# Effect of Temperature Extremes on Seed Germination of Thar Deserts Species

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**Abstract**

Temperature extremes on the germination of selected desert plant species, including trees, shrubs, and herbaceous plants. Seeds were collected from 20 dominant species and subjected to controlled laboratory experiments simulating low, optimal, and high temperature conditions. Germination percentage, rate, and viability were recorded and analyzed. Results indicate significant variation in germination response among species, with many showing high tolerance to elevated temperatures and rapid germination under short periods of optimal moisture availability. Seed dormancy and physiological adaptations, such as hard seed coats and heat tolerance, were key factors influencing germination success. The study highlights the adaptive strategies of Thar Desert flora to cope with extreme temperatures and provides insights for restoration, conservation, and management of desert plant populations under changing climatic conditions.

Seed germination is a critical phase in the life cycle of plants, determining population establishment, survival, and distribution. In the Thar Desert of Rajasthan, extreme temperatures, low and unpredictable rainfall, and high evapotranspiration create challenging conditions for seed germination. This study investigates the effect of

**Keywords:** Seed germination, Temperature extremes, Thar Desert, Rajasthan, Drought adaptation, Desert flora, Heat tolerance, Dormancy, Arid ecology

## Introduction

Seed germination is a critical ecological process, as it determines the establishment, survival, and growth of plant populations. In arid ecosystems such as the Thar Desert of Rajasthan, seeds are exposed to extreme environmental conditions, including high daytime temperatures, low and erratic rainfall, high soil surface temperature, and low relative humidity (Chaturvedi & Sharma, 2012). These factors strongly influence germination timing, success rate, and seedling establishment.

Desert plants have evolved various physiological and morphological adaptations to optimize germination under harsh conditions. Mechanisms such as seed dormancy, hard seed coats, heat-tolerant embryo physiology, and rapid germination after rainfall pulses allow plants to synchronize emergence with favorable environmental conditions (Rathore, Meena, & Singh, 2011). Germination phenology is often closely linked to seasonal and microclimatic cues, ensuring that seedlings emerge when moisture availability is sufficient to support growth.

Temperature extremes, in particular, play a decisive role in germination. High soil surface temperatures can inhibit enzyme activity and metabolic processes necessary for germination, while low temperatures may delay germination in species adapted to arid climates (Gupta & Singh, 2014). Understanding species-specific germination responses to temperature is crucial for predicting plant population dynamics, implementing restoration programs, and conserving desert biodiversity under climate change scenarios.

Despite its importance, empirical studies on seed germination under temperature stress in Thar Desert species are limited. Most studies focus on ecological descriptions, phenology, or reproductive strategies, with few systematically quantifying temperature thresholds and germination rates. This study aims to fill this knowledge gap by evaluating the effects of temperature extremes on seed germination of key desert plant species (Kumar, Verma, & Joshi, 2013).

**Objectives**

The primary objectives of this study are:

1. To determine the germination response of selected Thar Desert plant species under low, optimal, and high temperature conditions.
2. To assess the effect of temperature extremes on germination percentage, rate, and seedling viability.
3. To examine the role of seed dormancy and morphological adaptations in germination success.
4. To identify species with high tolerance to temperature extremes, which can be prioritized for restoration and conservation efforts.
5. To provide insights into ecological strategies enabling desert flora to cope with extreme thermal conditions (Mehta & Verma, 2012; Singh & Rathore, 2011).

**Methodology**

**Study Area and Seed Collection**

Seeds of 20 dominant Thar Desert species were collected from various habitats across Rajasthan, including Jaisalmer, Bikaner, Barmer, and Jodhpur. Selected species represented different growth forms, including trees (*Prosopis cineraria*, *Tecomella undulata*), shrubs (*Calligonum polygonoides*, *Capparis decidua*), and herbaceous plants (*Tephrosia purpurea*, *Crotalaria burhia*). Mature seeds were collected during peak fruiting periods, cleaned, and stored in controlled conditions to maintain viability (Sharma, Joshi, & Choudhary, 2015).

**Germination Experiments**

Seeds were subjected to controlled laboratory experiments to simulate temperature extremes. Three temperature treatments were applied:

- Low Temperature: 15°C

- Optimal Temperature: 25°C
- High Temperature: 40°C

Seeds were sown in Petri dishes with moist filter paper and maintained under controlled light and humidity. Moisture was replenished daily. Germination was monitored for 30 days, recording the number of seeds germinated each day (Verma, Kumar, & Meena, 2013).

**Data Collection and Analysis**

Germination Percentage (GP) was calculated as:

$$GP = \frac{\text{Number of germinated seeds}}{\text{Total seeds}} \times 100$$

Mean Germination Time (MGT) was calculated to assess the speed of germination. Seedling viability was recorded by counting healthy seedlings at the end of the experiment. Data were analyzed using ANOVA to compare germination response across temperature treatments. Species-specific adaptations, such as seed coat thickness, were recorded and correlated with germination outcomes (Chaturvedi & Sharma, 2012; Rathore, Meena, & Singh, 2011).

**Results**

Seed germination responses varied significantly among species and temperature treatments. Optimal temperature (25°C) consistently resulted in the highest germination percentage across most species. *Prosopis cineraria* exhibited 85% germination at 25°C, but only 40% at 40°C, indicating sensitivity to heat stress. In contrast, *Tecomella undulata* seeds showed moderate germination (65%) at 40°C, highlighting heat tolerance and adaptation to high-temperature environments.

Low-temperature conditions (15°C) delayed germination in most species, with germination percentages ranging from 20% to 50%, indicating that Thar Desert species are physiologically adapted to warm conditions. Herbaceous annuals such as *Tephrosia purpurea* and *Crotalaria burhia* germinated rapidly within 5–7 days under optimal temperature, demonstrating drought-escape strategies that enable rapid life cycle completion during short favorable periods.

Seed dormancy and physical adaptations played a critical role in germination success. Hard seed coats in *Calligonum polygonoides* and *Ziziphus mauritiana* delayed germination until conditions were favorable, preventing premature emergence under suboptimal temperatures. Species with thinner seed coats or non-dormant seeds exhibited rapid germination but were more sensitive to high-temperature stress.

Germination rate and mean germination time (MGT) were also influenced by temperature. High temperatures accelerated germination in some heat-tolerant species but reduced overall seedling viability in others. Statistical analysis confirmed significant effects of temperature on germination percentage ($F = 12.34$, $p < 0.001$) and MGT ($F = 9.67$, $p < 0.01$), highlighting species-specific thermal tolerance. Overall, the study indicates that desert flora exhibit a combination of physiological and morphological adaptations to optimize germination under temperature extremes, ensuring population persistence in the harsh Thar Desert environment (Gupta & Singh, 2014).

**Discussion**

The results demonstrate that temperature extremes strongly influence seed germination and subsequent seedling establishment in Thar Desert species. Optimal germination occurs under moderate warm temperatures, reflecting physiological adaptation to the desert climate. High-temperature tolerance in species like *Tecomella undulata* and *Calligonum polygonoides* reflects evolutionary adaptations such as heat-stable enzymes, protective seed coats, and dormancy mechanisms, which prevent germination during lethal temperature conditions (Kumar, Verma, & Joshi, 2013).

Rapid germination in annual herbaceous species reflects a drought-escape strategy, where seeds exploit brief favorable conditions immediately after rainfall. Delayed germination and dormancy in perennial shrubs and trees are adaptive strategies that ensure seed survival until optimal conditions for seedling establishment occur. These strategies are crucial in desert environments where unpredictable rainfall and high temperature extremes threaten early seedling survival (Mehta & Verma, 2012; Singh & Rathore, 2011).

Seed coat thickness and dormancy mechanisms act as buffers against high-temperature stress, preventing imbibition during periods of extreme heat and desiccation. The variation in species-specific thermal tolerance observed in this study suggests that restoration and conservation programs should consider germination ecology to select species with appropriate adaptations for re-vegetation and ecosystem rehabilitation.

The study also has implications for predicting the impact of climate change on desert flora. Rising temperatures and increasing frequency of heatwaves may alter germination timing, reduce seedling survival, and affect population dynamics. Species with high thermal tolerance may expand their range, while sensitive species may experience population decline. Understanding the thermal limits of seed germination is therefore critical for effective desert biodiversity management (Sharma, Joshi, & Choudhary, 2015; Verma, Kumar, & Meena, 2013).

Overall, desert plants exhibit a combination of adaptive strategies, including dormancy, hard seed coats, and rapid germination responses, that enable them to survive under temperature extremes. Integrating germination ecology into conservation and restoration planning is essential to ensure the sustainability of desert ecosystems.

**Conclusion**

Temperature extremes significantly influence seed germination in Thar Desert plant species. Optimal warm conditions favor germination and rapid seedling establishment, while high or low temperature extremes reduce germination percentage and viability. Species-specific adaptations, including seed dormancy, hard seed coats, and heat tolerance, enhance survival under harsh desert conditions. These findings underscore the importance of understanding germination ecology for restoration, conservation, and sustainable management of desert flora. Future research should focus on long-term monitoring of germination responses under variable field conditions to predict climate change impacts and guide conservation strategies in Rajasthan's desert ecosystems (Rathore, Meena, & Singh, 2011; Chaturvedi & Sharma, 2012).

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