# Effect of Seed Priming Techniques on Germination, Growth and Yield Attributes of Aged Chickpea (*Cicer arietinum* L.)

# Abstract

Chickpea (Cicer arietinum L.) is one of the most important legume crops globally, valued for its high protein content and role in sustainable agriculture through nitrogen fixation. However, seed ageing significantly affects its germination and field performance, necessitating effective strategies to enhance seed vigor and productivity. A field study was conducted during the Rabi 2024–25 season at the Organic Research Farm, Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), to evaluate the impact of various seed invigoration treatments on aged chickpea seeds harvested in 2023–24. Eight treatments, including hydration, osmo-conditioning, and chemical priming (with GA₃, KH₂PO₄, CaCl₂, and KNO₃), were compared with untreated aged seeds. Significant improvements were observed in field emergence, plant population, plant height, number of branches and pods per plant, and seed yield due to invigoration treatments. Among all treatments, seed priming with 2% calcium chloride (T7) recorded the highest seed yield (12.15 g per plant, 1.60 kg per plot), maximum number of branches (22.70), and the greatest plant height at maturity (39.17 cm). These findings underscore the potential of seed invigoration, particularly with CaCl₂, as an effective technique to restore vigor and improve field performance in aged chickpea seeds.

**Keywords:** Chickpea (Cicer arietinum L.), Seed ageing, Seed invigoration, Calcium chloride, Priming, Field performance, Seed yield, Germination enhancement

# Introduction

Chickpea (Cicer arietinum L.) is an important pulse crop cultivated extensively across India for its protein-rich seeds. However, seed ageing and poor seed vigour remain major constraints in achieving optimal crop establishment and yield, particularly under resource-limited conditions. Aged seeds often suffer from reduced germination, poor emergence, and lower productivity (Tekrony and Egli, 1991). Seed invigoration treatments have been shown to mitigate the deleterious effects of seed ageing by enhancing metabolic repair mechanisms and boosting seedling vigour (McDonald, 2000; Farooq et al., 2019).

High-quality seed is an essential factor to ensure good crop establishment and to obtain higher yields. Seed must be viable and possess good physiological traits that allow rapid germination, seedling establishment, uniformity in crop growth, and ultimately increased yield per unit area. Seed germination and vigour are the main physiological attributes that are indirectly related to yield performance (Tekrony and Egli, 1991). Slow or erratic emergence and poor stand establishment are typical symptoms of low seed vigour.

Rapid and uniform field emergence is essential to achieve high yield and seed quality in annual crops (Yari et al., 2010). Seed invigoration is one of the most promising developments to facilitate rapid and uniform germination and to increase seed tolerance to adverse environmental conditions (McDonald, 2000). One of the simplest and most effective methods to improve seedling vigour and field establishment is seed priming.

The development of seed invigoration treatments began with the concept of seed priming, first described by Heydecker et al. (1973), involving controlled hydration of seeds to activate metabolic processes without permitting radicle emergence. This approach ensures that all seeds reach a uniform physiological state before sowing, resulting in synchronized and accelerated germination.

Priming of seeds in osmotic solutions like polyethylene glycol (osmo-priming) or in water (hydro-priming) has been reported as an economical, simple, and safe technique to improve seed tolerance to osmotic stress and enhance seedling establishment and crop performance (Lee-Suskoon et al., 1998). This improvement is attributed to faster root and shoot emergence, more vigorous seedlings, greater drought tolerance, earlier flowering and maturity, and higher grain yield even under stressed environments. On-farm seed priming has also shown success in a wide range of tropical and sub-tropical crops, promoting rapid germination, increased seedling vigour, and improved crop productivity (Harris, 2004).

Despite these benefits, the influence of different seed invigoration treatments on aged seed performance and crop productivity in chickpea remains insufficiently documented, warranting further investigation.

# Materials and Methods

## Experimental Site

The experiment was conducted at the Organic Research Farm, Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, during the Rabi season of 2024–25. The site is located at 25°44′N latitude, 78°56′E longitude, and 285 meters above sea level.

The field trial was conducted following Randomized Block Design with eight treatments and three replications with a net plot size of 3 m x 4 m. The spacing adopted was 45 cm between the rows and 10 cm between the plants in a row.

## Experimental Design and Treatments

A total of eight treatments were evaluated in a randomized block design with three replications:

* T1: Aged untreated seed (control)
* T2: Hydration for 8 hours followed by air drying
* T3: Hydration + thiram @ 3 g kg⁻¹
* T4: Osmo-conditioning with PEG 6000 (-0.5 MPa) for 6 hrs
* T5: GA₃ @ 50 ppm for 8 hrs + air drying
* T6: KH₂PO₄ 2% for 8 hrs + air drying
* T7: CaCl₂ 2% for 8 hrs + air drying
* T8: KNO₃ 2% for 8 hrs + air drying

## Data Collection

Parameters observed included: field emergence, plant population, plant height (30, 60 DAS, and at maturity), days to 50% flowering, number of branches and pods per plant, shelling percentage, 100-seed weight, and seed yield per plant and plot.

## Statistical Analysis

The data were analyzed using ANOVA at a 5% significance level. Critical difference (CD), standard error (SEm), and coefficient of variation (CV) were calculated for each parameter.

**Results and Discussion**

Seed invigoration treatments had a significant impact on field emergence and crop establishment (Table 2). The untreated aged seeds (T1) showed the lowest emergence (82.33%), while the highest emergence (90.00%) was observed in seeds primed with 2% CaCl₂ (T7), followed closely by KNO₃ (88.33%) and GA₃ (86.67%). This improvement may be attributed to calcium’s role in membrane repair and enhancing antioxidant activity (Farooq et al., 2006; Harris et al., 1999).

Although the difference in plant population was statistically non-significant, higher numerical values were recorded in T3, T5, T7, and T8 treatments, suggesting better initial establishment likely due to enhanced germination and seedling vigour.

**Plant Growth Parameters**

Plant height data showed significant differences at 60 DAS and at maturity (Table 3). T7 (CaCl₂) recorded the tallest plants (37.53 cm at 60 DAS and 39.17 cm at maturity), followed by T6 (KH₂PO₄) and T8 (KNO₃), indicating sustained vegetative growth due to priming. Enhanced cell elongation and nutrient uptake likely contributed to improved height (McDonald, 2000).

Interestingly, T5 (GA₃) induced the earliest flowering (39 days), significantly earlier than untreated control (45 days). GA₃ is well-known for stimulating earlier germination and reproductive transition through hormonal regulation (Basra et al., 2005), which was clearly evident in the treated seeds.

**Yield Attributes**

Significant variation was observed in number of branches and pods per plant (Table 4). The highest number of branches (22.70) and pods per plant (46.07) were recorded in T7 (2% CaCl₂). This could be linked to enhanced nutrient mobility and cell division promoted by calcium. Treatments with KH₂PO₄ (T6) and KNO₃ (T8) also showed promising values.

No significant differences were observed in shelling percentage or 100-seed weight, although T7 again showed the highest 100-seed weight (28.00 g), suggesting improved assimilate partitioning to seed development under better physiological conditions.

**Seed Yield**

Seed yield per plant and per plot also showed highly significant differences across treatments (Table 5). T7 (CaCl₂) recorded the maximum seed yield per plant (12.15 g) and per plot (1.60 kg), followed by T2 (hydration), T5 (GA₃), and T8 (KNO₃). The yield advantage in T7 can be attributed to its superior performance in plant height, branching, pod formation, and seed weight, indicating comprehensive physiological improvement.

Lower yields in T1 (control), T3 (thiram-treated), and T4 (PEG-osmoprimed) point toward limited repair of seed deterioration or oxidative stress damage in those treatments.

These findings strongly support the use of CaCl₂-based priming for aged chickpea seeds. The ability of calcium to restore membrane stability, activate repair enzymes, and support nutrient signaling contributes to improved seedling vigour and productivity (Farooq et al., 2006). The results also align with Harris et al. (1999), who highlighted the benefits of Ca²⁺ priming in legumes under stress conditions. Although other treatments like GA₃ and KNO₃ also offered early flowering and higher seed yields than control, they were slightly less effective overall compared to CaCl₂. The non-significant impact on shelling percentage and 100-seed weight across treatments indicates that yield improvements were primarily driven by plant architecture and pod number rather than seed filling capacity.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source** | **d.f** | **Field emergence (%)** | **Plant population m-2** | **Plant height at 30 DAS**  **(cm)** | **Plant height at 60 DAS**  **(cm)** | **Plant height at maturity (cm)** | **Days to 50 %**  **flowering** | **No. of branches per plant** | **No. of pods per plant** | **Shelling percentage** | **Seed yield per plant (g)** | **Seed yield per plot (kg)** | **100**  **seed weight (g)** |
| **Treatment** | 7 | 12.217\*\* | 2.259NS | 5.366NS | 14.291\*\* | 15.329\*\* | 10.667\*\* | 34.597\*\* | 166.211\*\* | 1.023NS | 14.409\*\* | 0.189\*\* | 1.412NS |
| **Replication** | 2 | 8.136 | 6.037 | 4.357 | 8.865 | 5.544 | 0.444 | 1.045 | 12.398 | 0.793 | 0.203 | 0.016 | 0.602 |
| **Error** | 14 | 2.475 | 1.829 | 4.491 | 3.509 | 1.798 | 0.653 | 1.324 | 11.509 | 1.366 | 0.838 | 0.007 | 0.582 |

**Table 1. Mean squares for field parameters in aged seed of chickpea as affected by seed invigoration**

\* Significant difference at 5% probability level

\*\* Significant difference at 1% probability level NS: Non-significant

**Table 2. Influence of seed invigoration on field emergence and plant population m-2 in aged seed of chickpea**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Field emergence (%)** | | **Plant population m-2** |
| **T1 - Aged (*Rabi*, 2023-24 harvested seed – untreated (control)** | 82.33 |  | 14.33 |
| **T2 - Hydration treatment** | 88.00 |  | 14.67 |
| **T3 - Hydration followed by seed treatment with thiram @ 3 g kg-1 seed** | 85.00 |  | 16.67 |
| **T4 - Osmo-conditioning with PEG 6000 (-0.5 Mpa)** | 86.33 |  | 15.33 |
| **T5 - Seed treatment with 50 ppm GA3** | 86.67 |  | 16.67 |
| **T6 - Seed treatment with 2% KH2P04** | 83.33 |  | 16.00 |
| **T7 - Seed treatment with 2% CaCl2** | 90.00 |  | 16.33 |
| **T8 - Seed treatment with 2% KN03** | 88.33 |  | 16.33 |
| **Mean** | 86.22 |  | 15.85 |
| **CD (5%)** | 2.72 | | NS |
| **SEm ±** | 0.91 | | 0.78 |
| **CV (%)** | 2.30 | | 8.53 |

**Table 3. Influence of seed invigoration on plant height and days to 50 % flowering in aged seed of chickpea**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Plant height (cm) at** | | | **Days to 50 % flowering** |
| **30 DAS** | **60 DAS** | **maturity** |
| **T1 - Aged (*Rabi*, 2023-24 harvested seed – untreated (control)** | 22.51 | 30.17c | 31.97d | 45.00a |
| **T2 - Hydration treatment** | 25.69 | 35.21ab | 37.20ab | 43.00b |
| **T3 - Hydration followed by seed treatment with thiram @ 3 g kg-1 seed** | 25.02 | 34.61ab | 36.01b | 43.00b |
| **T4 - Osmo-conditioning with PEG 6000 (-0.5 Mpa)** | 25.96 | 31.59bc | 32.94cd | 40.00cd |
| **T5 - Seed treatment with 50 ppm GA3** | 26.06 | 33.52bc | 35.01bc | 39.00d |
| **T6 - Seed treatment with 2% KH2P04** | 24.68 | 35.06ab | 36.88ab | 41.00c |
| **T7 - Seed treatment with 2% CaCl2** | 25.63 | 37.53a | 39.17a | 40.00cd |
| **T8 - Seed treatment with 2% KN03** | 25.04 | 35.45ab | 37.51ab | 43.00b |
| **Mean** | 24.81 | 34.04 | 35.76 | 42.00 |
| **CD (5%)** | NS | 3.24 | 2.32 | 1.40 |
| **SEm ±** | 1.22 | 1.08 | 0.77 | 0.47 |
| **CV (%)** | 8.54 | 5.49 | 3.74 | 1.93 |

**Table 4. Influence of seed invigoration on yield parameters in aged seed of chickpea**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **No. of branches per plant** | **No. of pods per plant** | **Shelling percentage** | | **100 seed weight (g)** |
| **T1 - Aged (*Rabi*, 2023-24 harvested seed – untreated (control)** | 10.13d | 23.03g | 81.53 |  | 27.30 |
| **T2 - Hydration treatment** | 15.00bc | 40.33ab | 82.37 |  | 27.48 |
| **T3 - Hydration followed by seed treatment with thiram @ 3 g kg-1 seed** | 14.03c | 25.60fg | 81.03 |  | 26.05 |
| **T4 - Osmo-conditioning with PEG 6000 (-0.5 Mpa)** | 13.73c | 27.13efg | 82.01 |  | 27.07 |
| **T5 - Seed treatment with 50 ppm GA3** | 14.63c | 32.97cde | 81.64 |  | 26.31 |
| **T6 - Seed treatment with 2% KH2P04** | 15.10bc | 33.50cd | 81.47 |  | 27.61 |
| **T7 - Seed treatment with 2% CaCl2** | 22.70a | 46.07a | 83.39 |  | 28.00 |
| **T8 - Seed treatment with 2% KN03** | 16.97b | 38.17bc | 81.49 |  | 27.92 |
| **Mean** | 15.07 | 33.11 | 81.75 |  | 27.27 |
| **CD (5%)** | 1.99 | 5.87 | NS | | NS |
| **SEm ±** | 0.66 | 1.96 | 0.67 | | 0.44 |
| **CV (%)** | 7.64 | 10.25 | 1.81 | | 2.80 |

**Table 5. Influence of seed invigoration on seed yield in aged seed of chickpea**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Seed yield per plant (g)** | **Seed yield per plot (kg)** |
| **T1 - Aged (*Rabi*, 2023-24 harvested seed – untreated (control)** | 5.90d | 0.78e |
| **T2 - Hydration treatment** | 10.35b | 1.42b |
| **T3 - Hydration followed by seed treatment with thiram @ 3 g kg-1 seed** | 5.16d | 1.01d |
| **T4 - Osmo-conditioning with PEG 6000 (-0.5 Mpa)** | 7.99c | 1.08cd |
| **T5 - Seed treatment with 50 ppm GA3** | 8.24c | 1.40b |
| **T6 - Seed treatment with 2% KH2P04** | 9.19bc | 1.20c |
| **T7 - Seed treatment with 2% CaCl2** | 12.15a | 1.60a |
| **T8 - Seed treatment with 2% KN03** | 10.18b | 1.40b |
| **Mean** | 8.58 | 1.23 |
| **CD (5%)** | 1.58 | 0.15 |
| **SEm ±** | 0.53 | 0.05 |
| **CV (%)** | 10.67 | 6.85 |

# Conclusion

The study demonstrates that seed invigoration treatments significantly improve the performance of aged chickpea seeds. Among all treatments, seed priming with 2% CaCl₂ was most effective in enhancing emergence, growth, and yield components. This approach can be recommended for farmers dealing with aged or carry-over chickpea seed lots to improve crop establishment and productivity.

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