Research Article:

EFFECT OF SEED PRIMING ON GERMINATION AND SEEDLING GROWTH OF TOMATO (*Solanum lycopersicum* L. cv. Gaurabh 555)

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ABSTRACT

Tomato (*Solanum lycopersicum* L.) is a widely grown profitable vegetable in Nepal. However, low seed germination and poor seedling growth have been major constraints in tomato production. Seed priming as a pre-sowing treatment enhances germination and produces uniform and vigorous seedlings that tolerate field stresses. This experiment was conducted in Gauradaha, Jhapa, Nepal, during August-September 2022 to evaluate the effect of seed priming on seed germination and seedling growth of tomato variety 'Gaurabh 555' under greenhouse conditions. This experiment was laid out in Completely Randomized Design (CRD) with eleven treatments and three replications including control, hydropriming (distilled water for 24 hours), hot water (50°C for 5 minutes), Potassium nitrate (0.25%, 0.5%, 0.75%, 1% for 24 hours) and Gibberellic acid (25 ppm, 50 ppm, 75 ppm, 100 ppm for 24 hours). Germination percentage, germination index, and mean germination time were non-significant at 5% level of significance, but seedling growth parameters were significant. The maximum shoot length (18.5 cm), root length (5.8 cm), number of leaves (5.2), seedling vigor index (2203), seedling fresh weight (1.16 g), and seedling dry weight (0.08 g) were observed in the seeds primed with KNO_3 0.75%. Thus, KNO_3 0.75% was found to be most suitable priming agent for growth, fresh and dry weight of tomato seedlings.

सारांश

गोलभेडा नेपालमा खेती गरिने महत्वपूर्ण तरकारी बाली हो । तर बीउको न्यून उमार शक्ति र विरुवाको कमजोर वृद्धि विकास यस बालीका बिरुवा उत्पादनका प्रमुख समस्याका रूपमा रहेका छन् । बीउलाई रोप्नुअघि विभिन्न प्राइमिङ प्रविधिद्वारा पूर्व-उपचार गर्दा अंकुरण दर सुधार हुनुका साथै समान, सबल र प्रतिकूल अवस्थासँग सामना गर्न सक्ने विरुवा उत्पादन गर्न सकिन्छ । यो अनुसन्धान गोलभेडाको बीउको उमार शक्ति र वृद्धिमा प्राइमिङको प्रभाव अध्ययन गर्न वि.सं २०७९ सालको साउन-भदौ महिनामा झापा जिल्लाको गौरादहमा गरिएको थियो । उपचारहरूमा नियन्त्रण, हाइड्रोप्राइमिङ (डिस्टिल्ड पानीमा २४ घण्टा), तताइएको पानी (५० डिग्री सेल्सियसमा ५ मिनेट), पोटासियम नाइट्रेट (०.२५%, ०.५%, ०.७५%, १% मा २४ घण्टा) र जिबर्लिक एसिड (२५, ५०, ७५, १०० पि.पि.एम मा २४ घण्टा) गरी तीन पटक दोहोर्याइ राखिएको थियो । परिणामस्वरूप अंकुरण प्रतिशत, अंकुरण सूचकाङ्क र औसत अंकुरण समय ५% सम्भाव्यता स्तरमा उल्लेखनीय नभए पनि विरुवा वृद्धिमा भने महत्वपूर्ण प्रभाव देखियो । विशेषत: सबैभन्दा बढी विरुवाको लम्बाइ (१८.५ से.मी.), जराको लम्बाइ (५.८ से.मी.), पात संख्या (५.२), विरुवा सबलता सूचक (२२०३), ताजा पदार्थ (१.१६ ग्राम) र सुख्खा पदार्थ (०.०८ ग्राम) ०.७५% पोटासियम नाइट्रेटमा उपचार गरिएको बीउमा प्राप्त भयो । त्यसैले बीउ उपचार गर्न ०.७५% पोटासियम नाइट्रेट प्रयोग गरिएको अवस्थामा गोलभेडाको विरुवा वृद्धिमा उल्लेखनीय सुधार हुने देखिएको छ ।

Keywords: Gibberellic acid, greenhouse condition, hydro priming, potassium nitrate, seedling vigor index

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a popularly cultivated solanaceous vegetable (Naika et al., 2005). It has various culinary uses and is rich in nutrients such as vitamin C, lycopene, flavonoids, and carotene. A ripe tomato contains (average value per 100 g of edible portion) water (95%), energy (18 calories), protein (0.9 g), carbohydrate (3.9 g), sugar (2.6 g), fibre (1.2 g), fat (0.2 g) (Ali et al., 2020). It is native to South America and has been cultivated in outdoor fields, greenhouses, and nethouses. In Nepal, it occupies third rank in terms of area (22911 ha) and productivity (18.75 t/ha) after cauliflower and cabbage (MoALD, 2023). Low seed germination and poor seedling growth lead to poor stand establishment of crops (Hadas, 2005). The poor establishment of crops affects the yield and quality, which greatly influence the economic factors of agriculture (Maiti et al., 2013).

Germination begins with the activation of water uptake, the phenomenon known as imbibition (Bewley et al., 2013)which can include the endosperm, perisperm, testa, or pericarp. The absorption of water by the seed (imbibition. During germination, metabolic pathways of the seed are activated, leading to embryo growth and emergence of a new seedling (Rasmussen et al., 2015). For optimizing crop production, plant stand establishment is very important. Poor germination of seeds and suboptimal environmental conditions are common in field conditions. Often, the temperature and moisture of soil or media become suboptimal for the germination of seeds (Sghaier et al., 2022). Sometimes, for this process, special treatment is required (Singh et al., 2018). Among various research approaches, seed priming has been successfully applied so far in improving germination and crop growth (Gebeyaw, 2020). Seed priming treatment is a technique which is done before sowing for proper imbibition of water. There are various techniques of seed priming, such as hydropriming, halopriming, and hormonal priming. It enables metabolic events before germination and radicle emergence, followed by drying and maintaining moisture close to the original state (Pawar & Laware, 2018). It acts as a low-risk and low-cost intervention which increases and stabilizes production and has a greater impact on the livelihoods of farmers (Koirala, 2006). It is a physiological seed enhancement method to overcome poor and erratic seed germination that breaks seed dormancy and makes the seed ready to germinate (Patil, 2018). Seed priming can also address the challenges of adverse environmental stress, both biotic and abiotic (Seleiman et al., 2021).

Primed tomato root tip cells were arrested in the G2 phase of mitosis and did not complete cell division (Sliwinska, 2009), potentially activating stress response pathways to better cope with challenging conditions. Despite this delay in root tip cells, seed priming promotes shoot growth by accelerating cell elongation and division in the sub-apical meristematic region, leading to increased internodal length and regulating mitotic activity in that area (Harris et al., 2001) almost 1250 on-farm trials were implemented by farmers in India for maize, upland rice and chickpea between 1995 and 1998 and 91 trials for maize and sorghum in Zimbabwe in 1997–1998. In each trial, farmers were asked to soak seed overnight, surface-dry it then sow it in the normal way in a plot next to a plot with dry seed. The farmers in each village evaluated the trials during farm walks and group discussions. These group methods allowed farmers to assess the effect of seed priming over a wide range of soils and levels of management. Direct benefits in all crops included: faster emergence; better, more uniform stands; less need to re-sow; more vigorous plants; better drought tolerance; earlier flowering; earlier harvest; and higher grain yield. In India, where a post-rainy season crop is often grown on residual soil moisture or using supplementary irrigation, indirect benefits reported were: earlier sowing of following crops; earlier harvesting of those crops, which allowed earlier seasonal migration from the area in search of work for cash; increased willingness to use fertilisers because of reduced risk of crop failure; and use of time saved to grow a third crop (mung bean. This suggests that while seed priming may temporarily halt root cell division, it enhances growth in other plant regions by optimizing mitosis and cell expansion. Potassium nitrate plays an important role as a seed priming agent on seedling establishment and vigour (Ali et al., 2020). Seed priming with nitrate solutions resulted in better seed germination and seedling establishment (Harris, 2001). Pre-sowing seed treatment hydropriming technique improved germination rates and is preferred in enhancing crop productivity (Sushma et al., 2023). Tomato seeds subjected to KNO_3 resulted in quicker germination, higher final emergence percentage, root and shoot length, and seedling dry weight (Farooq et al., 2005). Gibberellic acid (GA_3) is essential for increasing the seedling vigour index. It removes seed dormancy, encourages seed germination, and reduces the germination period (Maiti, 2013). Thus, this research was conducted to study the effect of different seed priming methods on seed germination and seedling growth of tomato.

RESEARCH METHODS

Climatic conditions of the experimental site

This experiment was carried out at the Gauradaha Agriculture Campus, Gauradaha municipality-02, Jhapa, Nepal, at an altitude of about 79 m above sea level. Generally, Jhapa receives 250 to 300 cm of rainfall per annum, which occurs mostly during the monsoon season (June-August) (DHM, 2024). The average daily temperature and RH recorded were 30.58 ºC and 81%, respectively, during the experimental period.

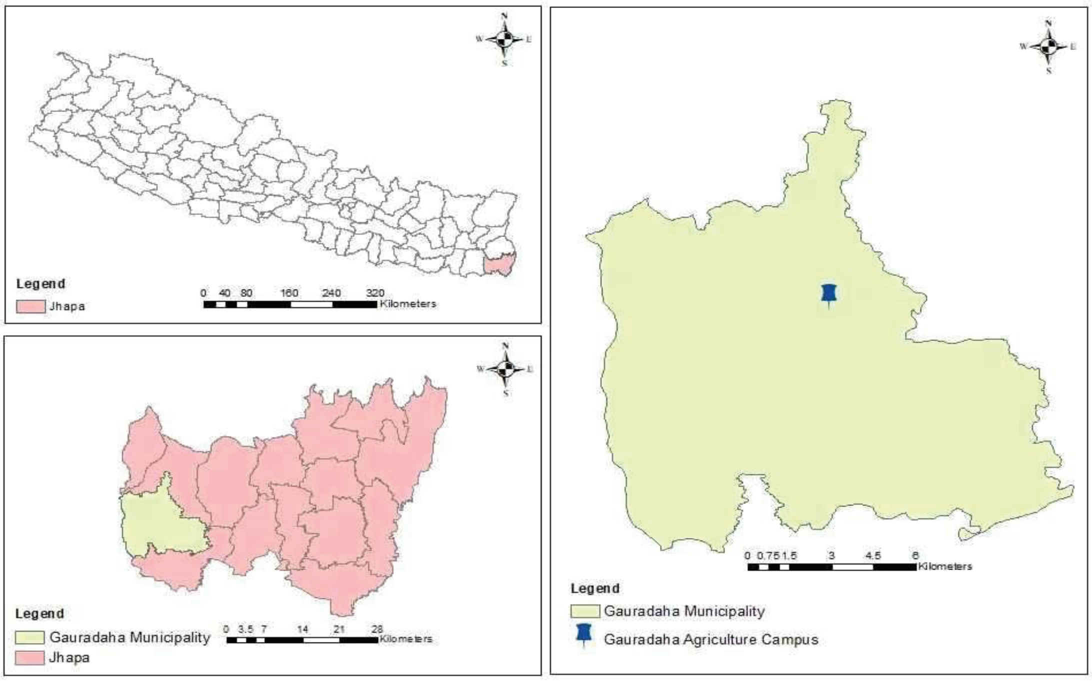

Fig. 1. Location map of the experimental site

Source of seed

The F_1 hybrid tomato cultivar "Gaurabh 555" was obtained from Iris Hybrid Seed Company with a purity of 98% and germination of 80-85%. It is a semi-determinate cultivar (250-300 cm tall). Fruits are oval-shaped and bright red in color. It was registered in 2009 AD in Nepal, matures in 100-105 days, has a potential yield of 106 t/ha, and is recommended for the terai region of Nepal up to 150 masl (MoALD, 2025).

Experimental design and treatment details

This experiment was laid out in a Completely Randomized Design (CRD) with eleven treatments and three replications (Table 1). Tomato seeds were primed with Potassium nitrate (KNO_3) at

0.25%, 0.50%, 0.75%, 0.1% (w/v); Gibberellic acid (GA_3) at 25 ppm, 50 ppm, 75 ppm, 100 ppm, hydropriming for 24 hours at 25 ºC, and hydropriming with hot water at 50 ºC for 5 minutes.

Table 1. Treatment details

S.N.	Name of treatments
T_1	Control
T_2	Hydro priming
T_3	Hydro priming with hot water
T_4	0.25% KNO_3
T_5	0.50% KNO_3
T_6	0.75% KNO_3
T_7	1.00% KNO_3
T_8	25 ppm GA_3
T_9	50 ppm GA_3
T_{10}	75 ppm GA_3
T_{11}	100 ppm GA_3

Preparation of priming solution

Priming solutions of GA_3 and KNO_3 were prepared first (Table 2). GA_3 and KNO_3, each with 99% purity, were used in the experiment.

Table 2. Preparation method of priming solutions used in the experiment

SN	Priming solution	Method of preparation
1.	0.25% KNO_3	0.25 g of KNO_3 was added to 100 ml volumetric flask and distilled water was added up to the mark to make final 100 ml solution.
2.	0.50% KNO_3	0.50 g of KNO_3 was added to 100 ml volumetric flask and distilled water was added up to the mark to make final 100 ml solution.
3.	0.75% KNO_3	0.75 g of KNO_3 was added to 100 ml volumetric flask and distilled water was added up to the mark to make final 100 ml solution.
4.	1.00% KNO_3	1 g of KNO_3 was added to 100 ml volumetric flask and distilled water was added up to the mark to make final 100 ml solution.
5.	25 ppm GA_3	25 mg GA_3 was first dissolved in 10 ml of ethyl alcohol, and then the solution was brought up to 1 L by adding distilled water.
6.	50 ppm GA_3	50 mg GA_3 was first dissolved in 10 ml of ethyl alcohol, and then the solution was brought up to 1 L by adding distilled water.
7.	75 ppm GA_3	75 mg GA_3 was first dissolved in 10 ml of ethyl alcohol, and then the solution was brought up to 1 L by adding distilled water.
8.	100 ppm GA_3	100 mg GA_3 was first dissolved in 10 ml of ethyl alcohol, and then the solution was brought up to 1 L by adding distilled water.

Seed treatment

A total of 600 seeds were imbibed on 10 blotter papers (60 seeds per treatment) in a 9 cm diameter petri dish with an appropriate concentration of different solutions, followed by covering the dishes with aluminum foil. For aeration, a hole was provided at the center of aluminum foil in each petri dish. After each treatment, seeds were rinsed thoroughly with distilled water and dried back closer to original moisture level under shade for 6 hours. Non-primed seeds were maintained as a control for comparison.

Media preparation and seed sowing

The sand was collected, washed, and sterilized, and once dried, it was mixed with cocopeat and farmyard manure (FYM) in a 1:1:1 ratio by volume. The germination trays (plastic trays) having 105 cells were filled with media, and 60 seeds were sown for each treatment. All the trays were placed in the greenhouse under uniform environmental conditions. Trays were irrigated every evening with a fine mist based on the moisture status of the media.

Observation and measurements

Weather conditions

The data were recorded daily at morning time (8 am) starting from the sowing date. The climatic data (temperature and relative humidity) of the greenhouse during the entire research period were recorded by using digital Thermohygrometer.

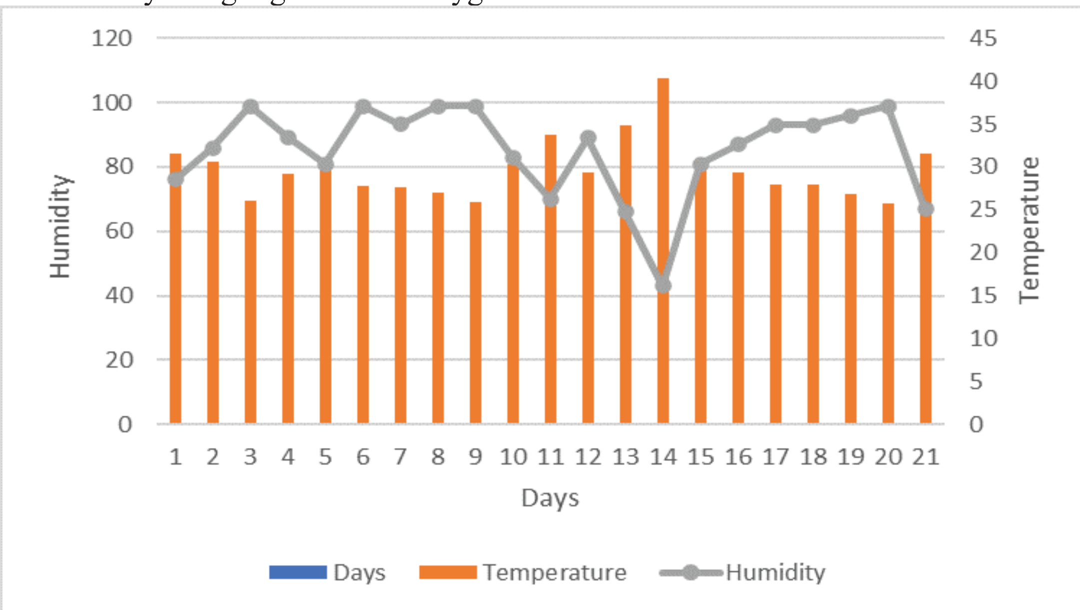

Fig. 2. Weather conditions inside the greenhouse during the experiment

Germination percentage

The total number of seeds germinated was recorded daily. Final emergence was calculated as the ratio of number of seeds germinated and total number of seeds sown and expressed as a percentage at the end of the experiment.

$$\text{Germination percentage} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100\%$$

Germination index

Germination index measures both the number of seeds germinated and the speed of germination, indicating the vigor and uniformity of germination (AOSA,1983).

$$\text{Germination index (GI)} = \frac{\text{Number of germinated seeds}}{\text{Days to first count}} + \_\_ + \frac{\text{Number of germinated seeds}}{\text{Days to final count}}$$

Mean emergence time

Mean emergence time (days) was recorded based on the procedure given by Ellis and Roberts (1981).

$$\text{Mean germination time (MGT)} = \frac{\sum n.d}{\sum N}$$

Where, d = number of days counted from the beginning of the emergence

n = number of seed germinated on d day

N = total number of seeds germinated at the termination of the experiment

Shoot and root length of seedlings

The five sample plants were selected from each treatment and measured their shoot length (ground level to growing points) and root length (collar end to tip of root).

Number of leaves per seedling

The number of photosynthetically active leaves from five sample plants was counted and averaged to get number of leaves per seedling.

Fresh and dry weight of seedling

Fresh and dry weights of seedling at the end of the experiment, i.e., 20 days after sowing, were recorded. For dry weight, the seedling was kept in the oven for 24 hours at 70ºC (Ali et al., 2020).

Seedling vigor index

Seedling vigor index is the sum of the activity and performance of germination and seedling length in a wide range of biotic and abiotic stress (Abdul-Baki & Anderson, 1973).

Seedling vigor index (SVI) = Germination percentage × Seedling length (cm)

Statistical analysis

The data were entered in Microsoft Excel (2016) and subjected to analysis of variance in R Studio (version 4.2.1), and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Effect of seed priming on germination parameters

The germination percentage, germination index, and mean germination time of tomato seeds were not significantly different due to different priming methods (Table 3). The highest germination percentage (96.7%) was recorded in 0.75% KNO_3, 0.5% KNO_3, 1 % KNO_3, hydro priming with hot water, 50 ppm GA_3 and the control, while the lowest germination percentage was in 75 ppm GA_3 (90%). The maximum germination index (13.7) was observed in tomato seed primed with 0.75% KNO_3, whereas the lowest germination index (11.9) was observed in 75 ppm GA_3. The number of days required by seeds to germinate, i.e., mean germination time, was minimum (0.99 days) in seeds treated with 0.75% KNO_3, and the maximum number of days to germinate (1.21 days) was observed in 25 ppm GA_3.

Table 3. Effect of seed priming on germination percentage, germination index and mean germination time of tomato seeds

Treatments	Germination parameters		
	Germination percentage	Germination index	Mean germination time (days)
Control	96.70±3.33	12.7±0.50	1.20±0.06
Hydro priming	95.00±2.89	13.5±0.54	1.08±0.08
Hydro priming with hot water	96.70±3.33	13.1±0.87	1.10±0.06
0.25% KNO_3	95.00±2.89	13.1±0.70	1.06±0.03
0.50% KNO_3	96.70±3.33	13.3±0.65	1.09±0.05
0.75% KNO_3	96.70±1.67	13.7±1.12	0.99±0.01
1.00% KNO_3	96.70±3.33	13.3±0.52	1.05±0.07
25 ppm GA_3	95.00±0.00	12.3±0.58	1.21±0.09
50 ppm GA_3	96.70±3.33	13.6±0.79	1.06±0.05
75 ppm GA_3	90.00±2.89	11.9±0.12	1.18±0.08
100 ppm GA_3	93.30±3.33	12.3±0.79	1.20±0.09

SEm (±)	0.870	0.202	0.019
$LSD_{0.05}$	8.45^{ns}	2.01^{ns}	0.147^{ns}
CV (%)	5.32	9.29	8.10
Grand mean	95.30	12.98	1.09

Means with the same letter(s) within a column are non-significant at p = 0.05 by DMRT. NS: Non-significant at 5% (P >0.05). SEm = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variation

The similar results for Germination percentage, Germination index, and Mean germination time for all treatments might be due to high germination percentage (minimum 90%), viability, and vigor (purity 98%) of the tested variety 'Gaurabh 555' (Bhandari & Kharal, 2019). This result is in line with Santika et al. (2022) who observed a non-significant result while comparing KNO_3 and hydropriming treatments in germination percentage, germination index, and mean germination time in tomato seeds.

Effect of seed priming on seedling growth parameters

Different seed priming methods significantly affected the number of leaves, root length, shoot length, and vigor index of tomato seedlings (Table 4). The maximum number of leaves (5.57) was observed in tomato seed primed with 1% KNO_3, whereas the minimum number of leaves (4.30) was reported in 25 ppm GA_3 and 50 ppm GA_3. The longest shoot length (18.50 cm) was recorded in 0.75% KNO_3, followed by 1% KNO_3, while the shortest shoot length (13.30 cm) was observed in 25 ppm GA_3, which was similar to 50 ppm GA_3 and the control. The longest root length (5.80 cm) was observed in 0.75% KNO_3 and was statistically similar to 1% KNO_3 and 75 ppm GA_3, whereas the shortest root length (4.37 cm) was recorded in 50 ppm GA_3, which was statistically at par with 25 ppm GA_3 and 100 ppm GA_3. The highest seedling vigor index (2203) was obtained in 0.75% KNO_3 and was similar to 1% KNO_3, whereas the lowest seedling vigor index (1635) was observed in 50 ppm GA_3.

Table 4. Effect of seed priming on number of leaves, shoot length, root length, and seedling vigor index of tomato seedlings

Treatments	Seedling growth parameters			
	Number of leaves	Shoot length (cm)	Root length (cm)	Seedling vigor index
Control	4.60 ± 0.23^{bc}	13.40±0.38^{c}	4.53±0.14^{c}	1648±57.50^{c}
Hydro priming	5.13±0.47^{abc}	17.10±1.06^{ab}	4.47±0.26^{c}	2013±122^{abc}
Hydro priming with hot water	4.80±0.42^{abc}	14.70±1.02^{bc}	4.72±0.16^{bc}	1879±120^{abc}
0.25% KNO_3	5.07±0.07^{abc}	16.80±0.92^{ab}	5.43±0.31^{ab}	2130±171^{ab}
0.50% KNO_3	5.13±0.24^{abc}	16.30±1.22^{abc}	4.61±0.26^{c}	2098±189^{ab}
0.75% KNO_3	5.20±0.00^{ab}	18.50±0.92^{a}	5.80±0.18^{a}	2203±140^{a}
1.00% KNO_3	5.57±0.23^{a}	16.40±0.54^{abc}	5.59±0.44^{a}	2141±73^{a}
25 ppm GA_3	4.30±0.15^{c}	13.30±0.51^{c}	4.63±0.03^{c}	1734±74.80^{bc}
50 ppm GA_3	4.30±0.15^{c}	13.50±1.64^{c}	4.37±0.44^{c}	1635±112^{c}
75 ppm GA_3	4.40±0.20^{bc}	15.90±1.39^{abc}	5.17±0.09^{a}	1900±151^{abc}
100 ppm GA_3	4.93±0.18^{abc}	16.90±0.28^{ab}	4.43±0.34^{c}	1958±26.6^{abc}
SEm (±)	0.095	0.338	0.105	45.54
$LSD_{0.05}$	0.74*	2.84*	0.696**	352.04*
CV (%)	9.25	10.87	8.55	10.89
Grand mean	4.85	15.72	4.88	1939.93

Means with the same letter(s) within a column are non-significant at p = 0.05 by DMRT. *Significant at 5% (P< 0.05), **Significant at 1% (P< 0.01). SEm = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variation

Tomato seeds primed with KNO_3 improve seedling performance (Afzal et al., 2011). Seed priming increases the production of amino acids (Abdelkader et al., 2023), metabolic changes such as DNA repair, an increase in RNA biosynthesis (Bray, 2017), and the establishment of the respiration process in seeds (Chen & Arora, 2013). In general, moderate levels of total soluble sugars and phenolics were associated with improved germination performance in tomato seeds primed with KNO_3 compared to the non-primed control (Ali et al., 2020). KNO_3 has also been reported to increase the expression of genes involved in N and C metabolism and energy production (Barba Espin et al., 2022). In comparison to growth regulators, the nitrate solution was more effective in enhancing the shoot length in tomato seedlings, as it increases growth by enhancing cellular elongation and division in the stems (Jyoti et al., 2016). Seed priming is a dual beneficial approach for promoting speedy and uniform emergence, achieving high vigor, and improving yield in different tomato cultivars (Farooq et al., 2005). Although there were variations among the treatments, priming techniques enhanced plant growth and yield (Maiti, 2013).

Effect of seed priming on seedling weight

Seed priming methods significantly affected the fresh and dry weight of tomato seedlings (Table 5). The maximum fresh weight of seedling (1.16 g) was observed when seeds were primed with 0.75% KNO_3, followed by 1% KNO_3, whereas the minimum fresh weight (0.49 g) was observed with 25 ppm GA_3. The maximum dry weight (0.08 g) was observed in 0.75% KNO_3, which was statistically at par with 0.25% KNO_3, 0.50% KNO_3, 1% KNO_3, and 50 ppm GA_3, whereas the minimum (0.4 g) was in 25 ppm GA_3.

Table 5. Effect of seed priming on fresh weight and dry weight of tomato seedlings

	Seedling weight (g)	
Treatments	Fresh weight	Dry weight
Control	0.63 ± 0.06^{de}	0.05 ± 0.01^{bc}
Hydropriming	0.93 ± 0.13^{abcd}	0.07 ± 0.01^{a}
Hydropriming with hot water	0.68 ± 0.10^{cde}	0.07 ± 0.01^{ab}
0.25% KNO_3	0.79 ± 0.05^{bcde}	0.07 ± 0.01^{a}
0.50% KNO_3	0.96 ± 0.07^{abc}	0.08 ± 0.01^{a}
0.75% KNO_3	1.16 ± 0.06^{a}	0.08 ± 0.01^{a}
1.00% KNO_3	1.04 ± 0.07^{ab}	0.08 ± 0.01^{a}
25 ppm GA_3	0.49 ± 0.03^{e}	0.04 ± 0.00^{c}
50 ppm GA_3	0.76 ± 0.07^{bcde}	0.07 ± 0.01^{a}
75 ppm GA_3	0.79 ± 0.17^{bcde}	0.07 ± 0.01^{ab}
100 ppm GA_3	0.91 ± 0.12^{abcd}	0.07 ± 0.01^{a}
SEm (±)	0.039	0.002
$LSD_{0.05}$	0.267**	0.017**
CV (%)	19.29	15.31
Grand mean	0.831	0.068

Means with the same letter(s) within a column are non-significant at p = 0.05 by DMRT. **Significant at 1% (P< 0.01) SEm = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variation

Seed priming agents have a significant impact on the dry and fresh weights of tomato seedlings (Saifi et al., 2010). A higher dry weight increases the likelihood of stress tolerance, as it reflects greater nutrient and water retention that supports challenging conditions, such as drought, and improves seedlings performance (Marthandan et al., 2020). The investigation revealed that nitrogen-based priming resulted in maximum dry root weight, indicating that these priming treatments improved salinity tolerance, biomass accumulation, protein synthesis, and chlorophyll production (Biswas et al., 2023).

CONCLUSION

Although seed priming did not significantly affect the germination parameters, it had a significant positive impact on the seedling growth parameters and fresh and dry seedling weight of tomato. Among the different seed priming methods, 0.75% KNO_3 was more effective than other concentrations of KNO_3 and GA_3 in improving seedling growth. Hydropriming can be used as an alternative control method. The primed seeds with KNO_3 solutions produced maximum seedling length, root length, fresh weight, dry weight, and increased vigor index compared to non-primed seeds. Although 0.75% KNO_3 was found to be promising among the tested priming agents, there is space for further study with higher concentrations of KNO_3.

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AUTHOR CONTRIBUTIONS

Author A: Conceptualization, Methodology, Writing- Original draft Author B: Conceptualization, Methodology

Author C: Supervision, Data Curation, Visualization, Writing- Review and Editing, Author D: Writing- Review and Editing, Supervision

CONFLICT OF INTEREST

The authors agree in not having any conflict of interest regarding the published material. All the authors had gone through the document prior to the submission to the Journal of Agriculture and Forestry University.

ETHICS APPROVAL

No human participants or animals were involved during the study, and prior approvals were obtained where applicable.

REFERENCES

Abdelkader, M., Voronina, L., Puchkov, M., Shcherbakova, N., Pakina, E., Zargar, M., & Lyashko, M. (2023). Seed priming with exogenous amino acids improves germination rates and enhances photosynthetic pigments of onion seedlings (*Allium cepa* L.). *Horticulturae*, *9*(1), 1–16. https://doi.org/10.3390/horticulturae9010080

Abdul-Baki, A. A., & Anderson, J. D. (1973). Vigor determination in soybean seed by multiple criteria. *Crop Science*, *13*(6), 630–633. https://doi.org/10.2135/cropsci1973.0011183X001300060013x

Afzal, I., Hussain, B., Basra, S. M. A., & Ullah, S. H. (2011). Halopriming triggers higher germination potential and early seedling growth of tomato. *Journal of Agriculture and Social Sciences*, *7*(3), 105–108.

AOSA. (1983). Seed Vigor Testing Handbook. Contribution No. 32 to the handbook on Seed Testing. Association of Official Seed Analysis. Springfield, IL.

Ali, M. M., Javed, T., Mauro, R., Afzal, I., & Yousef, A. (2020). Effect of seed priming with potassium nitrate on the performance of tomato. *Agriculture*, *10*(11), 498. https://doi.org/10.3390/agriculture10110498

Barba Espin, G., Jurado-Mañogil, C., Díaz-Vivancos, P., & Hernandez, J. (2022). Potassium nitrate and hydrogen peroxide as seed germination promoters: Modulation of antioxidant metabolism and hormone profile. *Free Radical Biology and Medicine*, *189*, 46–47. https://doi.org/10.1016/j.freeradbiomed.2022.06.195

Bewley, J. D., Bradford, K. J., Hilhorst, H. W. M., & Nonogaki, H. (2013). Germination. In J. D. Bewley, K. J. Bradford, H. W. M. Hilhorst, & H. Nonogaki (Eds.), *Seeds: Physiology of development, germination and dormancy* (pp. 133–181). Springer. https://doi.org/10.1007/978-1-4614-4693-4_4

Bhandari, A., & Kharal, B. (2019). Effect of different growth medium on seed vigor characteristics of tomato (*Solanum lycopersicum* L. cv. Gaurav-555) in Arghakhanchi, Nepal, *10*(4), 40-48. https://doi.org/10.9734/ajahr/2023/v10i4242

Biswas, S., Seal, P., Majumder, B., & Biswas, A. K. (2023). Efficacy of seed priming strategies for enhancing salinity tolerance in plants: An overview of the progress and achievements. *Plant Stress*, *9*, 100186. https://doi.org/10.1016/j.stress.2023.100186

Chen, K., & Arora, R. (2013). Priming memory invokes seed stress-tolerance. *Environmental and Experimental Botany*, *94*, 33–45. https://doi.org/10.1016/j.envexpbot.2012.03.005

DHM. (2024). *Preliminary precipitation and temperature summary - December 2024*. Department of hydrology and meteorology.

Ellis, R. H., & Roberts, E. H. (1981). The quantification of ageing and survival in orthodox seeds. *Seed Science and Technology*, *9*(2), 373-409.

Farooq, M., Basra, S., Saleem, B., Nafees, M., & Chishti, S. (2005). Enhancement of tomato seed germination and seedling vigor by osmopriming. *Pakistan Journal of Agricultural Sciences*, *42*(3), 1-6.

Gebeyaw, M. (2020). Review on: Recent achievement of seed priming in improving seed germination and seedling growth in adverse environmental conditions. *International Journal of Scientific and Research Publications*, *10*, 651–655. https://doi.org/10.29322/IJSRP.10.08.2020.p10482

Hadas, A. (2005). Germination and seedling establishment. In D. Hillel (Ed.), *Encyclopedia of soils in the environment* (pp. 130–137). Elsevier. https://doi.org/10.1016/B0-12-348530-4/00149-1

Harris, D., Pathan, A., Gothkar, P., Joshi, A., Chivasa, W., & Nyamudeza, P. (2001). On-farm seed priming: Using participatory methods to revive and refine a key technology. *Agricultural Systems*, *69*, 151–164. https://doi.org/10.1016/S0308-521X(01)00023-3

ISTA. (2015). *International rules for seed testing* (pp 1–276). International Seed Testing Association.

Jyoti, B., Gaurav, S., & Pant, U. (2016). Use of growth regulators as priming agent for improvement of seed vigour in tomato (*Lycopersicum esculentum*). *Journal of Applied and Natural Science*, *8*, 84–87. https://doi.org/10.31018/jans.v8i1.752

Koirala, K. (2006). Improving livelihoods of resource-poor farmers through on-farm seed priming in western hills of Nepal. *Nepal Agricultural Research Council.*

Maiti, R., Rajkumar, D., Jagan, M., Pramanik, K., & Vidyasagar, P. (2013). Effect of seed priming on seedling vigour and yield of tomato and chilli. *International Journal of Bio-Resource and Stress Management*, *4*(2), 119–125.

Marthandan, V., Geetha, R., Kumutha, K., Renganathan, V. G., Karthikeyan, A., & Ramalingam, J. (2020). Seed priming: A feasible strategy to enhance drought tolerance in crop plants. *International Journal of Molecular Sciences*, *21*, 8258. https://doi.org/10.3390/ijms21218258

MoALD. (2023). *Statistical information on Nepalese agriculture.* Ministry of Agriculture and Livestock Development, Government of Nepal.

Naika, S., de Jeude, J., de Goffau, M., Himli, M., & van Dam, B. (2005). Determining the effects of selected organic fertilizer on growth and yields of tomato (*Lycopersicon esculentum* var. Rio Grande Tomatoes) in Mundri West County, Western Equatoria State, South Sudan. *Agricultural Sciences*, *14*(9), 1343-1374. https://doi.org/10.4236/as.2023.149089

Patil, K., Anilkumar, R., Trivedi, V., Hirpara, A., & Neetiyath, S. (2018). Effect of seed priming treatment in chickpea (*Cicer arietinum* L.). *International Journal of Chemical Studies, 6*(4), 1064–1069.

Pawar, V. A., & Laware, S. (2018). Seed priming: A critical review. *International Journal of Scientific Research in Biological Sciences, 5*(5), 94-101. https://doi.org/ 10.26438/ijsrbs/v5i5.94101

Rasmussen, H. N., Dixon, K. W., Jersáková, J., & Těšitelová, T. (2015). Germination and seedling establishment in orchids: A complex of requirements. *Annals of Botany*, *116*(3), 391–402. https://doi.org/10.1093/aob/mcv087

Saifi, S., Ahmed, H., Hasan, S., Morsi, M., & El-Shatoury, R. (2010). Seed priming influences seed germination and seedling growth of tomato under different salinity levels. *Journal of Plant Production*, *1*, 159–170. https://doi.org/10.21608/jpp.2010.86343

Santika, P., Muhklisin, I., & Makama, S. (2022). Effect of aeration and KNO_3 in seed priming on the germination of tomato (*Solanum lycopersicum*) seeds. *Agroteknika*, *5*, 151–160. https://doi.org/10.55043/agroteknika.v5i2.153

Seleiman, M. F., Al-Suhaibani, N., Ali, N., Akmal, M., Alotaibi, M., Refay, Y., Dindaroglu, T., Abdul-Wajid, H. H., & Battaglia, M. L. (2021). Drought stress impacts on plants and different approaches to alleviate its adverse effects. *Plants*, *10*(2), 259. https://doi.org/10.3390/plants10020259

Sghaier, A. H., Tarnawa, Á., Khaeim, H., Kovács, G. P., Gyuricza, C., & Kende, Z. (2022). The effects of temperature and water on the seed germination and seedling development of rapeseed (*Brassica napus* L.). *Plants*, *11*(21), 2819. https://doi.org/10.3390/plants11212819

Singh, V., Singh, A., Singh, P., & Kumar, A. (2018). Interaction of plant growth promoting bacteria with tomato under abiotic stress: A review. *Agriculture Ecosystems & Environment*, *267*, 129–140. https://doi.org/10.1016/j.agee.2018.08.020

Sliwinska, E. (2009). Nuclear DNA replication and seed quality. *Seed Science Research, 19*(1), 15–25. https://doi.org/10.1017/S0960258508186275

Sushma, M., Yadav, S. K., Yadav, S., Choudhary, R., Anbalagan, A., Navya, K., & Kaushal, K. (2023). Hydro-priming as a sustainable approach for improving germination and seedling growth in tomato (*Solanum lycopersicum* L.). *Journal of Seed Research*, *51*(1), 11–17. https://doi.org/10.56093/sr.v51i1.154654