamo and Barbanti, 2012) and activation of antioxidant enzymes which lower peroxidation in seeds (Stephen *et al*., 2018).

Seed priming of okra with KH_2PO_4 (nutri-priming) taking different concentration and priming duration (Table 5) showed that 1% of KH_2PO_4 (C_2) individually caused peak germination percent (86.5), energy of germination (69.1%), germination index (38.2), seedling dry biomass (30.1) and seedling vigor index (2.62) while as minimum time taken to 50 percent germination (2.29) and mean germination time (1.87) were recorded with 0.5% KH_2PO_4 solution (C_1). Likewise, a priming duration of 18 hours (D_2) had resulted in uppermost level of germination percent (85.30), energy of germination (67.3), germination index (37.4), seedling dry biomass (25.2) and seedling vigor index (2.20) with minimum T50 and MGT values of 2.61day and 2.57day in in D1 (12 hours) and D2, respectively.

Confirming the individual effects of concentration and duration, interaction of these two factors ($C_2 \times D_2$) also produced maximum germination percent (91.0), energy of germination (81.3), germination index (44.4), seedling dry biomass (40.6) and seedling vigor index (3.69) while as minimum time taken to 50 percent germination (2.13) and mean germination time (1.70) were recorded with ($C_1 \times D_3$).

Table 5: Effect of KH_2PO_4 concentration (C) and priming duration (T) on seed germination attribute in okra

Treatments	FG (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
			Individual effects				
C_1	77.5	2.29	49.8	1.87	28.5	9.9	0.77
C_2	86.5	3.20	69.1	2.69	38.2	30.1	2.62
C_3	84.4	2.96	65.4	2.54	36.0	23.4	2.02
CD ($p \leq 0.05$)	**4.2**	**0.31**	**3.4**	**0.33**	**2.3**	**3.7**	**0.17**
D_1	80.03	2.61	55.1	2.19	30.6	16.7	1.36
D_2	85.30	3.09	67.3	2.57	37.4	25.2	2.20
D_3	82.9	2.76	62.0	2.33	34.7	21.5	1.84
CD ($p \leq 0.05$)	**3.4**	**0.40**	**3.5**	**0.19**	**3.0**	**2.4**	**0.11**
			Interaction effects				
C_1D_1	75.2	2.15	46.2	1.73	26.3	8.7	0.65
C_1D_2	81.3	2.6	56.7	2.18	32.1	12.0	0.98
C_1D_3	75.9	2.13	46.6	1.70	27.1	9.0	0.68
C_2D_1	85.5	3.06	66.5	2.68	36.4	30.8	2.6
C_2D_2	91.0	3.85	81.3	2.02	44.4	40.6	3.69
C_2D_3	83.1	2.70	59.4	2.36	33.8	18.8	1.56
C_3D_1	80.1	2.61	52.5	2.17	29.1	10.5	0.84
C_3D_2	83.5	2.82	63.8	2.52	35.6	23.1	1.93
C_3D_3	89.7	3.44	79.9	2.94	43.2	36.7	3.29
CD ($p \leq 0.05$)	**2.8**	**0.28**	**5.7**	**0.55**	**3.6**	**4.8**	**0.33**

C – Concentration, C_1 = 0.5%, C_2 = 1.0%, C_3 = 1.5%; D – Time duration, D_1= 12 h, D_2 = 18h, D_3 = 24 h

Table 6: Effect of KH_2PO_4 concentration (C) and priming duration (T) on seed germination attribute in parsley

Treatments	FG (%)	T_{50} (day)	GE (%)	MGT (day)	GI	DBM (mg)	VI
			Individual effects				
C_1	70	8.4	44	7.7	11.7	3.02	0.21
C_2	73.2	6.8	52.8	6.3	13.0	3.67	0.27
C_3	63.9	8.5	42.4	7.7	9.4 0	2.47	0.16
CD ($p \leq 0.05$)	**4.8**	**0.65**	**3.4**	**0.6**	**1.4 0**	**0.33**	**0.04**
D_1	73.8	8.0	46.3	7.1	12.3	3.16	0.24
D_2	68.0	7.6	47.9	7.1	11.4	3.03	0.21
D_3	65.2	8.0	45.0	7.4	10.5	3.0	0.19
CD ($p \leq 0.05$)	**3.8**	**0.3**	**2.2**	**NS**	**1.6 0**	**NS**	**0.03**
			Interaction effects				
C_1D_1	73.7	9.2	39.6	8.0	12.3	3.16	0.23
C_1D_2	68.0	7.9	46.9	7.3	10.8	2.94	0.20
C_1D_3	68.3	8.0	45.5	7.8	11.9	2.97	0.20
C_2D_1	80.2	6.4	57.2	6.2	13.6	3.81	0.31
C_2D_2	71.0	6.8	52.6	6.6	13.7	3.64	0.26
C_2D_3	68.4	7.2	48.6	6.2	11.8	3.55	0.24
C_3D_1	67.7	8.5	42.2	7.2	10.9	2.52	0.17
C_3D_2	65.0	8.2	44.2	7.5	9. 6	2.52	0.16
C_3D_3	58.9	8.8	40.8	8.3	7.8	2.38	0.14
CD ($p \leq 0.05$)	**5.1**	**0.8**	**1.3**	**0.5**	**1.4**	**0.19**	**0.06**

C – Concentration, C_1 = 0.5%, C_2 = 1.0%, C_3 = 1.5%; D – Time duration, D_1= 24 h, D_2 = 48h , D_3 = 72 h

Nutri-priming of parsley seeds (Table 6) showed that 1% of KH_2PO_4 (C_2) individually resulted in peak germination percent (73.2), energy of germination (52.8%), germination index (13.0), seedling dry biomass (3.67) and seedling vigor index (0.27) corresponded with minimum time taken to 50 percent germination (6.8) and mean germination time (6.3). A priming duration of 24 hours (D_1) gave highest germination percent (73.8) however, maximum energy of germination (47.9), germination index (11.4) and seedling vigor index (0.21) were again recorded with 48 hours of priming duration (D2) corresponding with minimum T50 and MGT values of 7.6day and 7.1day. Conforming to individual effects of concentration and duration, interaction of $C_2 \times D_2$ also produced maximum germination percent (80.2), energy of germination (57.2), germination index (13.6), seedling dry biomass (3.81) and seedling vigor index (0.31) with minimum time taken to 50 percent germination (6.4) and mean germination time (6.2).

The positive effects of KH_2PO_4 priming in improving germination related traits and seedling emergence has also been previously reported (Toklu *et al*., 2015; Khan *et al*., 2016b). The increase in germination characters due to KH_2PO_4 may be due to the quick availability of ATP and DNA production and better functionality of cell membranes as phosphors is an integral part of living membranes (Rawyler, *et al*., 1999).

CONCLUSION

Hydropriming of okra and parsley seeds for 18 and 24 hours, respectively at 25±2°C has been proved as the best priming duration in terms of obtaining elevated germination percent, speed of germination and seedling vigour. Accordingly, these priming durations were also found as most effective for vermi- and nutri-priming of okra and parsley seeds. However, osmo-priming of okra and parsley seeds for achieving best germination potential required 24 and 48 hours of priming duration, respectively.

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