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

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study investigated the germination and seedling vigour of tomato seeds cultivar BCT-25 under different priming treatments with the objective of enhancing the crop establishment under field conditions. We primed seeds with Moringa leaf extract for 18 hours; 1% NaCl for 36 hours; 10% Polyethylene glycol (PEG) for 12 hours; 100 ppm GA_3, 5% KNO_3 (under dark condition) and 1000 ppm Thiourea for 24 hours; distilled water for 12 hours; 2% KH_2PO_4 and 93 ppm NAA (at 4°C) for 6 hours and the control (T_0). All the treatments improved the seed germination and seedling vigour; however, we found the highest vigour from hydro priming followed by KH_2PO_4 in both years in contrast with the minimum vigour index from T_0. The highest mean germination percentage was found with hydro priming (T_7) followed by T_8, T_1, T_2, T_3 during both years, while the lowest average germination percentage was recorded for T_0. The highest magnitude of seedling emergence under field conditions was recorded with 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 had the highest field vigour indexes than all other treatments. Hydro-priming and KH_2PO_4 had the best performance than other priming treatments. But, in some cases the hydro-priming and KH_2PO_4 were similar in both laboratory and field condition. We concluded that during the initial stage of plant growth hydro-priming and KH_2PO_4 had the best responses than other priming treatments.

Keywords: Priming; tomato; seedling vigour; germination.

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1. INTRODUCTION

Tomato is normally grown as an annual plant from the Solanaceae family with a weak woody stem that usually scrambles over other plants. The fruit is an edible berry with brightly red coloured red because of the lycopene. This species has a diploid genome with 12 chromosome pairs, i.e., 2n (24). One hundred gram of raw tomato supplies 18 kcal of 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 because of dormancy. Dormancy has also been reported even in one year old seeds. The minimum germination percentage was maintained up to 8th month of storage under 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].

Currently, several priming techniques have been developed 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 ameliorating seed germination, seedling emergence and vigour as well as confirming the optimal evolution of all physiological processes throughout the season under greenhouse and field conditions under normal, stress or both conditions [8]. The seed treatments with growth regulators on yield components of common bean (*Phaseolus vulgaris* L.) lines were reported [9] because of the highest number of grains pod^{-1} and biological yield (14602 kg ha^{-1}) because of the growth regulator application in the line D81083 using 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 also studied [10]. All the parameters showed the best results when wheat seeds treated with 10% PEG solution was compared to non-primed and hydro-primed seeds, and the value decreased gradually with the increase of PEG concentration. The genotype, ESWYT-5 performed best. The positive effect of different priming agents and deionized H_2O was shown involving GA_3 (1 ppm), KNO_3 (5%), Na_2HPO_4 (2%), PEG (10%), $ZnSO_4$ (1%), Ascorbic acid (50 ppm) [11].

Seeds of different solanaceous vegetable crops (tomato, brinjal, chilli) were soaked for 24 hours and dried again to their original moisture content under shade dry condition. Observations on germination/field emergence, root length, shoot length, seedling length, seedling dry weight, seedling vigour index 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 rapid and uniform germination as well as better plant growth [12]. Priming technology has been reported to overcome dormancy in many vegetable crops including tomato was carried out to change because of priming and assess the influence of different priming treatments over untreated control under laboratory [13,14]. Thus, the current investigation condition or nursery bed under poly-house condition on germination, 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 the growing season 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° NL, 88.4337° EL), Nadia during Oct, 2019-Feb, 2020 and Oct, 2020-Feb, 2021. The seed for this investigation was from tomato (cv BCT-25); they were obtained from AICRP Vegetables, in Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.

2.1 Seed priming

Seed priming was done with Moringa leaf extract (T_1) (1 ml of fresh leaf extract diluted into 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) under 4°C for 6 hours. Non-primed seeds were the control

(T_0). Primed seeds and the control were tested for quality through glass plate method using complete randomized design with three replications under laboratory condition

2.2 Germination Parameters

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 [16] modified [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 are cumulative 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 [18]:

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

Where n indicates the number of seeds 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) was 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 4th 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 are 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

To determine the field vigour, primed seeds of each treatment were broadcasted in nursery bed under poly-house condition in 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

3.1 Germination Potential

3.1.1 Time to 50% germination

Significant responses were noticed among the priming treatments for all the physiological parameters under laboratory condition excepting dry weight of seedlings in second year. Minimum time 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 and T_2 in both years, although in second year T_1 and T_2 performed similarly in second year; maximum time to 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 to 50% germination and higher vigour index in maize [23].

3.1.2 Mean germination time (MGT)

During both the years, T_8 (7.45 days in 2019-2020 and 7.37 days in 2020-2021) had the shortest mean germination time, and it was closely preceded by T_7 although in first year T_8 and T_7 performed similarly. Similar result was reported [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 treatments as well as the control [25].

3.1.3 Germination percentage

The 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 in first year and 74.27 in second year). This result is in agreement with [26], who observed higher germination and improved seedling growth of lentil in hydro-primed seeds

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3.1.4 Germination index (GI)

The 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. Similar result was shown wharn priming with KH_2PO_4 advanced germination index in sunflower [24].

3.1.5 Germination energy (%)

The maximum energy of germination was recorded in T_8 (37.88% and 37.56%) in two respective years, followed by T_7, T_1, and 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 and maximum 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.

3.1.6 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, although T_1, T_2 and T_8 showed non-significant difference among themselves in both the years; while it was minimmized 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].

3.1.7 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.

3.1.8 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 1. Influence of priming on germination parameters of tomato seeds cv BCT-25

2019-2020					
Treatments	**Time to 50% germination (days)**	**Mean germination time (days)**	**Germination (%)**	**Germination Index**	**Germination energy (%)**
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

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

2019-2020					
Treatments	**Root length (cm)**	**Shoot length (cm)**	**Fresh weight (g)**	**Dry weight (g)**	**Vigour index**
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

2019-2020					
Treatments	**Root length (cm)**	**Shoot length (cm)**	**Fresh weight (g)**	**Dry weight (g)**	**Vigour index**
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	0.010	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**

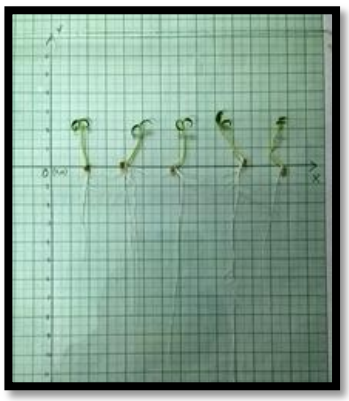
Note: T_0 = Control, T_1=Moringa leaf extract, T_2 = 1% NaCl, T_3 = 10% Polyethylene glycol (PEG), T_4 = 100 ppm GA_3, T_5 = 5% KNO_3, T_6 = 1000 ppm,Thiourea, T_7 =Distilled water, T_8 = 2% KH_2PO_4, T_9 = 93 ppm NAA

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

2019-2020			
Treatments	**Field emergence (%)**	**Seedling length (cm)**	**Vigour index**
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

Control (T_0)

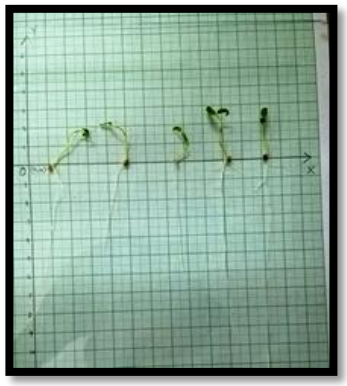


Seed priming with MLE (T_1)

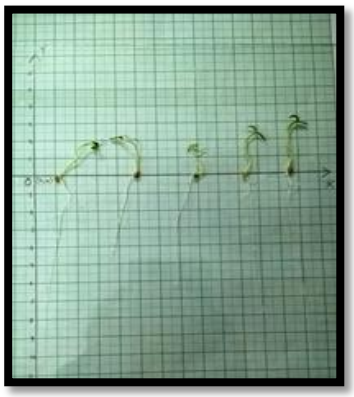
Seed priming with NaCl (T_2)

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. 1. Evaluation of seedling vigour under laboratory condition

Fig. 2. 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. 3. Seedlings vigour in field

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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