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Research Article

Effect of gibberellic acid (GA3) and temperature on seed germination of *Capparis spinosa* L.

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Abstract
Seed germination of *Capparis spinosa* L. is highly important for ecology, medicine, and economics. The present study aimed to determine the effects of six pretreatments and two temperature regimes, T_1: 9/35.7°C (Laboratory) and T_2: 1/43°C (Greenhouse), on *Capparis spinosa* L. seeds' germination rate and latency time. Different pretreatments were tested, including scarification (P_1) and seed imbibition in water (P_2 and P_3) and gibberellic acid (GA3) (P_4, P_5 and P_6).The results showed that the highest germination rate (68.33%) was observed in the laboratory for the control seeds (T_1, P_0), followed by (58,33%) for seeds soaked in water for 48 hours (T_1 P_3),(56,67%) for seeds soaked in 200 ppm ofGA3 (T_1, P_4),(53,33%)for seeds soaked in 400 ppm and 600 ppm of GA3 (T_1, P_5andT_1, P_6), (48,33%)for seeds soaked in water for 24 hours (T_1 P_2), and (51,43%) for the control seeds in greenhouse (T_2, P_0), whereas the lowest germination rate (12.86%) was recorded in the greenhouse temperature, which was detrimental to seed germination, for seeds soaked in 600 ppm of GA3 (T_2, P_6). Germination latency times were shorter after soaking the seeds in water for 24 hours. Finally, seed germination of *C. spinosa* is subjected to several factors that may influence the total percentage of germination and latency time.

Keywords: *Capparis spinosa*, Germination, Pretreatments, Temperature, Latency time

INTRODUCTION

The caper plant (*Capparis spinosa)* is a promising aromatic and medicinal plant. Medicinal plants have long been used as therapeutic agents to cure diseases as they possess bioactive components beneficial to health (Locatelli *et al*., 2014). According to the World Health Organization (WHO, 2021), 2.4% of the world's popula-

tion primarily depends on traditional medicine.

In addition to its medicinal importance, the caper plant has a crucial ecological role. It is also used for landscaping and erosion control.

The caper plant has been used for centuries in traditional herbal medicine as an antifungal, anti-inflammatory, antihepatotoxic, hypoglycemic, diuretic, antihypertensive, etc (Saleem *et al*., 2021). It also has significant antioxidant activity. In addition to its multiple therapeutic virtues and aromatic qualities highly appreciated in Mediterranean kitchens, the caper plant is increasingly requesting the quality of its essential oils from alternative medicine, the pharmaceutical, cosmetic and food industries (Aksay *et al*., 2021).

In Morocco, it is present in several localities and is cultivated by farmers in Fes, Taounate, Meknes, Safi, and Marrakech (Kenny, 1997). Smaller populations exist in Settat, Nador, Missour, Alhoucima, Taza, Ouarzazate, and Taroudant (Fici, 2001). However, several difficulties hinder its development, including a lack of precise knowledge about its agroecological characteristics (Marković *et al*., 2019). Furthermore, capers have a relatively limited valuation, even though they have much more to offer to the consumer.

In addition, seed germination of *Capparis sp.* is essential for the production of its edible fruits. However, it can be affected by various factors, such as environmental conditions and pretreatments. (Abadi *et al*., 2021)

Thus, the main objective of this study is to contribute to preserving *Capparis spinosa* biodiversity by mastering the sexual reproduction of this species and determining the appropriate pretreatments and temperature for seed germination, which could improve the production of this plant.

MATERIALS AND METHODS

Material

The seeds of *Capparis spinosa*L., used in the present study were collected by random sampling from a plot in the Province of Boulemane, in the locality of Missour (N 33°00'43.1'' W 4°02'22.3''). The seeds were cleaned and placed in sterilized boxes, then stored under ambient conditions in the Regional Center for Agronomic Research laboratory in Oujda for five months (August - December). The seeds of*C. spinosa*wereoval-shape, with cotyledons folded around the embryo (Fig. 1).

Experimental design

The experiment was conducted from 31/12/2021to 30/06/2022 in two locations: the greenhouse (Tmin 1° C: Tmax 43 °C) and the Laboratory of Plant Ecology at the Regional Center for Agronomic Research in Oujda (CRRAO) (Tmin 9°C: Tmax 35.7°C).

The seed germination tests of *C. spinosa* were performed on germination rate and latency time at the two temperature regimes and using six pretreatments.The seeds used were carefully sorted and only those without any apparent morphological anomalies were kept for the experiment. Subsequently, they were disinfected with a 10% bleach solution for three minutes and then rinsed with distilled water.

Temperature regimes

T_1:Laboratory temperature

T_2:Temperature of the greenhouse

Pretreatments applied:

P_0: Control (withoutt reatment)

P_1: Scarification

P_2: Soaking in water for 24 hours

P_3: Soaking in water for 48 hours

P_4: Soaking in 200 ppm of GA3 for 2 hours

P_5: Soaking in 400 ppm of GA3 for 2 hours

P_6: Soaking in 600 ppm of GA3 for 2 hours

Protocol

The seeds were separated into two lots: The first was germinated in the laboratory, and the second in the greenhouse, in alveolar plates containing pasteurized special seed soil. Each test contained 120 seeds. A complete randomized block design (CRBD) with 4 repetitions of 30 seeds was adopted to study the effect of the six pretreatments. Germination corresponded to the appearance of a seedling with two cotyledon leaves (Fig. 2).

Measured parameters

The measured parameters were:

Germination rate GR=G/N*100 Eq.1

Where G is the number of germinated seeds and N is the total number of seeds germinated.

Latency time was the time elapsed between sowing and the first germination (the appearance of the coleoptile).

Statistical analysis

After arc-sine transformation of all percentages, the germination data were submitted to an analysis of variance (ANOVA) with two factors of variation (pretreatment and temperature regime) using the SPSS program. The means were compared by the Tukey test to determine homogeneous groups at α=0.05.

Fig. 1. *Seeds of Capparis spinosa L.*

Fig. 2. *Germination test of Capparis spinosa, seeds in the dimpled trays*

RESULTS AND DISCUSSION

The analysis of variance showed highly significant effects of pretreatment, temperature regime, and their interaction on the germination rate of seeds of *C. spinosa*. Thus, the effects of pretreatment, temperature regime, and their interaction were highly significant for the germination latency time variable.

Effect of pretreatment

Regardless of the temperature regime, the highest germination rates were observed in untreated seeds (control P_0) (59.88%). Thus, the average germination percentages, irrespective of temperature, were 43.38% and 33.09% for soaking in 400 ppm and 600 ppm of GA3, respectively (P_5 and P_6), 33.48% and43.66%, respectively for soaking in 200 ppm of GA3 and in water for 48 hours (P_4 and P_3). Furthermore, for all temperatures combined, the shortest latency time (15 days) was observed for the pretreatment related to soaking in water for 24 hours (P_2).

Effect of temperature regime

Analysis of variance revealed a highly significant effect of temperature on the germination rate and latency time of caper seeds. Germination percentages were 51.19% and 28.9%, respectively, for the laboratory and the greenhouse (T_1 and T_2). Latency times for germination across all pretreatments were 30.43 and 55 days, respectively, for the laboratory and the greenhouse (T_1 and T_2).

Effect of the interaction between pretreatment and temperature regime

Statistical analysis showed a highly significant effect of the interaction between pretreatment and temperature regime on the germination rate of *Capparis spinosa* L seeds. Table 1 and Fig. 3, in the laboratory (T_1) showed the best germination rate (68.33%) for the control(P_0), followed by soaking in water for 48 hours (58.33%) (P_3), then soaking in 200 ppm of GA3 (56.67%) (P_4), then soaking in 400 ppm and 600 ppm of GA3 (53.33%) (P_5 and P_6), then soaking in water for 24 hours (48.33%) (P_2), and finally scarification (20%) (P_1). Table 2 and Fig. 4 show germination performance was less significant in the greenhouse (T_2). The highest germination rates were recorded for the control (51.43%) (P_0), followed by soaking in water for 24 hours (39%)(P_2), then soaking in 400 ppm of GA3 (31.43%) (P_5), then soaking in water for 48 hours (29%) (P_3), then scarification (24.29%)(P_1), then soaking in 200 ppm of GA3 (14.29%) (P_4), then soaking in 600 ppm of GA3 (12.86%) (P_6).

Latency time of germination

Fig. 3 and 4 show the temporal evolution of germination rates in the laboratory and greenhouse. It appears that in the laboratory (T_1), the first germinations appear on the twenty-third day after germination for seeds soaked in water for 24 hours (P_2), the twenty-fifth day

Table 1. Germination rates of *Capparis spinosa* seeds according to pretreatment applied in the laboratory (temperature regime 9-35.7 °C)

Pretreatment	Germination rate (%)
P_0 :Control (no treatment)	68.33±0.13 a
P_1 :Scarification	20±0.03 d
P_2 :Soak in water for 24 hours	48.33±0.08 b
P_3 :Soak in water for 48 hours	58.33±0.11 a
P_4 :Soak in 200 ppm of GA3 for 2 hours	56.67±0.1 a
P_5 :Soak in 400 ppm of GA3 for 2 hours	53.33±0.09 b
P_6 :Soak in 600 ppm of GA3 for 2 hours	53.33±0.096b

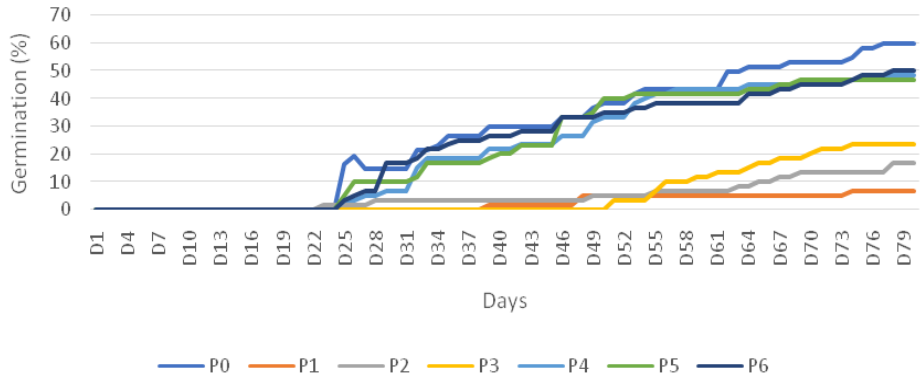

Fig. 3. *Germination kinetics of Capparis spinosa seeds according to applied pretreatment and laboratory temperature*

Table 2. Germination rates of *Capparis spinosa* seeds according to pretreatments applied in green house

Pretreatment	Germination rate (%)
P_0 : Control (no treatment)	51.43±0.1 a
P_1 : Scarification	24.29±0.05 c
P_2 : Soak in water for 24 hours	39±0.07 b
P_3 : Soak in water for 48 hours	29±0.05 c
P_4 : Soak in 200 ppm of GA3 for 2 hours	14.29±0.02 d
P_5 : Soak in 400 ppm of GA3 for 2 hours	31.43±0.06 c
P_6 : Soak in 600 ppm of GA3 for 2 hours	12.86 ±0.02 d

Significant difference among pretreatments (r), a : r≥0.1, b : 0.07≤r<0.1,c : 0.05≤r<0.07, d<0.5

for untreated seeds (P_0), seeds soaked in 200 ppm, 400 ppm, and 600 ppm of GA3 (P_4, P_5, and P_6), the thirty-ninth day for scarified seeds (P_1), and the fifty-first day for seeds soaked in water for 48 hours (P_3). For the greenhouse (T_2), the latency time was 7 days for soaking in water for 24 hours (P_2), 14 days for soaking in water for 48 hours (P_3), 48 days for scarification (P_1), 62 days for soaking in 400 ppm of GA3 (P_5), 65 days for soaking in 600 ppm of GA3 (P_6), 81st day for the control (P_0), and 104th day for soaking in 200 ppm of GA3 (P_4).

The germination of *C. spinosa* seeds varied according to the type of treatment applied and the temperature regime. The absence of seed treatment positively impacted germination capacity and kinetics, whereas pretreatments had a negative effect on germination and prolonged the latency period. Untreated seeds of *Capparis spinosa* L. showed a higher germination rate, contrary to the results of Saifi *et al*. (2014) and Orphanos (1983), who demonstrated that gibberellic acid significantly improved the germination rate: 1500 ppm overnight. Moreover, soaking the seeds in water for 24 hours slightly minimized the latency period. Suleiman *et al*. (2008) reported that combining several treatments, scarification with 1% H2SO4 for 20 min followed by 0.04% GA3 and one week of chilling at 4°C, positively affects the germination of *C. spinosa* seeds.

Germination was favoured by the laboratory temperature (10 – 30°C), which was confirmed by the results of Labbafi (2018). The results obtained indicate that germination occurred in a staggered manner over time. The present study obtained a higher germination rate for untreated seeds compared to the best percentage of treated seeds by Saifi *et al* (2014). This could be due to the low concentrations of GA3 and scarification, which can damage the embryo.

Temperature variation in the greenhouse can affect many ecophysiological processes determining seed germination capacity, including membrane permeability, membrane-linked protein activity, and cytosol enzymes (Bewley and Black, 1994). In another work, treating seeds with gamma irradiation can also improve their germination capacity and promote the growth and development of seedlings (Ngoenngam *et al*., 2019). It has been reported that several factors can affect seed germination, such as plant genotype, culture medium components, plant growth regulators (PGRs), seed coat, pretreatments and culture conditions (Mazri *et al*., 2022), and storage duration of seeds (Foschi *et al*., 2022).

Conclusion

The present study highlighted the importance of pretreatments and temperature regimes on the germination rate and latency period of *C. spinosa* seeds. The results revealed that it would be possible to improve germination capacity without pretreatment and by exposing them to temperatures between 9 and 35.7°C, which are optimal for breaking dormancy, improving germination capacity, and ensuring uniform germination. To further improve germination rates, it would be appropriate to test other hormonal pretreatments. In conclusion, this study is important for farmers as it pro-

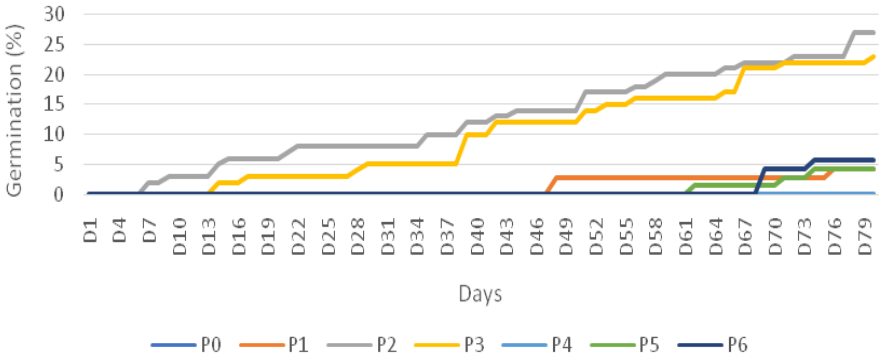

Fig. 4. *Germination kinetics of Capparis spinosa seeds according to applied pretreatment and greenhouse temperature; P0: Control (no treatment), P1: Scarification, P2: Soak in water for 24 hours, P3: Soak in water for 48 hours, P4: Soak in 200 ppm of GA3 for 2 hours, P5: Soak in 400 ppm of GA3 for 2 hours, P6: Soak in 600 ppm of GA3 for 2 hours*

vides useful information on methods to improve the germination rate of *C. spinosa* seeds, which can have significant economic and environmental benefits.

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Conflict of interest

The authors declare that they have no conflict of interest.

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