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Effect of priming treatment and storage containers to enhance the seed quality of tomato seeds

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Abstract— *A study was undertaken at the Department of Seed Science and Technology, CCS Haryana Agricultural University, to investigate the Effect of priming treatment and storage containers to enhance the seed quality of tomato seeds. The experiment, conducted in 2021-2022, utilized a randomized complete block design to assess various seed priming techniques and their influence on tomato germination and morphological characteristics. Eighteen month-old seeds of tomato seeds were exposed to the following priming treatments T0: Control (untreated). T1: Priming with GA_3 @ 25, 50 and 75 ppm for 24 hours and drying at room temperature. T2: Priming with KNO_3 (Potassium Nitrate) @ 0.5 %, 1 %, and 1.5 % for 24 hours followed by drying at room temperature. T3: Priming with Ethanol @ 25, 50 and 75 ppm for 24 h and drying at room temperature. Within the various priming treatments, tomato seeds subjected to GA_3 priming at a concentration of 50 ppm exhibited the highest rates of germination, seedling length, seedling dry weight, seed vigor index, viability percentage, and radicle emergence. Following closely were seeds primed with KNO_3 at 1.5%. Conversely, ethanol at 50 ppm resulted in the lowest values for germination percentage, seedling length, seedling dry weight, seed vigor index, and viability percentage. Notably, GA_3 priming at 50 ppm demonstrated a substantial improvement, enhancing tomato germination by 24.6% compared to unprimed seeds in 18-month-old seed samples.*

Keywords— ***Priming, Storage containers, Germination percentage, Seed vigor***

I. INTRODUCTION

In India, vegetables form a significant part of the diet due to the large number of vegetarians in the country. Individuals consume an average of 400 grams of vegetables per day, surpassing the World Health Organization's recommended daily intake of 300 grams (World Health Organization). Among the various vegetables, tomatoes (*Solanum lycopersicon* L) hold great importance as they are consumed both fresh and cooked [1].

Tomatoes are cultivated across more than four million hectares of land worldwide, solidifying their status as one of the most extensively grown and consumed vegetables on a global scal

[2].

In India, tomatoes are grown across an expanse of 841 thousand hectares, yielding an average annual production of 20.33 lakh million tons. [3]. Tomatoes belong to the Solanaceae family, which includes other well-known species such as potatoes, eggplants (brinjal), tobacco, and peppers. The origin of tomatoes can be traced back to the Americas. They were introduced to Africa in the 16th century and have since become one of the most widely grown vegetables by small-scale farmers [4].

Tomatoes are not only delicious but also highly nutritious. They are rich in vitamins A, C, and E, as well as antioxidants like lycopene [5]. Additionally, tomatoes are a good source of fiber, carbohydrates, essential amino acids, minerals, vitamins, iron, and phosphorus. They can be consumed raw in salads or used in various culinary preparations such as sauces, soups, ketchup, pure juices, and dishes with meat or fish. Due to their commercial appeal and high yield, tomatoes are considered an economically important crop with a relatively short growing season.

To enhance the performance of tomato seeds, particularly in terms of germination rate and uniformity, seed priming is a commonly practiced pre-sowing hydration technique [6-8]. Seed priming encompasses the immersion of seeds in water, osmotic solutions, or a blend of a solid matrix carrier and water at defined concentrations. This is succeeded by drying before the emergence of the radicle. The objective of seed priming is to induce qualitative enhancements in the seeds, with the intent that these improvements endure even after the treatment concludes. This simple, cost-effective, and low-risk strategy has been shown to increase seedling emergence, seedling vigor, and overall crop yields in various field crops [9].

The process of seed priming significantly contributes to aiding plants in mitigating the detrimental impacts of unfavorable environmental conditions. [10]. By enhancing the performance of seeds, priming contributes to improved germination, seedling establishment, and overall crop productivity. This technique has proven to be beneficial in mitigating the negative impacts of suboptimal conditions, thereby ensuring more robust and uniform crop growth.

II. MATERIAL AND METHODOLOGY

An investigation was conducted at the laboratory of the Department of Seed Science & Technology, CCS Haryana Agricultural University, Hisar, focusing on 18-month-old seeds subjected to various priming treatments. The seed material utilized consisted of Tomato (variety Selection-7) with a germination rate exceeding 70%, meeting the Indian Minimum Seed Certification Standard (IMSCS). These seeds were sourced from the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar.

Two types of containers were employed: seeds stored in a cloth bag (C1) and seeds stored in polythene bags exceeding 700 gauge (C2). These containers were placed under ambient conditions. Observations were made on seed quality parameters, including seed germination percentage, seedling length (cm), seedling dry weight (mg), vigour index -I, and vigour-II. The standard germination test, seedling length test, and vigour index were determined using established procedures. The results were statistically analyzed and presented in below table.

Priming treatment details: -

T0: Control (untreated).

T1: Priming with GA_3 @ 25, 50 and 75 ppm for 24 h at 25°C and drying at room temperature.

T2: Priming with KNO_3 (Potassium Nitrate) @ 0.5 %, 1 %, and 1.5 % for 24 h at 25°C followed by drying at room temperature.

T3: Priming with Ethanol @ 25, 50 and 75 ppm for 24 h at 25°C and drying at room temperature

Observation recorded

The different observations recorded were

I. Germination (%)

II. Seedling length (cm)

III. Seedling dry weight (mg)

IV. Seedling vigour index –I (Germination percentage × Seedling length)

V. Seedling vigour index –II (Germination percentage × Seedling dry weight)

VI. Test weight (g)

VII. Tetrazolium test (%)

I. Standard germination (%)

Three sets of one hundred seeds for each crop were individually positioned between adequately moistened rolled towel papers (BP) and placed in a seed germinator at 25ºC. The initial assessment was conducted on the 5th day, with the conclusive count performed on the 14th day. Only healthy seedlings were taken into account for calculating the percentage of germination, following the guidelines of the International Seed Testing Association [11].

II. Seedling length (cm)

At the final count, ten typical seedlings were randomly chosen from each replication of all seed lots, and their lengths were measured in centimeters. The average length of these selected seedlings was then computed.

III. Seedling dry weight (mg)

The ten healthy seedlings, previously utilized for measuring seedling length, were also employed for assessing seedling dry weight. These seedlings underwent a drying process in a hot air oven at 80ºC for 48 hours,

after which they were taken out, allowed to cool in desiccators for 30 minutes, and then weighed using an electronic balance. The average weight of the dried seedlings from each replication was calculated and reported in milligrams.

Seed vigour indices

Seedling vigour indices were calculated by using the formula suggested by [12] as follows: -

IV. Vigour Index-I

Vigour Index-I = Standard germination (%) × Average seedling length (cm)

V. Vigour Index-II

Vigour Index-II = Standard germination (%) × Average seedling dry weight (mg)

VI. Test weight (g):

A total of one thousand seeds from each variety, distributed across three replications, were meticulously counted and weighed utilizing an electronic balance. The resultant average seed weight for both crops was then expressed in grams.

VII. Tetrazolium test (%)

In three separate replicates, fifty seeds from each variety were submerged in 50 ml of water. These seeds were maintained under these conditions for 16 hours at 25°C to activate dehydrogenase enzymes. Following this, a longitudinal incision was made through the mid-section of both the embryo and the endosperm. Subsequently, the seeds were placed in petri plates and stained with a 0.5 percent tetrazolium solution (2, 3, 5-triphenyl tetrazolium chloride) for 4 hours at 38 °C. After draining the solution, the seeds underwent a brief rinse in tap water and were examined under magnification. Seeds displaying a red stain throughout the entire embryo were considered normal and viable, with the results expressed as a percentage.

III. RESULTS AND DISCUSSION

The priming treatments applied to tomato seeds had a significant positive impact on germination and viability even after 18 months of storage. The results showed that all priming treatments, except for ethanol at 75 ppm, significantly improved the germination percentage. Among the different priming treatments, seeds primed with GA3 @ 50 ppm exhibited the highest germination percentage, recording 76.33 % and 68.67 % germination rates. Following closely, seeds primed with KNO_3 @ 1.5 % showed a germination percentage of 71.67 % and 66.67 %. On the other hand, the lowest germination percentage was observed in seeds primed with ethanol @ 50 ppm, which recorded 61.33 % and 58.33 % germination rates in polythene and cloth bags, respectively. Polythene bags demonstrated a higher germination percentage at 64.50 % compared to cloth bags at 60.00 % (Table 1). However, ethanol @ 75 ppm negatively affected the germination percentage compared to the control.

Similar findings were reported by [13], who observed an increase in germination percentage with the application of GA_3. [14] found similar results in hot pepper, [15] in sesame seeds, [16] in Indian mustard, and [17] in their study on gibberellic acid treatment in various crops. [18] also reported a significant increase in germination percentage in wheat with GA_3 at 50 ppm. Research has shown that the release of gibberellic acid from the embryo during germination triggers specific genes responsible for α-amylase mRNA transcription [19]. Consequently, the introduction of external gibberellic acid (GA3) can activate these genes within the seeds. Additionally, exogenous GA3 has the capacity to impact cytokinin transport across membranes, playing a crucial role in initiating the biochemical processes essential for successful germination [20].

The favorable effects of priming treatments on both seedling length and seedling dry weight aligned with the patterns observed in germination percentages. Among the diverse priming treatments, seeds treated with GA3 at 50 ppm displayed the highest seedling lengths, measuring 10.17 cm and 8.77 cm. In close succession, seeds subjected to KNO3 at 1.5% exhibited seedling lengths of 9.81 cm and 8.53 cm. Conversely, seeds primed with ethanol @ 50 ppm demonstrated the minimum seedling length, recording 8.78 cm and 7.40 cm in polythene and cloth bags, respectively (Table 2). Regarding seedling dry weight, seeds primed with GA_3 @ 50 ppm recorded the highest values, with seedling dry weights of 16.89 mg and 14.36 mg. Seeds primed with KNO_3 @ 1.5 % followed closely with seedling dry weights of 16.29 mg and 14.15 mg. On the other hand, seeds primed with ethanol @ 50 ppm showed the lowest seedling dry weight, measuring 13.60 mg and 11.66 mg in polythene and cloth bags, respectively (Table 3).

Consistent with previous findings, the seed vigor indices, namely Seed Vigor Index-I and Seed Vigor Index-II, exhibited similar trends (Table 4 and 5). All priming treatments, except for ethanol @ 75 ppm, significantly improved the Seed Vigor Index-I. Among the treatments, seeds primed with GA_3 @ 50 ppm achieved the highest Seed Vigor Index-I values, measuring 776.2 and 602.3. Following closely, seeds primed with KNO_3 @ 1.5 % showed Seed Vigor Index-I values of 702.8 and 568.8. On the other hand, seeds primed with ethanol at 50 ppm

exhibited the lowest Seed Vigor Index-I, recording 535.3 and 431.7 in polythene and cloth bags, respectively.

Similar trends were observed in Seed Vigor Index-II, with seeds primed with GA_3 @ 50 ppm displaying the highest values, recording Seed Vigor Index-II of 1288.9 and 985.7. Seeds primed with KNO_3 @ 1.5 % followed closely, exhibiting Seed Vigor Index-II values of 1167.4 and 943.6. Conversely, seeds primed with ethanol at 50 ppm showed the lowest Seed Vigor Index-II, measuring 833.8 and 680.3 in polythene and cloth bags, respectively.

These results further validate the effectiveness of the priming treatments, particularly GA_3 @ 50 ppm, in enhancing seed vigor indices. The increased Seed Vigor Index-I and Seed Vigor Index-II values indicate improved seed quality, germination potential, and overall seedling performance. Similar findings have been reported in studies conducted on hot pepper by [14], on chilli by [22] and on tomato and chilli by [9].

Among the treatments, seeds primed with KNO_3 @ 0.5% exhibited the highest test weight, measuring 3.51 and 3.49 g, followed by seeds primed with GA_3 @ 25 ppm with test weights of 3.47 and 3.46 g. On the other hand, seeds primed with ethanol @ 75 ppm showed the lowest test weight, registering 3.43 and 3.41 g in polythene and cloth bags, respectively. Nevertheless, no notable impact of the varied priming treatments was observed on the test weight of the seeds. (Table 6). These findings are consistent with the results reported by [14] in hot pepper, which also showed no significant effect of different priming treatments on test weight.

The viability percentage of tomato seeds, even after 18 months of storage, demonstrated a significant positive response to the priming treatments. Notably, seeds subjected to GA3 priming at 50 ppm exhibited the highest viability percentages, reaching 77.67% and 73.33%. Following closely, seeds primed with KNO_3 @ 1.5% showed viability percentages of 75.67 % and 71.33 %. Conversely, seeds primed with ethanol @ 50 ppm recorded the lowest viability percentages, registering 65.33 % and 61.33 % in polythene and cloth bags, respectively (Table 7).

Table. 1 Effect of priming treatments and storage containers on seed germination (%) of tomato seeds

Treatments (T)	**Storage containers (C)**		
	Cloth bag	**Polythene bag**	**Mean**
Control	55.67 (48.24)	60.67 (51.14)	58.17 (49.69)
GA3 25ppm	61.33 (51.53)	67.00 (54.92)	64.17 (53.22)
GA3 50ppm	68.67 (55.97))	76.33 (60.87)	72.50 (58.42)
GA3 75ppm	57.67 (49.39)	63.67 (52.91)	60.67 (51.15)
KNO_3 0.5%	55.00 (47.85)	61.33 (51.53)	58.17 (49.69)
KNO_3 1%	63.00 (52.52)	66.00 (54.32)	64.50 (53.42)
KNO_3 1.5%	66.67 (54.71)	71.67 (57.82)	69.17 (56.27)
Ethanol 25ppm	61.67 (51.73)	64.00 (53.11)	62.83 (52.42)
Ethanol 50ppm	58.33 (49.78)	61.33 (51.53)	59.83 (50.65)
Ethanol 75ppm	52.00 (46.13)	53.00 (46.70)	52.50 (46.42)
Mean	60.00 (50.78)	64.50 (53.48)	
C.D (P=0.5)	C= 0.797, T= 1.783, CxT= 2.521		
SE(m)	C= 0.278, T= 0.621, CxT= 0.879		

Table. 2 Effect of priming treatments and storage containers on seedling length (cm) of tomato

Treatments (T)	**Storage containers (C)**		
	Cloth bag	**Polythene bag**	**Mean**
Control	7.30	8.77	7.90
GA3 25ppm	8.13	9.63	8.88
GA3 50ppm	8.77	10.17	9.47
GA3 75ppm	7.57	9.46	8.51

KNO_3 0.5%	7.46	8.70	8.08
KNO_3 1%	8.10	9.44	8.77
KNO_3 1.5%	8.53	9.81	9.17
Ethanol 25ppm	7.63	8.87	8.25
Ethanol 50ppm	7.40	8.78	8.09
Ethanol 75ppm	6.80	8.20	7.50
Mean	7.74	9.15	
C.D (P=0.5)	C=0.094, T= 0.211, CxT= 0.298		
SE(m)	C=0.033, T= 0.073 CxT=0.104		

Table. 3 Effect of priming treatments and storage containers on seedling dry weight (mg) of tomato

Treatments (T)	**Storage container (C)**		
	Cloth bag	**Polythene bag**	**Mean**
Control	9.60	11.42	10.51
GA3 25ppm	14.20	16.15	15.10
GA3 50ppm	14.36	16.89	15.62
GA3 75ppm	13.71	15.44	14.58
KNO_3 0.5%	13.01	15.41	14.21
KNO_3 1%	13.77	15.66	14.72
KNO_3 1.5%	14.15	16.29	15.22
Ethanol 25ppm	13.08	15.43	14.26
Ethanol 50ppm	11.66	13.60	12.63
Ethanol 75ppm	9.55	11.24	10.40
Mean	12.69	14.75	
C.D (P=0.5)	C=0.146, T=0.327, CxT=0.436		
SE(m)	C=0.051, T=0.114, CxT=0.161		

Table.4 Effect of priming treatments and storage containers on seed vigour Index-I of tomato

	Storage containers (C)		
Treatments (T)	**Cloth bag**	**Polythene bag**	**Mean**
control	391.8	531.9	461.9
GA3 25ppm	498.8	645.4	572.1
GA3 50ppm	602.3	776.2	689.3
GA3 75ppm	436.3	602.1	519.2
KNO_3 0.5%	410.7	533.6	472.2
KNO_3 1%	510.3	622.8	566.6
KNO_3 1.5%	568.8	702.8	635.8
Ethanol 25ppm	470.7	567.4	519.1
Ethanol 50ppm	431.7	535.3	483.5
Ethanol 75ppm	353.6	434.8	394.2
Mean	467.5	593.6	
C.D (P=0.5)	C=10.24, T=22.90, CxT=32.38		
SE(m)	C=3.57, T=7.98, CxT=11.29		

Table.5 Effect of priming treatments and storage containers on seed vigour index- II of tomato

Treatments (T)	Storage containers (C)		
	Cloth bag	Polythene bag	Mean
Control	534.1	692.8	613.4
GA3 25ppm	862.0	1081.8	971.9
GA3 50ppm	985.7	1288.9	1137.3
GA3 75ppm	790.4	983.4	886.9
KNO_3 0.5%	715.4	944.9	830.2
KNO_3 1%	867.7	1033.7	950.7
KNO_3 1.5%	943.6	1167.4	1055.5
Ethanol 25ppm	806.4	987.7	897.1
Ethanol 50ppm	680.3	833.8	757.0
Ethanol 75ppm	496.7	596.0	546.3
Mean	768.2	961.0	
C.D (P=0.5)	C=14.08, T=31.48, CxT=44.52		
SE(m)	C=4.91, T=10.97, CxT=15.52		

Table.6 Effect of priming treatments and storage containers on test weight (g) of tomato seeds

Treatments (T)	Storage containers (C)		
	Cloth bag	Polythene bag	Mean
Control	3.40	3.43	3.42
GA3 25ppm	3.46	3.47	3.47
GA3 50ppm	3.45	3.45	3.45
GA3 75ppm	3.44	3.44	3.44
$KNO_3$0.5%	3.49	3.51	3.50
KNO_3 1%	3.47	3.49	3.48
KNO_3 1.5%	3.45	3.47	3.46
Ethanol 25ppm	3.43	3.45	3.44
Ethanol 50ppm	3.43	3.44	3.44
Ethanol 75ppm	3.40	3.43	3.42
Mean	3.44	3.46	
C.D (P=0.5)	C=0.007, T=0.015 CxT=N.S		
SE(m)	C=0.002, T=0.005, CxT=0.008		

Table. 7 Effect of priming treatments and storage containers on viability (%) of tomato seeds

Treatments (T)	Storage containers (C)		
	Cloth bag	Polythene bag	Mean
Control	61.67 (51.73)	66.67 (54.72)	64.17 (53.22)
GA3 25ppm	70.33 (56.98)	73.67 (59.11)	72.00 (58.04)
GA3 50ppm	73.33 (58.91)	77.67 (61.78)	75.50 (60.35)
GA3 75ppm	66.67 (54.71)	69.00 (56.14)	67.83 (55.43)
KNO_3 0.5%	65.33 (53.92)	67.67 (55.33)	66.50 (54.62)
KNO_3 1%	68.67 (55.94)	72.67 (58.47)	70.67 (57.20)

KNO_3 1.5%	71.33 (57.61)	75.67 (60.42)	73.50 (59.02)
Ethanol 25ppm	67.33 (55.12)	70.00 (56.77)	68.67 (55.95)
Ethanol 50ppm	61.33 (51.53)	65.33 (53.91)	63.33 (52.72)
Ethanol 75ppm	56.00 (48.43)	61.00 (51.34)	58.50 (49.88)
Mean	66.20 (54.49)	69.93 (56.80)	
C.D (P=0.5)	C=0.814, T=1.821, CxT=2.145		
SE(m)	C=0.284, T=0.635, CxT=0.898		

IV. CONCLUSION

According to a research study, the priming of seeds with GA_3 @ 50 ppm has shown notable benefits. The germination rate of tomato seeds increased by 24.6 % compared to untreated seeds. Furthermore, GA_3 @ 50 ppm effectively controlled fungal infections and enhanced various seed quality parameters, including seedling length, seedling dry weight, seed vigor indices, viability percentage, test weight, seed density, and radicle emergence.

In summary, the research findings indicate that the application of GA_3 @ 50 ppm during seed priming offers significant advantages. It enhances germination rates for tomato, helps control fungal infections, and improves various seed quality characteristics, thereby contributing to overall seed performance.

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