Original Research Article

Invigorating Effect of Seed Priming as Pre-Treatment Factors on Germination and Seedling Vigour of Tomato

ABSTRACT

A study was undertaken to enhance germination and seedling vigour of tomato cultivar BCT-25 were subjected to different primingtreatments with an objective to enhance germination and seedling vigour. Seed was primed with different priming materials like Moringa leaf extract for eighteen hours; 1% NaCl for thirty-six hours; 10% Polyethylene glycol (PEG) for twelve hours; 100 ppm GA_3, 5% KNO_3 (under dark condition) and 1000 ppm Thiourea for twenty-four hours; distilled water for twelve hours; 2% KH_2PO_4 and 93 ppm NAA (at 4°C) for six hours. All the treatments resulted in improved germination and seedling vigour compared with untreated seeds; however, highest vigour was observed in subject to hydro priming, followed by KH_2PO_4 in both the years; minimum vigour index was noted for T_0. Highest mean germination percentage was found for hydro priming followed by T_8, T_1, T_2, T_3 during both the years, while lowest average germination percentage was recorded for T_0 in two consecutive years. In the field, highest magnitude of seedling emergence was recorded in hydro priming, i.e., 89.67% in first and 86.67% in second year, followed by T_8, T_1, T_2 while it was lowest for T_0 under laboratory condition. Hydro priming observed in highest field vigour indexas compared to all other treatments. All the cases, hydro-priming and KH_2PO_4 observed best performance than other priming materials. But, some cases hydro-priming and KH_2PO_4 were non-significant variation in both laboratory and field condition. From this experiment, it can be concluded that at initial stage of growth plant hydro-priming and KH_2PO_4 play the best performance than other priming materials.

KEY WORDS: Priming; tomato; seedling vigour; germination.

1. INTRODUCTION

Tomato is a perennial plant, normally grown as an annual plant, in the Solanaceae, with a weakly woody stem that usually scrambles over other plants. The fruit is an edible, brightly coloured (usually red, from the pigment lycopene) berry. This cultivable species has a diploid genome with 12 chromosome pairs, i.e., 2n (24). A 100 g of raw tomato supplies 18 kcal energy, 3.9 g of carbohydrates, 0.2 g of fat and 0.9 g of protein, and a moderate amount of vitamin C. Freshly harvested tomato seeds often fail to germinate due to presence of dormancy. Dormancy has also been reported even in one year old seeds. The minimum germination percentage was maintained upto 8th month of storage in refrigerated condition (1). Seed priming is one of the most important physiological methods which improves the seed performance and provides faster and synchronized germination (2). The primed seeds give earlier, more uniform and sometime greater germination and seedling establishment and growth (3). Now-a-days, several priming techniques have been evolved which are being utilized in different crops. Among them hydro-priming, halo-priming and osmo-priming are most common and popular techniques (4). Application of Gibberellic Acid (GA_3) has been reported to increase germination percentage and seedling growth of crop plants under salt stress (5). The influence of GA_3 has been found to enhance seedling growth of crop plants (6;

7). Classical seed priming methods, as well as seed bio-priming techniques, have beneficial effects on tomatoes, in terms of ameliorating seed germination, seedling emergence and vigour, as well as confirming the optimal evolution of all physiological processes throughout the seasons, both in greenhouse and field conditions, under normal and/or stress situations (8). The effect of seed treatments with growth regulators on yield and yield components of common bean (*Phaseolus vulgaris* L.) lines was shown (9). Highest number of grains pod^{-1} and biological yield (14602 kg ha^{-1}) due to growth regulator application was obtained from line D81083 in 0.5 m mol L^{-1} NAA. Effect of different concentrations of PEG on the germination, seedling growth and water relation behaviour of four wheat genotypes under laboratory condition was studied (10). All the parameters showed the best results when wheat seeds treated with 10% PEG solution compared to nonprime and hydro primed seeds, and the value decreased gradually with increasing PEG concentration. The genotype, ESWYT-5 performed best. The effect of different priming agents involving GA_3 (1 ppm), KNO_3 (5%), Na_2HPO_4 (2%), PEG (10%), $ZnSO_4$ (1%), Ascorbic acid (50 ppm) and deionized H_2O was shown (11). Seeds of different solanaceous vegetable crops were soaked for 24 hours and again dried back to their original moisture content under shade dry condition. Observations were recorded on germination/field emergence, root length, shoot length, seedling length, seedling dry weight, seedling vigour index-I & II in both lab and field tests. KNO_3 was found as the best priming treatment followed by Na_2HPO_4 and GA_3 in improving different seed quality parameters. Bio-priming treatment is potentially able to promote quick and even germination as well as better plant growth (12). Priming techniques has been reported to help in dormancy breakdown in many vegetable crops including tomato (13; 14). The present investigation was carried out to observe any change occurring due to priming and assess the influence of different priming treatments over untreated controlunder laboratory condition with that in nursery bed under poly-house condition through its germination potential, seedling growth and vigour status.

2. MATERIALS AND METHODS

The laboratory experiment was carried out in seed testing laboratory, Department of Seed science and Technology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India, during 2019-2020 and 2020-2021 following Complete Randomized Design with three replications. The field trial was conducted in Randomized Block Design with three replications at 'C' Block, Incheck Farm, Kalyani (22.9747° N, 88.4337° E), Nadia during Rabi Oct, 2019-Feb, 2020 and Oct, 2020-Feb, 2021. The seed material for the present investigation is comprised of one tomato genotype viz., BCT-25. Seeds were obtained from AICRP Vegetables, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.

2.1. Seed priming

Pre-sowing seed priming was made with different priming materials after standardisation was made for its concentrations and soaking durations as well. Seed priming was done with Moringa leaf extract (T_1) (1ml of fresh leaf extract diluted with 30 ml of distilled water) for 18 hours; 1% NaCl (T_2) for 36 hours; 10% Polyethylene glycol (PEG) (T_3) for 12 hours; 100 ppm GA_3 (T_4), 5% KNO_3 (T_5) (under dark condition) and 1000 ppm Thiourea (T_6) for 24 hours; distilled water (T_7) for 12 hours; 2% KH_2PO_4 (T_8) and 93 ppm NAA (T_9) (at 4°C) for 6 hours. Dry seeds were considered as the control (T_0).Primed seeds of each treatment were subjected to testing for its quality through glass plate method in Complete Randomized Design with three replications under laboratory condition anddifferent seed quality parameters were recorded accordingly:

2.2 Germination potential

2.2.1 Time to 50% germination

Number of seeds germinated was recorded daily according to the AOSA method (15).The time to obtain 50% germination (T_{50}) was calculated according to the following formulae of (16) modified by (17):

$$T_{50} = t_i + \frac{\left(\frac{N}{2} - n_i\right)(t_j - t_i)}{(n_j - n_i)}$$

Where, N stands for final number of germination and n_i, $n_j$arecumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$.

2.2.2 Mean germination time (MGT)

Mean germination time (MGT) was calculated according to the equation of (18):

$$MGT = \frac{\sum Dn}{\sum n}$$

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

2.2.3 Germination percentage

Germination percentage (G) is calculated as:

$$G = \frac{X}{Y} \times 100$$

Where, X is the number of normal seedlings produced and Y denotes total number of seeds taken for germination (19). It is expressed in percentage.

2.2.4 Germination index (GI)

Germination index (GI) was calculated as described in the Association of Official Seed Analysts (20) as the following formulae:

$$GI = \frac{\text{Number of germinated seeds}}{\text{Day of first count}} + - - - - + \frac{\text{Number of germinated seeds}}{\text{Day of last count}}$$

2.2.5 Germination Energy

Energy of germination (GE) was recorded 4^{th} day after planting. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested (21).

2.2.6 Seedling parameters

Root lengths and shoot lengths of ten seedlings were measured at 14 days after germination by glass plate method in the laboratory with the help of a scale and graph paper and average was made out, expressed in centimetre (cm). Fresh weight of ten seedlings was measured with the help of a digital balance. Then seedlings were dried at 60-70 °C for two hours in hot air oven and weighed in a digital balance. Both seedling fresh weight and dry weight is expressed in gram (g).

2.2.7 Vigour index

Vigour index (VI) was calculated by using the formula suggested by Abdul Baki and Anderson (22):$VI = G \times L$

Where, G indicates germination percentage and L denotes seedling length (cm).

2.2.8 Field vigour

A part of primed seeds of each treatment was broadcasted in nursery bed under poly-house conditionin Randomized Block Design with three replications to assess their field performance through various parameters such as field emergence (%), length of seedling (cm) and vigour index as mentioned earlier.

3. RESULTS AND DISCUSSION

3.2 Germination potential:

3.2.1 Time to 50% germination

Significant variation was noticed among the priming treatments for all the physiological parameters studied under laboratory condition excepting dry weight of seedlings in second year. Minimum duration to 50% germination was recorded in T_7, i.e., 6.50 days in first and 6.41 days in second year, preceded by T_8, T_1, T_2 in both the years, though in second year T_1 and T_2 performed similarly in second year; maximum time to reach 50% germination was observed for T_0, i.e., 10.49 days and 10.14 days in first and second year respectively (Table 1.). Hydro-priming resulted in lower time taken to 50% germination and higher vigour index in maize (23).

3.2.2 Mean germination time (MGT)

During both the years, T_8 (7.45 days in 2019-2020 and 7.37 days in 2020-2021) took shortest period for mean germination and it was closely preceded by T_7, though in first year T_8 and T_7 performed similarly. Similar result was noted by (24), provided lowest values for mean germination time in sunflower after priming with KH_2PO_4. *Vicia faba* and *Vicia sativa* cultivars observed that seed priming with KH_2PO_4could improve the negative effect of ageing by decreasing mean germination time and increasing germination index than other priming including control (25).

3.2.3 Germination percentage

Highest germination percentage was found for T_7 (94.38 in 2019-2020 and 91.84 in 2020-2021) followed by T_8, T_1, T_2, T_3 during both the years, while lowest average germination percentage was recorded for T_0 (75.13 and 74.27) in two consecutive years. This result is in agreement with (26), who observed higher germination and improved seedling growth of lentil in hydro-primed seeds.

3.2.4 Germination index (GI)

Highest germination index was determined for T_8, i.e., 25.66 in first and 25.57 in second year, followed by T_7, T_1, T_2, while it was lowest for T_0 in both years. Priming with KH_2PO_4 advanced germination index in sunflower (24).

3.2.5 Germination energy (%)

Maximum energy of germination was recorded in T_8 (37.88% and 37.56%) in two respective years, followed by T_7, T_1, T_2, while it was minimum for T_0 in both years. Seed priming treatments enhanced the energy of germination over that of untreated seeds andmaximum energy of germination was recorded with hydro-priming in rice (27). Low vigour seeds of hybrid sunflower showed significant decrease in mean germination time and increase in germination index as well as germination energy over non-primed low vigour seeds after priming with KH_2PO_4 (28). In most of the parameters, T_7 and T_8 showed best performance than other priming materials.

Table 1. Influence of seed priming on germination potential of Tomato

Treatments	Time to 50% germination (days)	Mean germination time (days)	Germination (%)	Germination Index	Germination energy (%)
2019-2020					
T_0	10.49	10.76	60.06 (75.13)	14.34	15.13
T_1	7.62	8.04	71.01 (89.44)	22.81	34.83
T_2	8.17	8.92	69.89 (88.21)	22.41	33.34
T_3	8.62	9.16	67.30 (85.14)	20.19	27.52
T_4	9.79	9.95	62.36 (78.51)	19.18	24.21
T_5	9.50	9.87	63.54 (80.19)	19.37	24.54
T_6	8.82	9.23	65.41 (82.72)	20.06	27.37
T_7	6.50	7.50	76.25 (94.38)	25.52	37.37
T_8	6.85	7.45	72.69 (91.18)	25.66	37.88
T_9	8.88	9.15	64.24 (81.15)	19.67	24.75
SEm(±)	**0.725**	**0.229**	**0.073**	**0.029**	**0.024**
LSD (0.05)	**0.244**	**0.077**	**0.218**	**0.085**	**0.070**
2020-2021					
Treatments	**Time to 50% germination (days)**	**Mean germination time (days)**	**Germination (%)**	**Germination Index**	**Germination energy (%)**
T_0	10.14	10.52	59.50 (74.27)	14.12	15.07
T_1	7.47	8.22	69.83 (88.14)	22.66	34.16
T_2	7.49	8.67	67.57 (85.47)	22.34	32.61
T_3	8.31	9.23	66.04 (83.55)	20.16	27.25
T_4	9.47	10.03	62.58 (78.82)	19.12	23.95
T_5	9.47	9.76	63.27 (79.81)	19.33	24.19
T_6	8.53	9.10	64.92 (82.07)	19.94	26.84
T_7	6.41	7.56	73.37 (91.84)	25.45	37.15
T_8	6.74	7.37	71.17 (89.61)	25.57	37.56
T_9	8.56	9.19	63.66 (80.35)	19.53	24.49
SEm(±)	**0.400**	**0.541**	**0.108**	**0.021**	**0.021**
LSD (0.05)	**0.135**	**0.182**	**0.320**	**0.063**	**0.061**

Note: **T_0** = Control, **T_1**=Moringa leaf extract, **T_2** = 1% NaCl, **T_3** = 10% Polyethylene glycol (PEG), **T_4** = 100 ppm GA_3, **T_5** = 5% KNO_3, **T_6** = 1000 ppm,Thiourea, **T_7** =Distilled water, **T_8** = 2% KH_2PO_4, **T_9** = 93 ppm NAA

3.2.6 Seedling parameters and vigour index

Maximum seedling root length was observed for T_7, i.e., 11.94 cm and 11.90 cm in first and second year respectively, it was followed by T_1 in first and T_8 in second year, though T_1, T_2 and T_8 showed non-significant difference among themselves in both the years; while it was minimum for T_0 (6.39 cm in 2019-2020 and 6.38 cm in 2020-2021) (Table 2.). The longest seedling shoot length also was recorded for T_7 (3.37 cm in first and 3.34 cm in second year) followed by T_3, though T_3, T_8 and T_9 performed similarly in both years. In case of fresh and dry weight of seedlings also, significant variation were noted in both years. Highest seedling fresh weight was observed for T_7, i.e., 0.193 g and 0.190 g in first and second year respectively, whereas, both T_7 and T_8 showed highest seedling dry weight with same magnitude of 0.017 in both years. Seed hydro-priming resulted in highest root and shoot fresh weight of seedlings in Bitter gourd (29) and sunflower seeds hydro primed for twelve hours exhibited highest seedling dry weight (30).

3.2.7 Vigour index

Considering vigour index, maximum value was calculated for T_7, i.e., 1445.54 and 1399.59 in first and second year respectively, followed by T_8 in both the years; minimum vigour index was noted for T_0, i.e., 674.95 in 2019-2020 and 665.21 in 2020-2021. In most of the parameters, T_7 and T_8 showed best performance than other priming materials. But, in some cases T_7 and T_8 were non-significant variation at laboratory condition.

Table 2. Influence of seed priming on seedling parameters and vigour index of Tomato:

Treatments	Root length (cm)	Shoot length (cm)	Fresh weight (g)	Dry weight (g)	Vigour index
2019-2020					
T_0	6.39	2.59	0.092	0.010	674.95
T_1	11.35	2.91	0.149	0.016	1275.41
T_2	11.33	2.81	0.148	0.016	1247.00
T_3	10.71	3.13	0.142	0.015	1178.34
T_4	8.79	2.65	0.112	0.012	897.59
T_5	9.58	2.67	0.116	0.012	982.29
T_6	9.94	2.69	0.127	0.014	1044.71
T_7	11.94	3.37	0.193	0.017	1445.54
T_8	11.33	3.05	0.168	0.017	1311.42
T_9	9.50	3.03	0.120	0.013	1017.08
SEm(±)	**1.785**	**0.456**	**0.006**	**0.001**	**0.948**
LSD (0.05)	**0.601**	**0.154**	**0.017**	**0.002**	**2.815**
2020-2021					
Treatments	**Root length (cm)**	**Shoot length (cm)**	**Fresh weight (g)**	**Dry weight (g)**	**Vigour index**
T_0	6.38	2.58	0.092	0.01	665.21
T_1	11.29	2.87	0.148	0.016	1248.70
T_2	11.28	2.78	0.141	0.015	1202.04
T_3	10.68	3.13	0.135	0.014	1153.22
T_4	8.74	2.62	0.113	0.012	894.91
T_5	9.53	2.65	0.112	0.012	972.35
T_6	9.88	2.67	0.127	0.013	1030.53
T_7	11.90	3.34	0.190	0.017	1399.59
T_8	11.30	3.03	0.162	0.017	1284.16
T_9	9.48	3.03	0.120	0.013	1005.18
SEm(±)	**1.243**	**0.474**	**0.001**	**-**	**1.524**
LSD (0.05)	**0.419**	**0.160**	**0.003**	**0.001**	**4.528**

Note: **T_0** = Control, **T_1**=Moringa leaf extract, **T_2** = 1% NaCl, **T_3** = 10% Polyethylene glycol (PEG), **T_4** = 100 ppm GA_3, **T_5** = 5% KNO_3, **T_6** = 1000 ppm,Thiourea, **T_7** =Distilled water, **T_8** = 2% KH_2PO_4, **T_9** = 93 ppm NAA

3.2.8 Field emergence (%), Seedling length (cm) and Field vigour

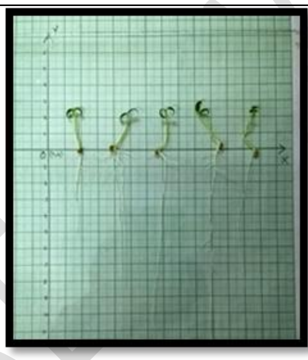
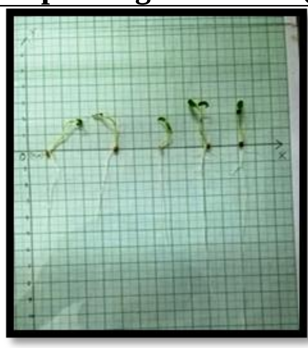
All the parameters recorded in nursery bed under poly-house condition such as, field emergence percentage, length of seedling and vigour index showed significant variation for priming materials during both 2019-2020 and 2020-2021. Highest magnitude of seedling emergence was recorded in T_7, i.e., 89.67% in first and 86.67% in second year, followed by T_8, T_1, T_2, though T_1 and T_2 were statistically non-significant for the trait in second year, while it was lowest for T_0 in both years almost similar to germination percentage observed under laboratory condition (Table 3.). Inhibition of germination due to deficit of water was alleviated by using hydro-primed lentil seeds (26). T_7 (18.08 cm and 18.90 cm) in two consecutive years, showed longest seedling length, while T_7 and T_8 showed non-significant difference amongst them for the character and followed byT_1 during both the years. It was recorded minimum for T_0 in both the years. Hydro-priming produced highest root and shoot length in rice at 30 days after sowing (27). T_7 (1621.47 in first and 1637.71 in second year) resulted in highest field vigour index compared with all other treatments including control. Seed hydro-priming potentially improved seed germination and vigour traits in wooly pod vetch under both laboratory and greenhouse condition (31). All the cases, T_7 and T_8 showed best performance than other priming materials. But, some cases T_7 and T_8 were non-significant variation at field condition also.

Table 3. Influence of seed priming on field vigour of Tomato

Treatments	Field emergence (%)	Seedling length (cm)	Vigour index
2019-2020			
T_0	58.24 (72.33)	9.54	690.30
T_1	67.74 (85.67)	16.99	1455.76
T_2	66.40 (84.00)	16.24	1363.88
T_3	65.13 (82.33)	14.45	1189.99
T_4	59.11 (73.67)	12.02	885.47
T_5	60.20 (75.33)	13.14	989.88
T_6	62.70 (79.00)	13.79	1089.41
T_7	71.24 (89.67)	18.08	1621.47
T_8	69.13 (87.33)	17.56	1533.57
T_9	61.09 (76.67)	13.27	1017.37
SEm(±)	**0.486**	**0.325**	**7.369**
LSD (0.05)	**1.454**	**0.974**	**22.063**
2020-2021			
Treatments	**Field emergence (%)**	**Seedling length (cm)**	**Vigour index**
T_0	56.98 (70.33)	9.56	672.62
T_1	66.14 (83.67)	17.87	1495.40
T_2	65.88 (83.33)	16.39	1365.56
T_3	64.13 (81.00)	15.13	1225.53
T_4	57.61 (71.33)	12.42	885.96
T_5	59.76 (74.67)	13.50	1008.00
T_6	61.77 (77.67)	13.95	1083.19
T_7	68.58 (86.67)	18.90	1637.71
T_8	67.19 (85.00)	18.46	1569.38
T_9	60.20 (75.33)	13.55	1020.52
SEm(±)	**0.429**	**0.157**	**7.26**
LSD (0.05)	**1.284**	**0.472**	**21.736**

Note: **T_0** = Control, **T_1**=Moringa leaf extract, **T_2** = 1% NaCl, **T_3** = 10% Polyethylene glycol (PEG), **T_4** = 100 ppm GA_3, **T_5** = 5% KNO_3, **T_6** = 1000 ppm,Thiourea, **T_7** =Distilled water, **T_8** = 2% KH_2PO_4, **T_9** = 93 ppm NAA

Fig. 1 Different seed priming chemicals

	
Control (T_0)	**Seed priming with MLE (T_1)**
	
Seed priming with NaCl (T_2)	**Seed priming with PEG (T_3)**
	
Seed priming with GA_3 (T_4)	**Seed priming with KNO_3 (T_5)**

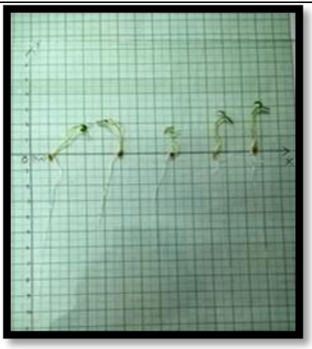
	
Seed priming with Thiourea (T_6)	**Seed priming with distilled water (T_7)**
	
Seed priming with KH_2PO_4 (T_8)	**Seed priming with NAA (T_9)**

Fig. 2 Evaluation of seedling vigour under laboratory condition

Fig. 3 Seedlings in nursery beds

T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9

Fig. 4 Seedlings vigour in infield

4. CONCLUSION

The field emergence was lower than laboratory germination but field vigour index value was quite greater than laboratory vigour index as the field seedlings were absorbed some amount nutrients from soil. So, field seedlings were vigorous than laboratory seedlings. All the cases, hydro-priming and KH_2PO_4 were best performer than other priming materials. So, it can be concluded that at initial stage of growth plant hydro-priming and KH_2PO_4 play the best performance than other priming materials.

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