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# Priming with Moringa Leaf Extract Enhances the Germination and Early Growth of Peas (*Pisum Sativum*)

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## ABSTRACT
Peas (*Pisum sativum*) are an important legume crop known for their high nutritional value and role in crop rotation systems. Despite their numerous benefits, pea seed germination and early seedling growth can be influenced by various environmental factors, often leading to reduced crop yield. To address this, seed priming has emerged as a technique to improve germination and seedling vigor. This study, conducted in 2024, aimed to evaluate the impact of priming with various concentrations of Moringa Leaf Extract (MLE) on germination and seedling characteristics of peas. The experiment was performed following a Completely Randomized Design (CRD), with three replications. The treatments included a control (no priming) and six different concentrations of MLE (1%, 3%, 5%, 7%, and 9%). Key parameters were assessed included; germination percentage, germination index, seedling vigor index, seedling height, root length, biomass of roots and shoots, leaver seedling-$^{1}$ and branches seedling-$^{1}$ and chlorophyll content. The results indicated that priming with 3% MLE significantly enhanced the germination rate (100%) and seedling vigor index (1513.3) had better result than the other treatments. The 3% MLE treatment also maximized seedling height (15.133 cm) and root length (6.5 cm). Furthermore, this treatment yielded the highest biomass for roots (0.8667 g) and shoots (1.3233 g), as well as the highest chlorophyll content (64.867). At 35 days after sowing, the 7% MLE treatment produced the highest number of leaves, branches, and root length, while the 5% MLE treatment resulted in the highest shoot biomass. Overall, the study suggests that priming with MLE can be an effective technique for improving germination, growth, and biomass production in pea seeds, with the optimal concentration varying depending on the specific growth parameter being measured.

**Keywords**: Germination, Growth, Moringa Leaf Extract (MLE), Priming, Peas

## INTRODUCTION
Peas (*Pisum sativum*) is one of the important rabi season pulse crops of the world that acts as a very good source of vegetative protein for human and animal nutrition (Pooniya et al., 2015). The establishment of crop stands in the field plays a crucial role in determining plant density, ensuring uniform growth, influencing crop management strategies, and ultimately affecting land productivity in agricultural production (Deng et al., 2012). For cost-intensive crops like peas, it is vital that seeds germinate consistently and quickly, endure unfavorable germination conditions, and develop into healthy seedlings (Zhiyuan and Kent, 1999).One possible reason for the low yield of peas is the lack of sufficient water in the fields, which hampers germination and seedling development (Lamichaney et al., 2021). To address this, using pre-sowing seed treatments could be a practical solution to help reduce the effects of environmental stress on crop production. This method is appealing due to its affordability and low risk (Kumar et al., 2023). Priming is considered the most effective pre-sowing treatment, as it has been demonstrated to enhance seed vigor more successfully than conventional soaking techniques (Ashraf, 2005). This technique involves soaking seeds in a solution with organic or inorganic components to control their hydration, followed by re-drying. This process

stimulates metabolic activity before germination while delaying the emergence of the root. Seed priming improves seed vigor by preserving the integrity of the plasma membrane, helping to prevent damage during periods of environmental stress (Farooq et al., 2019; Adetunji et al., 2021). As environmental challenges continue to rise, there has been an increased emphasis on organic crop production. Consequently, researchers are focusing on environmentally sustainable seed enhancement techniques aimed at improving germination rates and ensuring consistent crop establishment. The role of seed priming in enhancing crop tolerance to both biotic and abiotic stress has gained strong support, particularly in relation to the underlying mechanisms involved (Mustafa et al., 2017). Among the numerous natural sources explored for seed priming, *Moringa oleifera* L**.** has emerged as a promising candidate. Previous studies have highlighted the ability of moringa leaf extract to enhance plant growth by increasing the levels of phytohormones, osmo protectants, and antioxidant enzymes, especially in crops subjected to salinity stress (Farhat et al., 2023). In addition, applying moringa leaf extract as a seed priming treatment has been found to enhance seedling emergence, promote stronger establishment, speed up plant growth, and ultimately boost yields, even under difficult and less-than-ideal environmental conditions (Afzal et al., 2016). Moringa Leaf Extract has become of interest as a possible agricultural application that enhances seed germination and growth of a variety of crops. Various experiments have shown that Moringa leaf extracts act as natural bio-stimulants and improve seedling vigor, root development, and general plant health (Mashamaite et al., 2022; Rashid et al., 2021). Considering these findings, this research was conducted to assess the impact of seed priming with moringa leaf extract on the germination and growth of peas (*Pisum sativum*). The study seeks to explore whether this natural priming agent can improve seed germination, boost seedling growth, and enhance the overall performance of pea seedlings.

## MATERIAL AND METHODS

The present study was conducted in 2024 to investigate the effect of priming with different concentration of Moringa Leaf Extract (MLE) on the germination and seedling characteristics of peas in three replicated Completely Randomized Design (CRD). The treatments included: ($T_1$= Control-no priming), $T_2$ = Priming with 1% of MLE , $T_3$ =Priming with 3% of MLE, $T_4$ = Priming with 5% of MLE, $T_5$ = Priming with 7% of MLE, $T_6$ = Priming with 9% of MLE. The fresh seeds were collected from the Tandojam Market, then they were planted in plastic bags filled with canal silt. The experiment was set up as follows:

Experimental design - Completely Randomized Design (CRD)

Replications (03)

**Observations recorded**

**Germination percentage:** The trial was visited on daily basis for up to 15 days and the germination (%) was determined by utilizing the subsequent conditions as portrayed by (Larsen and Andreasen, 2004).

$$\mathbf{GP = \sum n / N \times 100}$$

Where n is a number of sprouted seeds at each check and N is all out seeds in every treatment.

**Germination index:** Germination Index was calculated on the basis of germination per day.

The germination index was calculated by using the fallowing used by association of official seed analysis (AOSA, 1983).

**Seedling vigour index (SVI)**: SVI was determined by utilizing subsequent equations, Abdul-Baki and Anderson (1970).

**Seedling vigor index (SVI) = [length of shoot (cm) × germination %]**

**Leaves seedling$^{-1}$:** The number of fully expanded leaves selected in each plant were counted and then average was taken out.

**Branches seedling$^{-1}$:** Branches selected in each plant were counted and then average was taken out.

**Seedling height (cm)**: Measuring tape was used to calculate the plant height from bottom to top of the plant.

Root length: The length of major primary root was calculated with the measuring scale.

**Biomass of root (g):** The fresh biomass of root was measured by using an electronic scale and the values were expressed in gram (g).

**Biomass of shoot (g):** The fresh biomass of shoot was measured by using an electronic scale and the values were expressed in gram (g).

**Data analysis:** Statistix 8.1 software was used to perform a statistical analysis of the data (Statistix, 2006).

Least Significant Difference (LSD) was done to compare the treatments where necessary.

## RESULTS

**Germination percentage:** The (Table 1) showing the results regarding germination percentage was statistically highly significant, as indicated by a P-value around 0.0006. The highest germination percentage, 100%, was obtained from the ($T_3$) priming with 3% MLE, indicating that priming with 3% MLE is highly effective in enhancing seed germination. Control treatment ($T_1$) had the lowest germination percentage, which was at 50%. Generally, treatments with MLE priming ($T_2$, $T_3$, $T_4$, $T_5$, and $T_6$) resulted in higher percentages of germination compared to the control. Among the primed treatments, 3% MLE was the most effective, followed by 5% MLE (80%) and 9% MLE (76%).

**Germination index:** The (Table 1) showing the results regarding Germination Index was statistically significant since the p-value is 0.0000; $p < 0.05$. For the results, $T_3$, which consisted of 3% MLE priming, showed the highest value of GI with (12.353) germinated seeds suggesting that $T_3$ led to the fastest uniform germination compared to all the others priming treatment. In contrast, $T_5$ (7% MLE priming) had the lowest GI value at (7.4633), the control group, $T_1$, had a moderate GI value of (10.313), which was lower than the 3% and 9% MLE priming treatments, suggesting that MLE priming enhances germination compared to the unprimed seeds. Notably, $T_6$ (9% MLE priming) also revealed a relatively high GI value (11.330), suggesting that a higher concentration of MLE (9%) can still support good germination though it did not reach the performance seen with 3% MLE.

**Seedling vigour index:** The p-value for Seedling Vigour Index is 0.0000, which was highly significant ($p < 0.05$). (Table 1) $T_3$ (3% MLE priming) showed the highest SVI (1513.3), meaning that this treatment produced the most vigorous seedlings. This is consistent with its better germination performance, meaning that not only did the seedlings of this treatment germinate well, but they also grew faster. $T_4$ (5% MLE priming) was also not so poor as the above-mentioned samples, which showed relatively higher SVI values (850.67), thereby showing that seedling vigor of 5%
MLE primed seeds was good compared with 3% MLE though not like it. Samples $T_5$ (7% MLE priming) and $T_6$ (9% MLE priming) gave average SVI values 692.00 and 777.33, respectively. Although these values were higher than $T_1$ (control), they were significantly lower compared with those observed in 3% and 5% MLE treatments.

**Table 1: Effect of priming on germination%, Germination Index (GI) and Seedling Vigour index (SVI) of peas.**

| Treatments | Germination % | Germination index (GI) | Seedling vigour index (SVI) |
|---|---|---|---|
| **$T_1$=Control** | 50 D | 10.313 A | 303.33 D |
| **$T_2$= Priming with 1% MLE** | 60 CD | 8.8367 D | 502.00 C |
| **$T_3$=Priming with 3% MLE** | 100 A | 12.353 C | 1513.3 A |
| **$T_4$=Priming with 5% MLE** | 80 B | 8.2500 D | 850.67 B |
| **$T_5$=Priming with 7% MLE** | 63 BCD | 7.4633 E | 692.00 BC |
| **$T_6$=Priming with 9% MLE** | 76 BC | 11.330 B | 777.33 B |
| **P-VALUE** | 0.0006 | 0.0000 | 0.0000 |
| **SE** | 7.9349 | 0.2831 | 88.985 |
| **LSD 0.05** | 17.289 | 0.6168 | 193.88 |
| **CV** | 13.56 | 3.55 | 14.10 |

**Number of leaves plant$^{-1}$ at 25 days after sowing:** The (Table 2) showing the results regarding number of leaves were statistically significant, as indicated by a P-value of 0.0095. The highest number of leaves (7.77) was found from the $T_3$ treatment (Priming with 3% MLE) the lowest number of leaves (4.88) was observed from the $T_1$ (control), these treatments were followed by $T_4$ treatment priming with 5% MLE (6.22), while $T_2$ and $T_6$ priming with 1% MLE and priming with 9% MLE (5.10 and 5.22).

**Number of branches plant$^{-1}$ at 25 days after sowing:** The (Table 2) showing the results regarding number of branches plant$^{-1}$ was statistically significant, as indicated by a P-value of 0.0000. Using a priming treatment which is priming with 3% MLE on $T_3$ plant gave the best results with maximum average of (9.5) branches which was significantly higher than all the treatments. On the other hand, $T_2$ priming with 1% MLE and $T_4$ priming with 5% MLE were a bit outperformed by $T_3$ having (5.33) branches and (6.33) branches respectively. It was also noted that $T_1$ (the control) scored the lowest number of branches which was at (3.55) thus it can be said that due to the priming treatments the number of branches were enhanced when compared to the control group. Also, $T_5$ priming with 7% MLE and $T_6$ (priming with 9% MLE) had a significantly lesser number of branches which averaged to (4.22 and 4.66)

**Seedling height (cm) at 25 days after sowing:** For the case of seedling height, its p-value showing in the (Table 2) that results highly significant at 0.0000 ($p < 0.05$). Thus, the priming treatments increase seedling height significantly from that of the control treatment; $T_3$ Priming with 3% MLE had the highest seedling height at (15.133 cm), which was significantly greater than all other treatments. And the lowest seedling height

(7.0667cm) was observed from the $T_1$ where no priming (control). $T_2$ (Priming with 1% MLE) had a significant increase in seedling height (8.3333 cm), much higher than the control, but still lower than higher concentrations of MLE priming. $T_4$ Priming with 5% MLE, $T_5$ Priming with 7% MLE, and $T_6$ Priming with 9% MLE had seedling heights of (10.633 cm), (11.000 cm), and (10.133 cm), respectively. These are greater than the control, but not as high as that in $T_3$. No differences were found between 5%, 7%, and 9% MLE treatments.

**Root length (cm) at 25 days after sowing:** The great variation was recorded in terms of root length of pea seedlings. The p-value for root length was 0.0000, (Table 2) indicates that all the priming treatments significantly increased root length compared to the control with the highest increase being in the 3% MLE treatment. $T_1$ (Control) had the shortest root length at (1.3667 cm). $T_2$ Priming with 1% MLE had an increase in root length at (2.3667 cm), which was significantly higher than the control but lower than the higher MLE priming treatments. $T_3$ Priming with 3% MLE had the longest root length at (6.5000 cm), which was significantly higher than the control and all other treatments. Root lengths of $T_4$ with 5% MLE were 3.5000 cm, $T_5$ that was subjected to 7% MLE, while $T_6$ that was treated at 9% MLE had root lengths of (5.4667 cm) and (4.7000 cm).

**Table 2: Effect of priming on number of leaves, number of branches per plant, plant height (cm) and root length (cm) of peas at 25 days after sowing.**

| Treatments | Leaves plant$^{-1}$ | Branches plant$^{-1}$ | Seedling height (cm) | Root length (cm) |
|---|---|---|---|---|
| **$T_1$=Control** | 4.88 B | 3.55 E | 7.0667 C | 1.3667 F |
| **$T_2$= Priming with 1% MLE** | 5.10 B | 5.33 C | 8.3333 C | 2.3667 E |
| **$T_3$=Priming with 3% MLE** | 7.77 A | 9.5 A | 15.133 A | 6.5000 A |
| **$T_4$=Priming with 5% MLE** | 6.22 B | 6.33 B | 10.633 B | 3.5000 D |
| **$T_5$=Priming with 7% MLE** | 5.88 B | 4.22 D | 11.000 B | 5.4667 B |
| **$T_6$=Priming with 9% MLE** | 5.22 B | 4.66 D | 10.133 B | 4.7000 C |
| **P- VALUE** | 0.0095 | 0.0000 | 0.0000 | 0.0000 |
| **SE** | 0.6675 | 0.2928 | 0.7100 | 0.2261 |
| **LSD 0.05** | 1.4544 | 0.6379 | 1.5469 | 0.4926 |
| **CV** | 13.98 | 6.41 | 8.37 | 6.95 |

**Root biomass (g) at 25 days after sowing**: The (Table 3) showing the results regarding root biomass (g) affected by priming with different concentration with MLE was statistically significant, as indicated by a P-value of 0.0104 ($p < 0.05$). The maximum root biomass was observed from the $T_3$ Priming with 3% MLE (0.8667 g), which was significantly higher than the control and all other treatments.$T_1$ (Control) resulted in the minimum root biomass of (0.4633 g), result regard to $T_4$ and $T_5$ treatments on priming 5% extract and 7% respectively increased the root biomass to (0.6300g) and (0.6533 g) respectively hence the two values are statistically similar. The second lowest in terms of root biomass was noted on $T_6$ which was priming with 9% MLE recording (0.5200 g) this was significantly different from $T_3$ but was not the same in all the other treatments.

**Shoot biomass (g) at 25 days after sowing:** The (Table 3) showing the results regarding shoot biomass (g) affected by priming with different concentration with MLE was statistically highly significant, as indicated by a P-value of 0.0011 ($p < 0.05$). maximum the shoot biomass was observed from the $T_3$ primed with 3% MLE (1.3233 g), significantly higher than all other treatments. Where the minimum the shoot biomass g was observed from the $T_1$ no priming (control) (0.5867 g), $T_2$ (Priming with 1% MLE), $T_4$ (Priming with 5% MLE), $T_5$ (Priming with 7% MLE), and $T_6$ (Priming with 9% MLE) had shoot biomass of (0.9367 g), (0.6667 g), (0.5533 g), and (0.6300 g), respectively. These treatments are statistically like each other.

**Chlorophyll content at 25 days after sowing:** The (Table 3) showing the results regarding chlorophyll content affected by priming with different concentration of MLE was statistically highly significant, as indicated by a P-value of 0.0000 ($p < 0.05$). The chlorophyll content was highest in $T_3$ priming with 3% MLE with a value of (64.867), which implies that this treatment significantly enhanced the production of chlorophyll. the lowest chlorophyll content at (28.100), recorded from the $T_1$ no priming(Control). All these $T_2$, $T_4$, and $T_5$, $T_6$ MLE priming treatments increased chlorophyll content compared to the control: With treatment having 9% MLE and on the second position was chlorophyll content is (57.433) then $T_5$ with 7% of MLE (42.633).

**Table 3: Effect of priming on root biomass (g), shoot biomass (g), and chlorophyll content (spad) of pea at 25 days after sowing.**

| Treatments | Root biomass (g) | Shoot biomass(g) | Chlorophyll content (Spad) |
|---|---|---|---|
| **$T_1$=Control** | 0.4633 B | 0.5867 C | 28.100 E |
| **$T_2$= Priming with 1% MLE** | 0.5800 B | 0.9367 B | 34.067 D |
| **$T_3$=Priming with 3% MLE** | 0.8667 A | 1.3233 A | 64.867 A |
| **$T_4$=Priming with 5% MLE** | 0.6300 B | 0.6667 BC | 35.800 D |
| **$T_5$=Priming with 7% MLE** | 0.6533 B | 0.5533 C | 42.633 C |
| **$T_6$=Priming with 9% MLE** | 0.5200 B | 0.6300 BC | 57.433 B |
| **P-VALUE** | 0.0104 | 0.0011 | 0.0000 |
| **SE** | 0.0886 | 0.1427 | 1.8751 |
| **LSD 0.05** | 0.1930 | 0.3110 | 4.0854 |
| **CV** | 17.53 | 22.33 | 5.24 |

**Leaves plant$^{-1}$ at 35 days after sowing**: The (Table 4) showing the results regarding number of leaves at 35 days after sowing was statistically- highly significant, as indicated by a P-value of 0.0000 .the highest number of leaves (17.490) was found from the $T_5$ treatment (Priming with 7% MLE ) the lowest number of leaves (11.403) was observed from the $T_1$ (control), these treatments were followed by $T_6$ treatment priming with 9% MLE (16.437), while $T_4$ and $T_3$ priming with 5% MLE and priming with 3% MLE (13.547 and 10.367).

**Branches plant$^{-1}$ at 35 days after sowing:** The (Table 4) showing the results regarding number of branches per plant at 35 days after sowing was statistically-highly significant, as indicated by a P-value of 0.0000. Using a priming treatment with 7% MLE on $T_5$ plant gave the best results with maximum average no of (13.000) branches which was significantly higher than all the treatments. On the other hand, $T_6$ priming with 9% MLE and $T_2$ priming with 1% MLE were a bit outperformed by $T_5$ having (11.440) branches and (9.8867) branches respectively. It was also noted that $T_1$ (the control) scored the lowest number of branches which was at (6.0733) thus it can be said that due to the priming treatments the number of branches were enhanced when compared to the control group. Also, $T_4$ priming with 5% MLE had a significantly lesser number of branches which averaged to (8.9933)

**Seedling height (cm) at 35 days after sowing:** For the case of seedling height, its p-value showing in the (Table 4) that results highly significant at 0.0000 ($p < 0.05$). Thus, the priming treatments increase seedling height significantly from that of the control treatment; $T_5$ Priming with 7% MLE had the highest seedling height at (26.66 cm), which was significantly greater than all other treatments. And the lowest seedling height (11.233 cm) was observed from the $T_1$ where no priming (control). $T_6$ (Priming with 9% MLE) had a significant increase in seedling height (23.600 cm), much higher than the control, but still lower than $T_5$. $T_4$ Priming with 5% MLE, $T_3$ Priming with 3% MLE, and $T_2$ Priming with 1% MLE had seedling heights of (19.000 cm), (22.700 cm), and (20.667 cm), respectively. These are greater than the control, but not as high as that in $T_5$.

**Root length (cm) at 35 days after sowing:** The great variation was recorded in term of Root length of pea seedling at 35 days after sowing. The p-value for root length was 0.0000, (Table 4) that all the priming treatments highly significantly increased root length compared to the $T_1$ (control) (3.7000 cm) with the highest increase being in the $T_5$ priming with 7% MLE (9.2667 cm). $T_6$ (Priming with 9% MLE) had a significant increase in root length (6.9333 cm), much higher than the control, but still lower than $T_5$. $T_4$ Priming with 5% MLE, $T_3$ Priming with 3% MLE, and $T_2$ Priming with 1% MLE, had root length of (4.6000 cm), (7.5000cm), and (5.6333 cm), respectively. These are greater than the control, but not as high as that in $T_5$.

**Table 4: Effect of priming on leaves plant$^{-1}$, branches plant$^{-1}$, seedling height (cm) and root length (cm) of peas at 35 days after sowing.**

| Treatments | Leaves plant$^{-1}$ | Branches plant$^{-1}$ | Seedling height (cm) | Root length(cm) |
|---|---|---|---|---|
| **$T_1$=Control** | 11.403 E | 6.0733 D | 11.233 E | 3.7000 E |
| **$T_2$= Priming with 1% MLE** | 12.277 D | 9.8867 C | 20.667 C | 5.6333 C |
| **$T_3$=Priming with 3% MLE** | 10.367 F | 9.5000 C | 22.700 B | 7.5000 B |
| **$T_4$=Priming with 5% MLE** | 13.547 C | 8.9933 C | 19.000 D | 4.6000 D |
| **$T_5$=Priming with 7% MLE** | 17.490 A | 13.000 A | 26.667 A | 9.2667 A |
| **$T_6$=Priming with 9% MLE** | 16.437 B | 11.440 B | 23.600 B | 6.9333 B |
| **P-VALUE** | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **SE** | 0.2067 | 0.4389 | 0.4177 | 0.2667 |
| **LSD 0.05** | 0.4504 | 0.9563 | 0.9100 | 0.5810 |
| **CV** | 1.86 | 5.48 | 2.48 | 5.21 |

**Root biomass (g) at 35 days after sowing**: The (Table 5) showing the results regarding Root biomass (g) at 35 days after sowing affected by priming with different concentration with MLE was statistically-highly significant, as indicated by a P-value of 0.0000 ($p < 0.05$). The maximum root biomass was observed from the $T_5$ Priming with 7% MLE (1.7333 g), which was significantly higher than the control and all other treatments. $T_1$ (Control) resulted in the minimum root biomass of (1.0167 g), result regard to $T_4$ and $T_2$ treatments on priming 5% extract and 1% respectively increased the root biomass to (1.4600 g) and (1.2233 g), regarding to $T_3$ and $T_6$ treatments on priming 3% extract and 9% respectively increased the root biomass to (1.3333g) and (1.1133g).

**Shoot biomass (g) at 35 days after sowing**: The (Table 5) showing the results regarding shoot biomass (g) at 35 days after sowing effected by priming with different concentration with MLE was statistically-highly significant, as indicated by a P-value of 0.0000 ($p < 0.05$). The maximum shoot biomass was observed from the $T_5$ Priming with 7% MLE (2.6233 g), which was significantly higher than the control and all other treatments. $T_1$ (Control) resulted in the minimum shoot biomass of (1.1167 g), result regard to $T_4$ and $T_2$ treatments on priming 5% extract and 1% respectively increased the shoot biomass to (2.2600 g) and (1.7767 g). regard to $T_3$ and $T_6$ treatments on priming 3% extract and 9% respectively increased the shoot biomass to (1.9167 g) and (2.0767 g), respectively hence the two values are statistically similar.

**Table No. 5 Effect of priming on root biomass (g) and shoot biomass (g) of peas at 35 days after sowing**

| Treatments | Root biomass (g) | Shoot biomass (g) |
|---|---|---|
| **$T_1$=Control** | 1.0167 E | 1.1167 E |
| **$T_2$= Priming with 1% MLE** | 1.2233 D | 1.7767 D |
| **$T_3$=Priming with 3% MLE** | 1.3333 C | 1.9167 CD |
| **$T_4$=Priming with 5% MLE** | 1.4600 B | 2.2600 B |
| **$T_5$=Priming with 7% MLE** | 1.7333 A | 2.6233 A |
| **$T_6$=Priming with 9 %MLE** | 1.1133 E | 2.0767 BC |
| **P-VALUE** | 0.0000 | 0.0000 |
| **SE** | 0.0455 | 0.0984 |
| **LSD 0.05** | 0.0992 | 0.2144 |
| **CV** | 4.25 | 6.14 |

## DISCUSSION

This study examined how different concentrations of Moringa Leaf Extract (MLE) used for seed priming affect the germination and early seedling growth of pea (*Pisum sativum L.*). Substantial improvement was observed in germination and seedling characteristics related to traits by use of priming with MLE. MLE contains natural growth-promoting substances, including cytokinins, auxins, and gibberellins, which stimulate seed germination and seedling development. Seed priming involves treating seeds with specific substances or solutions before planting to enhance germination and improve seedling growth. Moringa Leaf Extract has properties that make it an effective priming agent for seeds, helping to boost their vitality and performance. Moringa contains natural plant growth regulators, which are compounds that can promote seed germination, enhance root development, and support overall plant growth. These include: Cytokinins (promote cell division and growth). Auxins (regulate root development and stem elongation). Gibberellins (assist in seed germination and early growth). These findings are supported by Noor et al. (2016), who also reported enhanced germination and seedling growth in peas following MLE priming. Who described that priming with MLE revealed better results for germination and seedling growth related to attributes in peas. Priming with 3% MLE significantly increased germination percentage, germination index, and seedling vigor index compared to untreated seeds. Furthermore, priming with 7% MLE improved seedling height, number of leaves, and branches per plant, indicating enhanced vegetative growth, branches per plant and seedling height of peas was attributed to the fact that priming with MLE played a key role in producing healthy and high seeding. Earlier studies have shown that adequate concentration of MLE not only enhances leaves, and branches per plant but also aids in producing highest seedling and root length through improved activation of enzymes involved in peas as well as plant metabolism (Noreen et al., 2024). This positive effect of priming with MLE in increasing growth on the peas is in agreement with various studies conducted earlier. The outcomes of Basra et al. (2011) revealed that peas seedling plants which were primed with MLE had higher biomass of root and biomass of shoot than the control ones, which was quite in line with those outcomes of the current study. These results are in agreement with previous studies (Afzal et al., 2012; Yasmeen et al., 2013;; Wajid et al., 2018; Khan et al., 2024), which also demonstrated that MLE priming positively influences pea seedling growth and development.

## CONCLUSION

The study demonstrates that priming pea seeds with Moringa Leaf Extract, particularly at a concentration of 3%, and 7% significantly enhances germination rates and seedling vigor, while also improving various growth parameters. Such results indicate that Moringa Leaf Extract can be an effective method for promoting the growth and biomass production of pea seedlings.

## RECOMMENDATIONS

Based on the results of this study, it is recommended to use 3% Moringa Leaf Extract (MLE) for priming pea seeds, as it showed the best improvement in germination, seedling vigor, root and shoot growth, and chlorophyll content. For specific purposes, 5% MLE can be used to increase shoot biomass, and 7% MLE may help promote more leaves and branches. It is also suggested that further trials be conducted under field conditions to confirm these findings. Future studies should explore the long-term effects of MLE on flowering and yield, compare it with other priming agents, and investigate the mechanisms behind its positive effects.

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## AUTHORS CONTRIBUTION

**MAW** and **MA**:  designed the study and prepared the initial manuscript draft; **MAW**, **MNB**: conducted the study and gathered the data; **SAW**: provided valuable assistance with data analysis, offered technical insights, and contributed to the manuscript's development; **MC**: provided technical support throughout the research process. SA: assistance in organizing and compiling the data; **FM**: supported in the data analysis. **FAW**: offered technical expertise and contributed to the writing of the manuscript; **GHW**: reviewed and edited the manuscript.

## CONFLICTS OF INTEREST

The authors have declared no conflict of interest

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