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 widely grown profitable vegetable in Nepal. However, low seed germination and poor seedling growth have been major constraints in tomato production. Seed priming as pre-sowing treatment enhances germination and produces uniform and vigorous seedlings that tolerate field stresses. An 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'. 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 for 5 minutes), halopriming (potassium nitrate @ 0.25%, 0.5%, 0.75%, 1% for 24 hours) and hormonal priming (gibberellin @ 25 ppm , 50 ppm , 75 ppm , 100 ppm for 24 hours). Germination percentage, germination index and mean germination time were non-significant at 5% significance level but seedling growth parameters were significantly affected. 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 seeds primed with KNO_3 @ 0.75%. Thus, KNO_3 @ 0.75% enhanced the seedling growth, fresh and dry weight of tomato seedling under greenhouse conditions.

सारांश

गोलभेंडा नेपालमा खेती गरिने महत्त्वपूर्ण तरकारी बाली हो। बीउको न्यून उमारशक्ति र कमजोर बिरुवा विकास यस बाली 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 बिरुवा प्राप्त गर्न सकिन्छ । यो अध्ययन २०७९ साल साउन–भदौ महिनामा झापा जिल्ला, गौरादहमा सिड प्राइमिङको प्रभाव बीउको उमार शक्ति र वृद्धिमा मूल्याङ्कनका लागि गरिएको थियो । उपचारहरूमा नियन्त्रण, हाइड्रोप्राइमिङ डिस्टिल्ड पानीमा २४ घण्टा, तताइएको पानीमा ५ मिनेट), ह्यालोप्राइमिङ (०.२५%, ०.५%, ०.७५%, १% मा २४ घण्टा), र हर्मोनल प्राइमिङ (२५, ५०, ७५, १०० पि.पि.एम मा २४ घण्टा) तीन पटक दोहोर्याइ राखिएको थियो । परिणामस्वरूप अंकुरण प्रतिशत, अंकुरण सूचकांक र औसत अंकुरण समय ५% स्तरमा उल्लेखनीय नभए पनि बिरुवा वृद्धिमा भने महत्त्वपूर्ण प्रभाव देखियो । विशेषतः सबैभन्दा बढी बिरुवाको उचाई (१८.५ से.मी.), जराको लम्बाइ (५.८ से.मी.), पात संख्या (५.२), बिरुवा सबलता सूचक (२२०३), ताजा पदार्थ (१.१६ ग्राम) र सुख्खा पदार्थ (०.०८ ग्राम) ०.७५% ह्यालोप्राइमिङमा उपचार गरिएको बीउमा प्राप्त भयो । यसैले, ०.७५% ह्यालोप्राइमिङ प्रयोग गरिएको अवस्थामा गोलभेडाको बिरुवा वृद्धिमा उल्लेखनीय सुधार भएको निष्कर्ष निकालिएको 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 (Jyoti et al., 2016). 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 field, greenhouse and net house. 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 leads to the poor stand establishment of crops (Reed et al., 2022). The poor establishment of crops affect the yield, 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). 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, 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 (Maiti & Pramanik, 2013). 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 G_2 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 inter nodal length and regulating mitotic activity in that area (Yanglem et al., 2021). 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 (Rehman et al., 2024). Pre-sowing seed treatment hydropriming techniques improved germination rates and were preferred in enhancing crop productivity (Sushma et al., 2023). Tomato seeds subjected to KNO_3 halopriming resulted in quicker germination, higher final emergence percentage, root and shoot length, and seedling dry weight (Ali et al., 2020). 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 in 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.

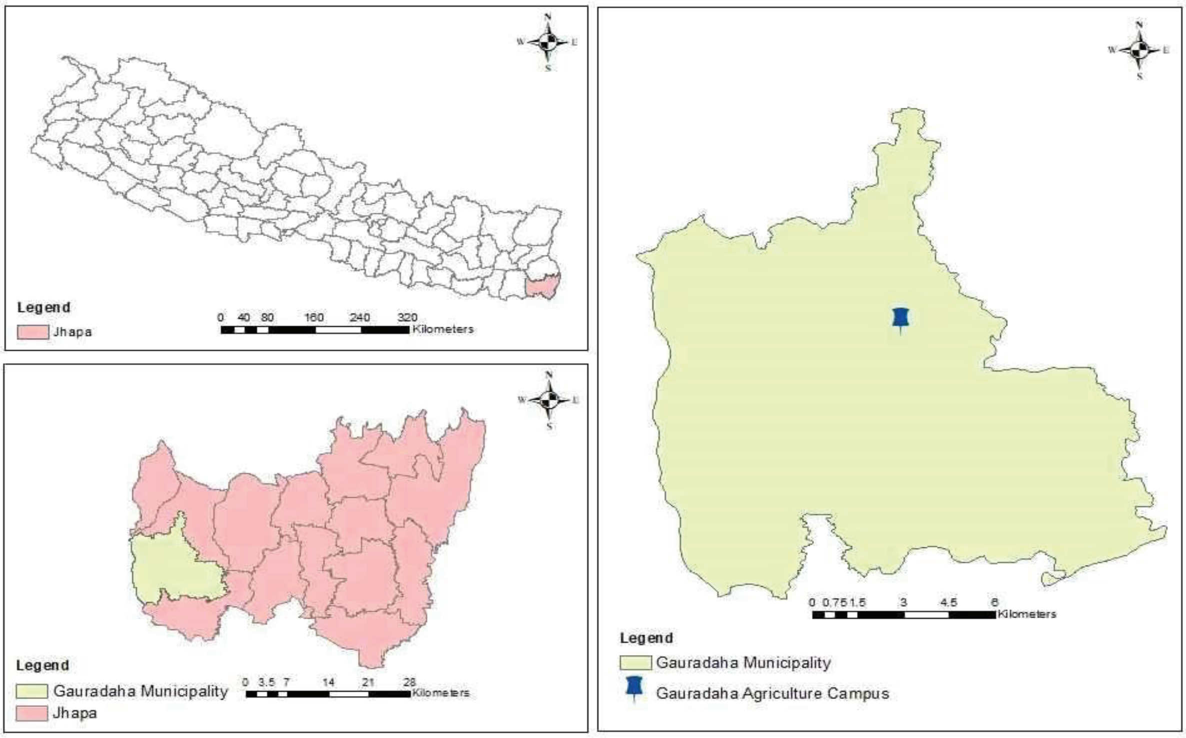

Fig. 1. Location map of the experiment site

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, potential yield is 106 t/ha, and is recommended for terai region of Nepal up to 150 masl (MoALD, 2025).

Experimental design and treatment details

The experiment was laid out in a Completely Randomized Design (CRD) with eleven treatments and each was replicated thrice in greenhouse conditions. Tomato seeds were primed with KNO_3 0.25%, 0.50%, 0.75%, 0.1% (w/v); GA_3 25 ppm , 50 ppm, 75 ppm, 100 ppm; hormonal priming for 24 hours at 25 ºC and hydropriming with hot water at 50 ºC for 5 minutes.

Table 1. Preparation of priming solution

Treatments	Preparation details
Potassium nitrate (KNO_3) in %	(g of KNO_3 in 100 ml distilled water)
0.25	0.25
0.5	0.50
0.75	0.75
1	1.00
Gibberellin (GA_3) in ppm	(mg of GA_3 in 1 L distilled water)
25	25
50	50
75	75
100	100

Priming solution of respective chemicals and plant growth regulators was prepared first. Gibberellic acid was first dissolved in 10 ml of ethyl alcohol. Gibberellic acid and potassium nitrate with purity percentage 99 was used.

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 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 (9:00 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 a digital Thermohygrometer.

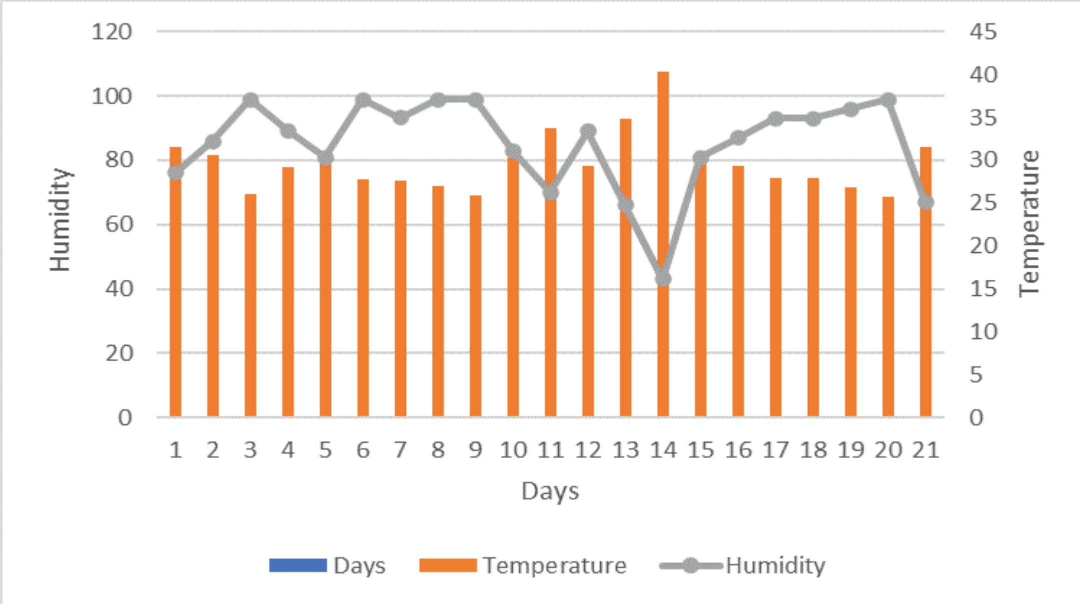

Fig. 2. Weather conditions inside the greenhouse during the experiment period

Germination percentage

The total number of seeds germinated was recorded on a daily basis. Final emergence was calculated as the ratio of number of seeds germinated and total number of seeds sown and expressed in percentage at the end of the experiment (AOSA, 1990).

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

Germination index (GI)

The germination index measures the both number of seeds germinated and the speed of germination, indicating the vigor and uniformity of germination.

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

Mean Germination time (MGT)

Mean germination time (days) was recorded based on the guidelines given by International Seed Testing Association (ISTA).

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

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

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 (cm)

The five sample plants were selected from each treatment and measured their shoot length (ground level to growing points), root length (collar end to tip of root) (Jyoti et al., 2016).

Number of leaves per seedling

The number of photo-synthetically active leaves from five sample plants was counted and averaged to get the number of leaves per seedling (Jyoti et al., 2016).

Fresh and dry weight of seedling (g)

Fresh and dry weight 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 (SVI)

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 the Microsoft Excel (2016) and subjected to analysis of variance in R studio (version 4.2.1) and means were separated using DMRT test 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 2). The highest germination percentage (96.7%) was recorded in KNO_3 @ 0.75%, KNO_3 @ 0.5%, KNO_3 @ 1 %, hydro priming with hot water, GA_3 50 ppm, and the control, while the lowest (90%) was in GA_3 75 ppm. The maximum germination index (13.7) was observed in tomato seed primed with KNO_3 @ 0.75% whereas the lowest (11.9) was observed in GA_3 75 ppm. The number of days required by seeds to germinate, i.e., mean germination time, was minimum (0.99) in seeds treated with KNO_3 @ 0.75% and maximum number of days to germinate (1.21) was observed in GA_3 25 ppm.

Table 2. Effect of seed priming on germination percentage, germination index and mean germination time of tomato seeds at Gauradaha, Jhapa, 2022

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
KNO_3 @ 0.25%	95.00±2.89	13.1±0.70	1.06±0.03
KNO_3 @ 0.50%	96.70±3.33	13.3±0.65	1.09±0.05
KNO_3 @ 0.75%	96.70±1.67	13.7±1.12	0.99±0.01
KNO_3 @ 1.00%	96.70±3.33	13.3±0.52	1.05±0.07
GA_3 @ 25 ppm	95.00±0.00	12.3±0.58	1.21±0.09
GA_3 @ 50 ppm	96.70±3.33	13.6±0.79	1.06±0.05
GA_3 @ 75 ppm	90.00±2.89	11.9±0.12	1.18±0.08
GA_3 @ 100 ppm	93.30±3.33	12.3±0.79	1.20±0.09
Grand mean	95.30	12.98	1.09
CV (%)	5.32	9.29	8.10
SEm (±)	0.870	0.202	0.019
$LSD_{0.05}$	8.45	2.01	0.147
F-test	NS	NS	NS

Note: 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 tested variety 'Gaurabh 555' (Bhandari & Kharal, 2019). This result is in line with Santika et al., (2022) who observed that there is a non-significant result while comparing KNO_3 and water soaking 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 3). The maximum number of leaves (5.57) was obtained in tomato seed primed with KNO_3 @ 1%, whereas the lowest (4.30) was in GA_3 25 ppm and GA_3 50 ppm. The longest shoot length (18.50 cm) was recorded in KNO_3 @ 0.75%, followed by KNO_3 @ 1% while the shortest shoot length (13.30 cm) was in GA_3 25 ppm, which was similar to GA_3 50 ppm and the control.

Longest root length (5.80 cm) was observed in KNO_3 @ 0.75% and was statistically similar to KNO_3 @ 1% and GA_3 75 ppm, whereas the shortest root length (4.37 cm) was recorded in GA_3 50 ppm, which was statistically at par with GA_3 25 ppm and 100 ppm. Maximum seedling vigor index (2203) was obtained in KNO_3 @ 0.75% and was similar to KNO_3 @ 1% whereas the lowest was in 50 ppm GA_3 (1635).

Table 3. Effect of seed priming on number of leaves, shoot length, root length and seedling vigor index of tomato seedlings at Gauradaha, Jhapa, 2022

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

Note: 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 seed primed with KNO_3 improves the performance of seedling (Afzal et al., 2011). Literatures on seed priming mention the production of amino acids (Abdelkader et al., 2023), metabolic changes such as repair of DNA and increase in the biosynthesis of RNA (Bray, 2017), and establishment in the respiration process of seed (Chen & Arora, 2013). In general, moderate levels of total soluble sugars and phenolics were associated with improved germination performance of 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, as well as energy production (Barba Espin et al., 2022). In comparing nitrate solution and growth regulators, the nitrate solution is more effective in enhancing the shoot length in tomato seedlings as it boosts growth by enhancing cellular elongation and division in the stems (Jyoti, 2016).

It has been determined that 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, a comparative study on the impacts of priming techniques demonstrated that they enhanced tomato and chilli 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 4). The maximum fresh weight of seedling (1.16 g) was obtained when seeds were primed with KNO_3 @ 0.75%, followed by KNO_3 @ 1% whereas the lowest (0.49 g) in GA_3 25 ppm. The maximum dry weight (0.08 g) was observed in KNO_3 @ 0.75% which was statistically at par with KNO_3 @ 0.25%, KNO_3 @ 0.50%, KNO_3 @ 1% and GA_3 50 ppm, whereas the lowest (0.4 g) in GA_3 25 ppm.

Table 4. Effect of seed priming on fresh weight and dry weight of tomato seedlings at Gauradaha, Jhapa, 2022

	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}
KNO_3 @ 0.25%	0.79±0.05^{bcde}	0.07±0.01^{a}
KNO_3 @ 0.50%	0.96±0.07^{abc}	0.08±0.01^{a}
KNO_3 @ 0.75%	1.16±0.06^{a}	0.08±0.01^{a}
KNO_3 @1.00%	1.04±0.07^{ab}	0.08±0.01^{a}
GA_3 25 ppm	0.49±0.03^{e}	0.04±0.00^{c}
GA_3 50 ppm	0.76±0.07^{bcde}	0.07±0.01^{a}
GA_3 75 ppm	0.79±0.17^{bcde}	0.07±0.01^{ab}
GA_3 100 ppm	0.91±0.12^{abcd}	0.07±0.01^{a}
Grand mean	0.8318	0.0681
CV (%)	19.29	15.31
SEm (±)	0.039	0.002
$LSD_{0.05}$	0.2672	0.0173
F-test	**	**

Note: 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

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

CONCLUSION

Though seed priming did not significantly affect the germination parameters, there was a significant positive impact on the seedling growth parameters and fresh and dry seedling weight of tomato. Among different seed priming methods, KNO_3 @ 0.75% was more effective than other concentrations of KNO_3 and GA_3 in improving seedling growth. The hydro priming can be an alternative to the control. The primed seeds with nitrate solutions produced maximum seedling length, root length, fresh weight, dry weight, and increased vigor index as compared to non-primed seeds.

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AUTHOR CONTRIBUTIONS

Author A: Conceptualization, Methodology, Writing- Original draft
Author B: Methodology, Resources
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 any human participants or animals were involved during the study and prior approvals were obtained where applicable.

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