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# Effects of different seed priming treatments on germination performance and early seedling growth of Sesame (*Sesamum indicum* L.)

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## Abstract

Sesame (*Sesamum indicum* L.) is one of the important oilseed crops, but its yield is sometimes limited by low and inconsistent germinability. The aim of this study was to evaluate the effect of various priming agents on the germination and early seedling growth of sesame seeds in a controlled environment. The study was conducted at the Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal, during 2025 in a completely randomized design (CRD). There were three replications and seven treatments: with priming agents: potassium dihydrogen phosphate ($KH_2PO_4$), calcium chloride ($CACL_2$), humic acid, zinc sulphate ($ZnSO_4$), water (hydropriming), potassium nitrate ($KNO_3$), and gibberellic acid($GA_3$). Seed priming increased germination percentage, shoot length, root length, and seedling vigour indices. Potassium nitrate had the highest germination percentage (86.66%) and better seedling growth, followed by gibberellic acid. None of the treatments significantly affected the mean germination time. The study indicates that gibberellic acid ($GA_3$) and potassium nitrate are good priming agents for improving seed germination and early growth in sesame.

***Keywords:*** Sesame; Seed priming; Germination; $GA_3$; Seedling vigour; Potassium nitrate

## Introduction

Sesame (*Sesamum indicum* L., Fam: *Pedaliaceae*) is an ancient oilseed crop, grown annually, and its oil is used for various rituals (Tizazu *et al.* 2019). The crop is widely cultivated in tropical and subtropical areas (Dossa *et al.* 2017). The sesame seeds have oil (50-60%) and protein (18-25%) content with natural antioxidants, which improve the oil's stability (Wei *et al.* 2022). Sesame crop is cultivated on millions of hectares worldwide and contributes notably to edible oil production in India, China, and Myanmar (FAO, 2021). The crop is a traditional oilseed grown in marginal areas in Nepal, but low productivity is observed owing to poor crop establishment (MoALD, 2023).

Among the different causes limiting the productivity of sesame, irregular germination is the main cause, resulting in low plant stand, which ultimately affects yield (Singh *et al.* 2021). Sesame seeds are mostly dormant and have a thick seed coat, restricting water movement and activation of metabolic activity (Upretee *et al.* 2024). Moreover, fluctuating temperature and moisture levels contribute to poor and variable germination (Balouchi *et al.* 2023). Seed priming is a pre-sowing treatment where seeds are hydrated to trigger metabolic processes without radicle growth, which results in increasing enzyme activity, repair of structural damage, and reserve mobilization, resulting in better germination and vigorous seedlings. Different types of priming, such as hydropriming, osmopriming, and hormonal priming, have been applied to enhance seed germination in various crops (Vinicius *et al.* 2020). Chemical priming with different chemicals like potassium nitrate, calcium chloride, and zinc sulphate has been reported to increase germination by accelerating nutrient availability and stimulating physiological processes (Macdonald and Mohan, 2025).

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Likewise, hormonal priming using gibberellic acid ($GA_3$) helps in lifting seed dormancy and quickening the germination process by enhancing the synthesis of enzymes and expansion of cells (Yamaguchi, 2021). However, the relative effectiveness of different seed primings in sesame under controlled environmental conditions is yet to be explored, especially in Nepal. As such, the present study was conducted to assess the effects of different priming treatments on seed germination and early seedling development of sesame.

**Materials and methods**

The experiment was carried out at the Department of Agronomy at the Agriculture and Forestry University (AFU) in Rampur, Chitwan, Nepal, located at a longitude of 84.7E and a latitude of 27.59N. The research was done from 16 to 30 March 2025, which is also a good time for the sesame season.

A single factorial experiment was performed using a completely randomized design (CRD) with 3 replications and 7 different treatments (Table I). The study was conducted on germination paper, using 30 seeds per paper, with a total of 21 papers involved. On each germination paper, 6 seeds were arranged in 5 rows. The seeds underwent soaking with the treatments and were then shade-dried for 1-2h. Subsequently, moist germination paper was prepared, the seeds were placed on it, folded over, and securely tied with a rubber band.

*Data collection and analysis*

Several germination and seedling development indices were measured, such as germination percentage, mean germination time, root length, shoot length, seedling dry weight, and seed vigour indices. The methods used were the same as those described in previous works (Ranal and Santana, 2006; Alvarado and Bradford, 2002).

Germination was evaluated daily from germination papers hold 30 seeds until the completion of germination. The percentage of germination was expressed as:

$$\text{Germination \%} = \frac{Final\ number\ of\ seedlings\ emerged}{Total\ number\ of\ seeds\ sown}$$

Germination rate was measured by mean germination time (MGT) which is the time required for 50% of the seeds to germinate. It was calculated as:

$$Mean\ Germination\ Time\ (days) = \frac{\sum n \times d}{\sum N}$$

where n = number of seeds germinated on each day, d = number of days from the beginning of the test, and N = total number of seeds germinated at the end of the experiment.

To analyse growth parameters of the seedlings, five seedlings were randomly chosen from each replication to determine the root and shoot length of the seedlings at specified days after sowing (DAS). Shoot length was measured from the bottom to the top and root length from the bottom to the top.

Likewise, another five seedlings were used for dry weight analysis. The fresh weight was measured immediately after harvesting on an electronic balance. The seeds were then oven dried at 70°C for 24h and weighed again. Seedling vigour indices were also calculated to determine the overall seedling performance using the following formulas (Abdul-Baki and Anderson, 1973):

**Table I. Treatment code and chemical combinations of the experiment**

| Treatment code | Treatment combination |
|---|---|
| T1 | Potasium dihydrogen |
| T2 | Calcium chloride |
| T3 | Humic acid |
| T4 | Zinc sulphate |
| T5 | Water |
| T6 | Potassium nitrate |
| T7 | Gibberlic acid |

Seed Vigor Index(SVI-1)=Seedlings length(cm)×Seed Germination%

Seed Vigor Index-II(SVI-II)=Seedling dry weight×Seed Germintion %

*Statistical analysis*

Data were recorded and tabulated in Microsoft Excel. Analysis of variance (ANOVA) was carried out to test for differences among treatments for all the parameters. Duncan's Multiple Range Test (DMRT) at the corresponding level of significance was used to separate mean values as per. Tables and figure were drawn in Microsoft Excel.

## Results and discussion

*Root length*

Root length was significantly affected by the priming treatments at 3, 5, and 7 d after sowing. Potassium nitrate (T6) exhibited the highest root length (2.30, 4.33 and 6.90 cm) at all observation stages, followed by gibberellic acid with 1.99, 4.00, and 6.14 cm, respectively. The shortest root length was observed in water-treated seedlings, i.e., (T5), especially in the later stages (2.53 and 3.28 cm at 5 and 7 days, respectively). Other treatments produced intermediate results, with potassium dihydrogen phosphate (T1) and zinc sulphate (T4) slightly outperforming calcium chloride (T2) and humic acid (T3). Potassium nitrate's positive effect may be due to its ability to boost early metabolic processes, as well as signaling with nitrate to stimulate root growth and cell division (Gomes *et al.* 2025). Nitrate is both a nutrient and a signaling molecule, which controls the expression of genes associated with seed germination and early seedling development. Likewise, gibberellic acid treatment enhanced root length relative to most other treatments, possibly because it is involved in activating enzymes such as amylase and lipase to facilitate mobilization of reserves, which promotes early seedling growth (Yan *et al.* 2016).

However, reduced root growth in seeds treated with water may be due to the lack of biochemical activity of priming agents. Relatively lower responses were observed in treatments like calcium chloride and humic acid, which may be due to delayed metabolic activation or less impact on early root development. In conclusion, these findings suggest that nutrient and hormone priming agents, especially potassium nitrate, improve root growth in the early stages of seedling growth. The detailed results are presented in Table II and Fig. 1.

*Shoot length*

Seeding treatments at 3, 5, and 7d after sowing significantly influenced shoot length. The highest shoot length was observed in potassium nitrate treatment at different stages of growth, with 1.80, 4.38, and 6.95 cm, respectively. It was followed by gibberellic acid, which also recorded higher values (1.51, 3.93, and 6.50 cm). On the other hand, the smallest shoot length was recorded in water-treated seeds (T5) at later stages (2.26 and 3.55 cm at 5 and 7d, respectively). The rest of the treatments, such as potassium dihydrogen phosphate (T1) and zinc sulphate (T4) performed moderately, while calcium chloride (T2) and humic acid (T3) exhibited relatively lower shoot lengths.

The higher shoot length of potassium nitrate could be due to the improved supply of N, which promotes vegetative growth, cell division, and elongation of shoots. N is an essential component of amino acids and proteins, and its optimal supply leads to rapid seedling establishment and biomass production. The positive effect on shoot growth under gibberellic acid treatment is due to the known role of this hormone in promoting stem growth via cell division and elongation.

By contrast, the shorter shoot length in seeds treated with water suggests that no biochemical and hormonal stimulation was provided by priming treatments. The other treatments exhibited moderate responses, implying that they may have some positive effects on seedling growth, but their effects are not as significant as nutrient- and hormone-based priming treatments. In general, the data showed that potassium nitrate and gibberellic acid are better at promoting shoot growth during early seedling development. The detailed results are presented in Table III and Fig. 2.

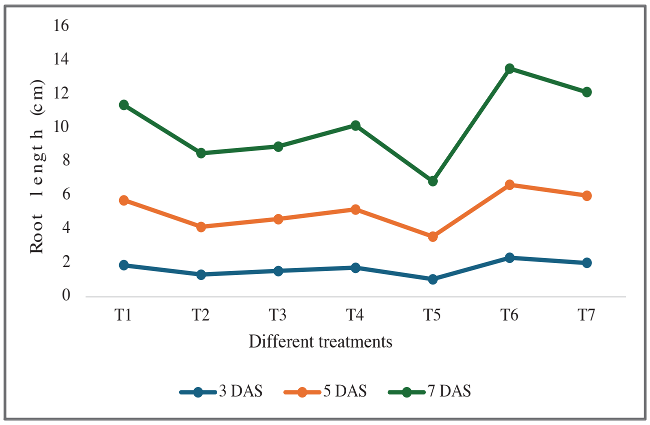


**Fig. 1. Effect of seed priming on root length of sesame at different days after sowing**

*Germination percentage and mean germination time*

The percentage of germination was also greatly influenced by seed priming treatments, which showed a

**Table II. Effect of different priming treatments on root length (cm) of seedlings at 3, 5, and 7 days after sowing**

| Treatment | Root length (cm) at 3 day | Root length (cm) at 5 day | Root length (cm) at 7 day |
|---|---|---|---|
| Potassium dihydrogen (T1) | 1.86[c] | 3.85[b] | 5.66[bc] |
| Calcium chloride (T2) | 1.30[f] | 2.83[e] | 4.38[d] |
| Humic acid (T3) | 1.51[e] | 3.09[d] | 4.30[d] |
| Zinc sulphate (T4) | 1.71[d] | 3.46[c] | 4.99[cd] |
| Water (T5) | 1.03[d] | 2.53[f] | 3.28[e] |
| Potassium nitrate (T6) | 2.30[a] | 4.33[a] | 6.90[a] |
| Gibberellic acid (T7) | 1.99[b] | 4.00[b] | 6.14[b] |
| LSD | 0.11 | 0.19 | 0.69 |
| SEM | 0.03 | 0.05 | 0.19 |
| F-probability | *** | *** | *** |
| CV | 3.99 | 3.11 | 7.68 |
| Mean | 1.67 | 3.44 | 5.09 |

better seed physiological performance as a result of seed priming. The highest germination was observed with potassium nitrate with 86.66 cm and gibberellic acid with 80.0 cm, indicating it has a high potential to promote metabolic activation and embryo development in sesame seeds. Reduced germination of hydropriming with 49.33 cm indicates that the use of soaking only was not as effective as chemical priming. The improved performance of $KNO_3$ could be because of the stimulation of the enzyme activity by nitrate and the breaking of dormancy, and the increase of hydrolytic enzyme production and mobilization of reserves in seeds by $GA_3$.

There was no significant difference in mean germination time, indicating that priming did not enhance the speed of germination, but primarily the final germination percentage. Nevertheless, a small decrease in MGT of $KNO_3$ indicates improved uniformity in germination. Generally, $KNO_3$ and $GA_3$ were the best priming agents to enhance the germination performance of sesame. The detailed results are presented in Table IV.

*Seedling vigour-I*

The effect of seed priming was significant ($p < 0.05$) on Seedling Vigour-I at 3, 5 and 7 DAS, suggesting variability in early seedling growth. The highest seedling

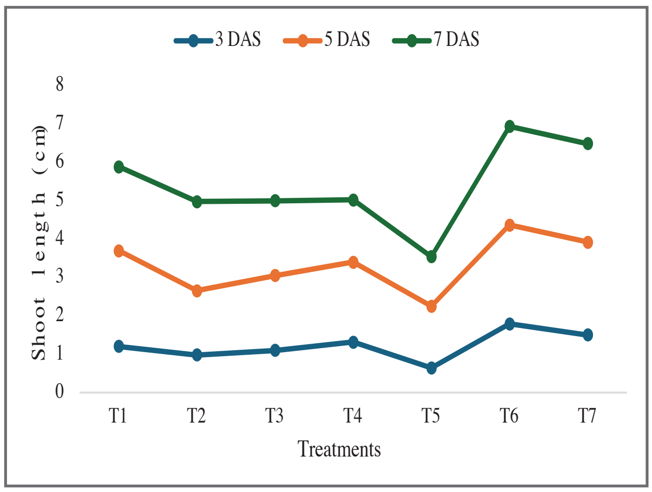


**Fig. 2. Effect of seed priming on shoot length of sesame at different days after sowing**

**Table III. Effect of different priming treatments on shoot length (cm) of seedlings at 3, 5, and 7 days after sowing**

| Treatment | Shoot length (cm) at 3 day | Shoot length (cm) at 5 day | Shoot length (cm) at 7 day |
|---|---|---|---|
| Potassium dihydrogen (T1) | 1.21b[cd] | 3.71[b] | 5.90[bc] |
| Calcium chloride (T2) | 0.99[d] | 2.66[e] | 4.99[c] |
| Humic acid (T3) | 1.11[cd] | 3.06[d] | 5.01[c] |
| Zinc sulphate (T4) | 1.32[bc] | 3.41[c] | 5.03[c] |
| Water (T5) | 0.65[e] | 2.26[f] | 3.55[d] |
| Potassium nitrate (T6) | 1.80[a] | 4.38[a] | 6.95[a] |
| Gibberellic acid (T7) | 1.51[ab] | 3.93[b] | 6.50[ab] |
| LSD | 0.32 | 0.23 | 1.02 |
| SEM | 0.09 | 0.06 | 0.28 |
| F-probability | *** | *** | *** |
| CV | 14.61 | 3.94 | 10.58 |
| Mean | 1.23 | 3.34 | 5.46 |

**Table IV. Effects of different priming treatment on germination percentage and mean germination time of seedlings**

| Treatment | Germination % | Mean germination time |
|---|---|---|
| Potassium dihydrogen (T1) | 70.66[bc] | 3.83[ab] |
| Calcium chloride (T2) | 52.00[de] | 4.15a |
| Humic acid (T3) | 58.66[cde] | 4.00[ab] |
| Zinc sulphate (T4) | 64.00[cd] | 3.91[ab] |
| Water (T5) | 49.33[e] | 3.95[ab] |
| Potassium nitrate (T6) | 86.66[a] | 3.67[b] |
| Gibberellic acid (T7) | 80[ab] | 3.71[b] |
| LSD | 12.22 | 0.39 |
| SEM | 3.43 | 0.11 |
| F-probability | *** | NS |
| CV | 10.42 | 5.74 |
| Mean | 65.90 | 3.89 |

**Table V. Effect of different priming treatments on seedling vigour I of seedlings at 3, 5, and 7 days after sowing**

| Treatment | Seedling vigour-I at 3 day | Seedling vigour-I at 5 day | Seedling vigour-I at 5 day |
|---|---|---|---|
| Potassium dihydrogen (T1) | 217.82[abc] | 534.20[abc] | 816.29[abc] |
| Calcium chloride (T2) | 116.22[c] | 282.73[cd] | 478.85[cd] |
| Humic acid (T3) | 154.09[bc] | 361.40[bcd] | 547.60[bcd] |
| Zinc sulphate (T4) | 194.65[bc] | 440.86[bcd] | 657.81[bcd] |
| Water (T5) | 81.01[c] | 234.33[d] | 337.64[d] |
| Potassium nitrate (T6) | 357.80[a] | 754.66[a] | 1198.13[a] |
| Gibberellic acid (T7) | 280.68[ab] | 634.28[ab] | 1010.00[ab] |
| LSD | 147.45 | 295.50 | 478.48 |
| SEM | 42.97 | 86.13 | 139.48 |
| F-probability | * | * | * |
| CV | 42.97 | 37.17 | 38.68 |
| Mean | 200.26 | 463.35 | 720.90 |

**Table VI. Effect of different priming treatments on seedling vigour-II of seedlings at 7 days after sowing**

| Treatment | Seedling vigour-II at 7 day |
|---|---|
| Potassium dihydrogen (T1) | 14.97[abc] |
| Calcium chloride (T2) | 33.28[ab] |
| Humic acid(T3) | 7.37[c] |
| Zinc sulphate(T4) | 10.74[bc] |
| Water(T5) | 39.00[a] |
| Potassium nitrate(T6) | 28.18[abc] |
| Gibberellic acid (T7) | 21.86[abc] |
| LSD | 25.80 |
| SEM | 7.52 |
| F-probability | * |
| CV | 67.79 |
| Mean | 22.19 |

vigour was observed in potassium nitrate (T6), followed by gibberellic acid (T7), indicating effective priming that improved early seedling growth. This could be due to the role of $KNO_3$ in nitrate signalling, enzyme activation, and better mobilisation of seed reserves, which promote rapid early seedling development. Nitrate also activates genes related to germination and early seedling stages, further promoting early growth (Kundu and Kumar, 2025).

Similarly, $GA_3$ enhances seedling vigour by activating hydrolytic enzyme activity, cell division, and cell elongation, leading to improved embryo growth and emergence (Baurai and Hasan, 2025). By contrast, the lowest vigour values were obtained from water priming, suggesting that hydropriming has little physiological effect compared to chemical priming. This may be because it lacks the hormonal and nutrient-related metabolic stimulation. In conclusion, the findings reveal that nutrient and hormonal priming treatments increase early seedling vigour in sesame, with $KNO_3$ being the most effective. The detailed results are presented in Table V.

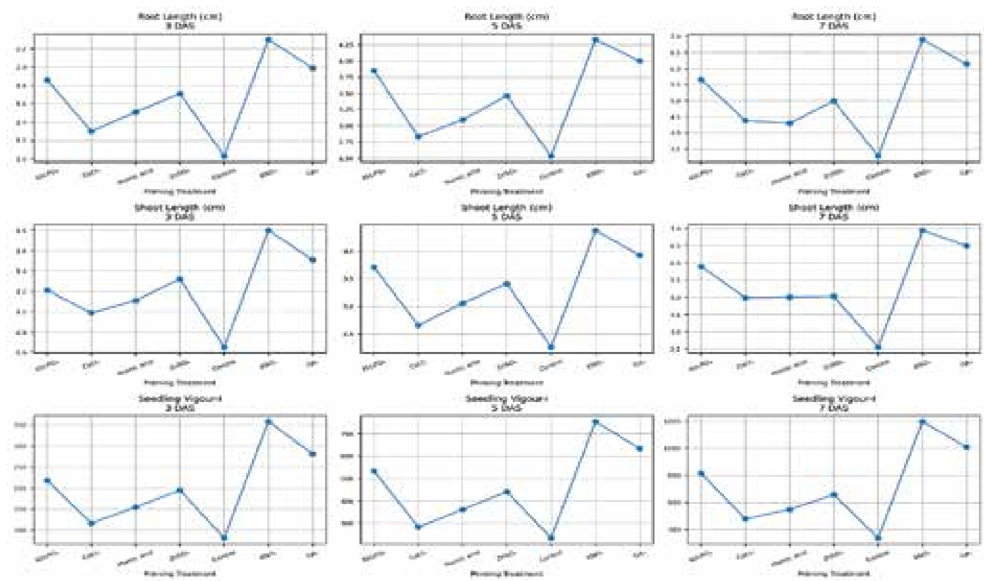


**Fig. 3. Combined effect of different seed priming treatments on root length, shoot length, and seedling vigour index-I of sesame seedlings at different days after sowing**

*Seedling vigour-II*

The study showed significant differences among the treatments. The highest mean value was observed in control, with the value of 39.00 indicating greater seedling vigour-II mainly due to higher accumulation of dry matter content. However, potassium nitrate, gibberlic acid, and humic acid showed lower values, illustrating less effect of priming on biomass (ISTA, 2019). The detailed results are presented in Table VI, and the combined effects of different seed priming treatments on root length, shoot length, and seedling vigour-I are illustrated in Fig. 3.

## Conclusion

This research showed that seed priming had great effects on seed germination and seedling development of sesame. Of the various treatments, potassium nitrate ($KNO_3$) was found to be the best in regard to root length, shoot length, germination percentage, and seedling vigour index-I on all the days of observation. Gibberellic acid ($GA_3$) also did well, especially in improving germination and seedling growth, at slightly less than $KNO_3$. Conversely, hydropriming had a relatively lower germination percentage and seedling vigour-I, but had higher seedling vigour-II, which implies higher dry matter accumulation. Calcium chloride, zinc sulphate, humic acid, and potassium dihydrogen phosphate were found to have moderate effects on germination and seedling growth. In general, the results indicate that potassium nitrate and gibberellic acid are useful priming agents to enhance germination and early seedling vigour in sesame. Thus, the application of these priming treatments can be suggested to have homogeneous crop establishment and enhanced initial growth of crops under similar conditions.

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