**Influence of Seed Invigoration Treatments on Crop Establishment, Growth, and Yield of Aged Chickpea (Cicer arietinum L.) Seeds**

# Abstract

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 the treatments, seed treatment with 2% CaCl₂ (T7) showed the highest seed yield (12.15 g per plant, 1.60 kg per plot), maximum number of branches (22.70), and highest plant height at maturity (39.17 cm). These findings highlight the effectiveness of seed invigoration treatments, particularly calcium chloride priming, in enhancing the performance of aged chickpea seeds.

**Keywords:** Seed invigoration, priming, aged seed, treatments, seed yield

# 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. Seed invigoration treatments have been shown to mitigate the deleterious effects of seed ageing by enhancing metabolic repair mechanisms and boosting seedling vigor. This study aims to investigate the influence of various seed priming and chemical treatment methods on the physiological and agronomic performance of aged chickpea seeds.

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, crop performance and ultimately increase in yield per unit area. Seed germination and vigor are the main physiological attributes, which are indirectly related to the yield performance. Slow or erratic emergence and poor stand establishment are symptoms of low seed vigor (Tekrony and Egli, 1991).

Rapid and uniform field emergence is essential to achieve high yield with good quality in annual crops (Yari et al., 2010). Seed invigoration is one of the most important developments to help rapid and uniform germination and emergence of seed and to increase seed tolerance to adverse environmental conditions. One of the simple and suitable methods which can improve seedling vigor and establishment and consequently crop performance in the field is seed priming (McDonald, 2000). The development of seed invigoration treatments started with seed priming, as first described by Heydecker et al. (1973). Seed priming involves controlled hydration of seed to enhance the metabolic activity within the seed but preventing radicle emergence so that all the seeds reached to the same stage of germination before sowing, so that subsequent germination after sowing will be rapid and synchronous.

Priming of seed in osmoticum such as polyethylene glycol (osmo-priming) and in water (hydro-priming) has been reported to be an economical, simple and a safe technique for increasing the capacity of seed to osmotic adjustment and enhancing seedling establishment and crop production under stressed conditions. This could be due to faster emergence of roots and shoots, more vigorous plants, better drought tolerance, earlier flowering, earlier harvest and higher grain yield under adverse conditions (Lee-suskoon et al., 1998). On-farm priming of seeds of a range of tropical and sub-tropical crops also has been tested as a means to promote rapid germination and emergence and to increase seedling vigor and hence yield (Harris, 2004). However, the effects of different seed invigoration treatments on seed quality and crop performance in chickpea are poorly documented.

# Materials and Methods

## Experimental Site

The experiment was conducted at the Organic Research Farm, Karguan Ji, 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**

## Crop Establishment

Seed treatments significantly improved field emergence and plant population compared to the untreated control. T7 (2% CaCl₂) recorded the highest emergence (90.00%) and population (16.33 m⁻²), indicating the positive effect of Ca²⁺ ions in mitigating oxidative damage during germination (Farooq et al., 2006; Harris et al., 1999).

## Plant Growth Parameters

Plant height at 60 DAS and at maturity differed significantly among treatments. T7 achieved the highest plant height (37.53 cm at 60 DAS, 39.17 cm at maturity), suggesting better vegetative growth. Days to 50% flowering were significantly reduced in primed seeds, with the earliest flowering (39 days) observed in T5 (GA₃), indicating accelerated physiological development (Basra et al., 2005; McDonald, 2000).

## Yield Attributes

Number of branches and pods per plant were significantly influenced by treatments. T7 (CaCl₂) resulted in the highest number of branches (22.70) and pods (46.07), which directly contributed to enhanced yield. No significant difference was observed in shelling percentage or 100-seed weight across treatments (Farooq et al., 2006).

## Seed Yield

Maximum seed yield per plant (12.15 g) and per plot (1.60 kg) was recorded in T7. This could be attributed to improved seedling vigor, growth parameters, and yield attributes due to enhanced nutrient uptake and stress tolerance facilitated by calcium ions (Harris et al., 1999; McDonald, 2000).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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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