Full Length Research Article
Advancements in Life Sciences – International Quarterly Journal of Biological Sciences

ARTICLE INFO

Date Received: 20/11/2023;
Date Revised: 21/03/2024;
Available Online: 10/07/2024;

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How to Cite:
Faraj AH, Colak ES, Isik D (2024). The influence of temperature, light, pH and salinity on germination and growth of *Cutandia memphitica* (Spreng.) Benth. Adv. Life Sci. 11(3): 565-571.

Keywords:
Light; Salinity; Seed Germination; Temperature; Weed; Date Palm

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The influence of temperature, light, pH and salinity on germination and growth of *Cutandia memphitica* (Spreng.) Benth

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Abstract

Background: There are many weed species that affect yield and quality in date palm orchards. *Cutandia memphitica* (Spreng.) Benth. is one of the weeds that is common in date palm orchards in Iraq. However, there is not enough information about *C. memphitica* in the literature. In order to provide information about the effect of key environmental factors (temperature, light, pH, and salt) on the seed biology of this weed species, this study was conducted.

Methods: Within 2020, seeds were collected from agricultural regions in southern Iraq, and trials were done at Erciyes University Faculty of Agriculture labs in Kayseri Türkiye. All experiments were carried out with 30 seeds in the sterile 90 mm (90x15) petri dishes containing two layers of sterile filter paper.

Results: The results of this investigation revealed that the seeds of this species germinated by 72.49% in three days when incubated at 25°C, and by 96.66% in 14 days when incubated at 15°C. The results also indicated that even during the longest incubation time examined, which was 28 days, the seeds of this species never germinated at 30 degrees or above. They can germinate during this period if kept at 5°C. The study also revealed that 90% of the seeds of this species germinated in complete darkness, whereas only 11.66% germinated in light. However, light has a significant impact on studied growth parameters (plant height and seedling fresh and dry weight). The results also demonstrate that the pH levels examined, which varied from 4 to 10, had no effect on the seed germination and growth parameters of seedling.

Conclusion: The results showed that the seeds of this species germinated at the highest salinity levels (250 mM NaCl) by 10.83%. Meanwhile, the best germination was recorded at 25 mM salinity level of 89.16%, but without significant differences with salinity level at 50 mM and control. Also, the growth indicators were reduced significantly at the salinity level of 250 mM compared to the control.

Introduction

Date palm is one of the most important agricultural crops in Basrah Iraq. There are plenty of noxious weeds in date palm gardens. Weeds are widely distributed plant species that can be considered biological components of many ecosystems [1]. Weeds are unwanted and distinctive from other plants because of their intrusive presence and more biological and ecological characteristics that enable them to compete successfully in agricultural areas [2]. *Cutandia memphitica* (Spreng.) Benth. one of the weeds that found date palm orchards.

Cutandia memphitica (Spreng.) Benth. one of the weeds that belong to Poaceae family, Cyperales order, Monocotyledons class and Vascular plants subkingdom. Poaceae, the grass family, is one of the top five flowering plant families in terms of species, with approximately 12,000 species and 800 genera, including cereal crop species and other important economic plants such as bamboos, as well as a number of weeds [3]. This weed is one of the Mediterranean basin weeds; it is plant native in many countries in this region. Flowering period from February to April is a branching annual grass whose stems reach a height of 30 cm. Although it is a desert grass, its presence has been recorded in fields of cereal crops and date palm orchards [4, 5].

Weed biology is concerned with weeds' geographical distribution, habitat, growth, population dynamics, and communities. Ecology, on the other hand, is the study of the interactions between organisms and their surroundings [6]. Ecology studies living things and their relationships with their environment. Weed ecology, which can be evaluated in the field of ecology, also examines the distribution, prevalence, behavior and survival of weeds. If it is wanting to change the normal life of any living thing in nature, the biology, behavior and survival potential of the living thing should be known and intervened accordingly. In the issue of weed control, if it is desired to prevent the damage of weeds to cultivated plants, comprehensive information about the ecology, biology and behavior of weeds will be needed. The first phases in weed population establishment are seed germination and seedling emergence, which are regulated by a variety of environmental conditions including temperature, water, light, and salinity stress [7]. The factors considered among the mentioned environmental stress factors affect the growth and development of weeds [8].

Temperature, one of the environmental stress factors, adversely affects plants in several ways, including plant germination, biomass, flower, and seed development. During heat stress, elements such as proteins, membranes, and mitochondria in plant cells can be damaged. With the effect of temperature stress, changes in photosynthesis, water and nutrient uptake, and changes in evapotranspiration are observed in plants. Similarly, lighting is a factor that can directly affect the photosynthetic activities and development of plants [9].

Lighting also plays a vital role in the development of weeds. The stress factor of light has a crucial role, especially in the germination phase. Although the effect of light on the germination rate varies according to the weed species, it also affects the *C. memphitica*, and the factor of light can disrupt the weed seed dormancy. Along with some studies, an attempt has been made to prevent the lighting factor that stimulates the germination of weeds by applying mulch [10].

Due to the lack of studies on biology and the effect of environmental conditions on seed germination, this work was conducted to study the impact of some ecological factors (temperature, light, pH, and salt stress) on the seed germination of the *C. memphitica.* With the change in the soil's pH level, there can be differences in the existing plants in the area and the species that will come to the area where the change is experienced. When there is a pH change, the competitive situation among plants can also change. So, it can be said that pH is effective in the formation of weed flora and the germination rate of weed species in a region [10].

The stress factor of salinity, which is one of the stress factors, also affects the development and survival of plants. The salinity factor affects plant growth and development as it causes a nutritional imbalance with excessive intake of ions such as sodium (Na^+) and chloride (Cl^-) [11].

The biology of *C. memphitica* on seed germination and seedling emergence has not been well documented. Here, we investigated the germination and emergence of this weed species in a set of experiments. The objectives of these studies were to determine the effects of environmental factors (temperature, light, pH and salinity levels) on seed germination and seedling emergence in *C. memphitica* populations. The results of the study would contribute to developing suitable and effective management strategies against these weed species. Basically, adopting an effective method of controlling weeds is important to end hunger, reduce poverty and support ecological as well as economic development as a result of protecting plant health [12].

Methods

Experimental site

Research was conducted to assess the germination characteristics of *C. memphitica* and the effect of various environmental conditions on seed germination in Erciyes University Faculty of Agriculture Herbology laboratories of Plant Protection Department. Study area is situated at 38°42' 33'' N latitude and 35° 38' 34'' E longitude and has an altitude of 1109 m. Investigational site (Kayseri province of Türkiye) has a semi-arid climate with hot and dry summers and cold and snowy winters.

Seed preparation

C. memphitica seeds were collected in the summer of 2020 from naturally ripened plants in date palm orchards in Iraq's South. The *C. memphitica* seeds were flailed and was separated from husks. Appendages and other things that must be removed were extracted from the seeds. Seeds were placed in paper bags and preserved at 20-25 °C in the lab until the experiment began. From November 2020 to March 2021. Once again, the seeds were cleaned, broken and decaying seeds, as well as any pollutants that were missed in the prior step, were eliminated in this step. Seeds were then sterilized in a safety cabinet with fluctuating UV light for 15 minutes.

Germination tests of seeds

30 seeds, counted at the beginning of the experiment, were sterilized by dipping in sodium hypochlorite solution (1%) for 1 minute for germination test and then washing with distilled water 5-6 times. Cleaned seeds with sodium hypochlorite solution were placed with two layers of Whatman No. 1 filter paper were found in 9 cm Petri dishes, then 5 ml of distilled water was added to the dishes. Petri dishes were enclosed with parafilm to avoid moisture loss [13].

Seed germination was examined at 1, 3, 7, 14 and 28 days with the germination criterion being visible protrusion of the radicle. When the radicle had emerged > 2 mm, seeds were considered germinated, and the radical protrusion was used to determine seed germination. The germination trials were carried out with 4 replicates of 30 seeds, per 9 cm diameter Petri dishes [13].

Environmental conditions

Temperature

Temperature experiments were conducted to find the optimum temperature requirement for seed germination. Four replications of Petri dishes containing 30 sterilized seeds were kept in an incubator maintaining different temperature levels (5, 10, 15, 20, 25, 30, 35 and 40°C) separately for 28 days. These temperature regimes were selected to reflect temperature variation during the general plants' growth period. To avoid drought, the water level was monitored on a regular basis, especially in high temperatures. The germination percentage was calculated after 1, 3, 7, 14, and 28 days.

Light

The influence of light on seed germination of *C. memphitica* was tested in a germination chamber under two conditions: a 12-hour daily photoperiod (light) and continuous darkness with fluctuating day/night temperatures of 25/15°C. Petri dishes were covered in double layers of aluminum foil for incubation under dark circumstances, as described by Baskin and Baskin [14]. The light treatment's germination is evaluated daily, and after 14 days of incubation, the final germination percentage for both dark and light settings were computed.

pH

Seed germination, as affected by pH levels, was assessed utilizing buffer solutions of pH 4 to 10 prepared according to the process defined by Chachalis and Reddy [15]. Pure water was used to adjust the pH. The acidity and alkalinity level of the solution was adjusted by adding hydrogen chloride and sodium hydroxide to the pure water. The pH was changed in the acidic direction using hydrogen chloride, and the pH level was changed in the alkalinity direction using sodium hydroxide. The germination percentage was calculated after 14 days of keeping Petri dishes with seeds at an alternate temperature of 25/15 °C.

Salinity

Seed germination as affected by salt stress was assessed using sodium chloride (NaCl) solutions of 0, 25, 50, 100, 150, and 200, and 250 mM. Seeds are placed in Petri dishes containing 5-mL solutions of 0, 25, 50, 100, 150, 200, and 250 mM NaCl made by dissolving 0, 0.375, 0.6, 1.45, 2.2, 2.925, and 3.65 g of NaCl per 250 mL of distilled water, respectively. After 14 days of incubation at fluctuating temperature regime, such as 25°C Day temperature and 15°C night temperature, the germination percentage were calculated.

Measurement

The following parameters were assessed in this study:

1. Seed germination percentage (%): The proportion of seeds that germinate was estimated using the following equation:

$$Percent\ germination\ (\%) = \frac{Seeds\ germinated}{total\ seeds} * 100$$

2. Shoot and root length (mm): A metric ruler was used to measure the seedling shoot and root length (mm).

3. Seedling weight: A sensitive balance was used to determine the fresh and dried weight (mg) of seedlings.

Statistical analysis

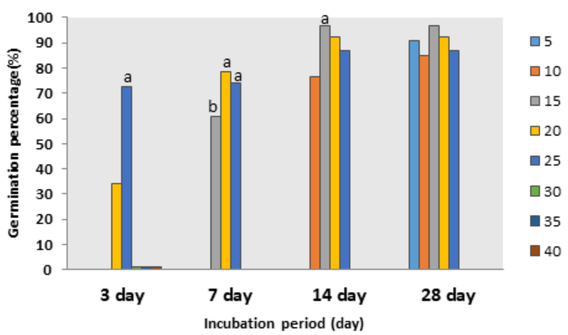
Trials were performed with four replicates in a completely randomized design. Using SPSS-22 software

(SPSS In., Chicago, IL., USA), the data were submitted to analysis of variance (ANOVA), and means were separated using Fisher's LSD test at 0.05 probability. A *P* value of less than 0.05 was used to determine statistical significance.

Results

Effect of temperature on seed germination

The influence of a range of constant temperatures (5-40°C) on seed germination of *Cutandia memphitica* was assessed for various incubation durations (1, 3, 7, 14, and 28 days), and the results indicated that seed of *C. memphitica* failed in germination at temperatures of 30, 35, and 40 at all incubation periods. No germination occurred at any temperature tested on the first day of experiment. Figure (1) shows that after 3 days of incubation, 34.16% of seed germinated at 20°C and 72.49% at 25°C, while after 7 days germinated at 60.83% at 15°C, 78.33% at 20°C, and 74.16% at 25°C. Furthermore, seeds of *C. memphitica* germinated at 76.66, 96.66, 92.49, and 86.66% at 10, 15, 20, and 25°C after 14 days, respectively, whereas at 5°C seeds germinated only after 28 days at 90.83%, meanwhile at 84.99 at 10°C, 96.66% at 15°C, 92.49% at 20°C and 86.66% at 25°C.



*Similar letters for each period indicate no significant differences.

Figure 1: Effect of a range of constant temperatures at different incubation periods in seed germination of *C. memphitica*.

Effect of light in seed germination

When examined effect of light condition seed germination percentages of *C. memphitica* under light and dark circumstances, revealing that seeds kept in the dark germinate at a high rate of 90%, compared to a low rate of 11.66% under light and this difference was statistically significant. This finding suggests that if other conditions are appropriate, seed from this species might germinate from deeper depths.

Effect of light on growth

Effect of light on shoot and root growth of *C. memphitica* are shown at Figure 2 and Figure 3. indicates that the length of *C. memphitica* roots was unaffected by light. On the contrary, it had a significant impact on shoot length, which reached 56,73 mm in the light and 8,72 mm in the dark conditions. The fresh and dry weight of *C. memphitica* seedlings was remarkably higher in the light than in the dark, according to the data shown in Figure 3. In the light, the fresh weight was 5,5 mg, while in the dark, it was 2,8 mg, and the dry weight was 3 and 1,1 mg, respectively.

Effect of pH on seed germination

Effect of pH on seed germination show that there is no significant effect of pH among all examined levels on seed germination of *C. memphitica*. However, the seed germinated at 82.5% at 6 pH level. *C. memphitica* does not have a strong predilection for a specific pH level, as evidenced by the fact that it germinates effectively across the pH range of 4 to 10. Regardless, the pH at 6 was preferred above the lower pH level examined.

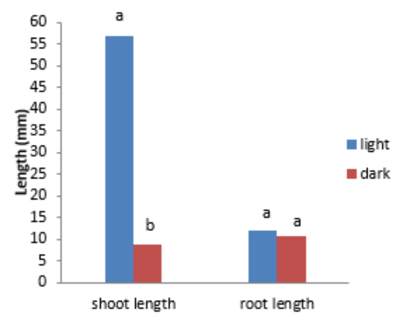


Figure 2: Effect of lighting condition on length of shoot and root of *C. memphitica*

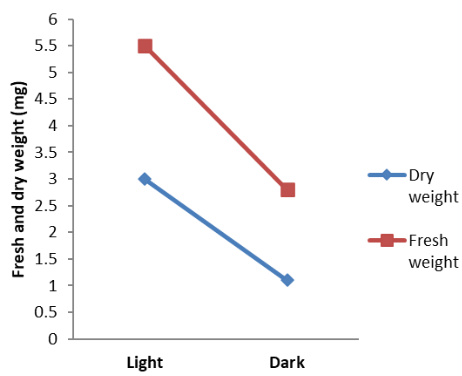
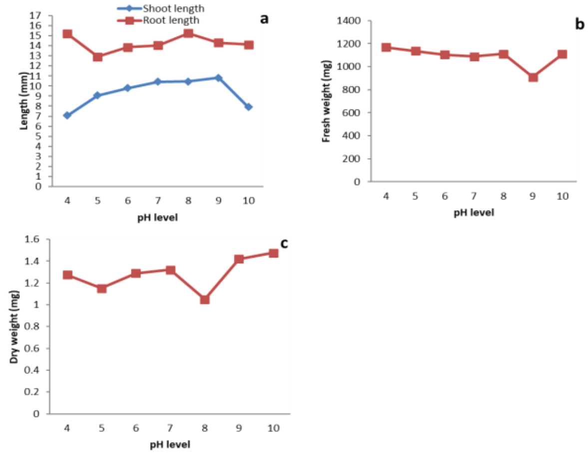


Figure 3: Effect of lighting condition on fresh and dry weight of *C. memphitica* seedling.

Effect of pH on growth

For the pH treatment, no significant effect was found for all tested pH levels on the growth of *C. memphitica* seedlings as shown in Figure (4, a-c). Noteworthy that the length of the roots of the seedlings was higher than the length of the shoots at all pH levels. The finding of this current study showed that pH had little impact on early growth stage parameters of weed seedlings under laboratory conditions, possibly during their early morphogenesis stages, and that the magnitude of the reaction to substrate nutrients was determined by the resources stored in the seeds.



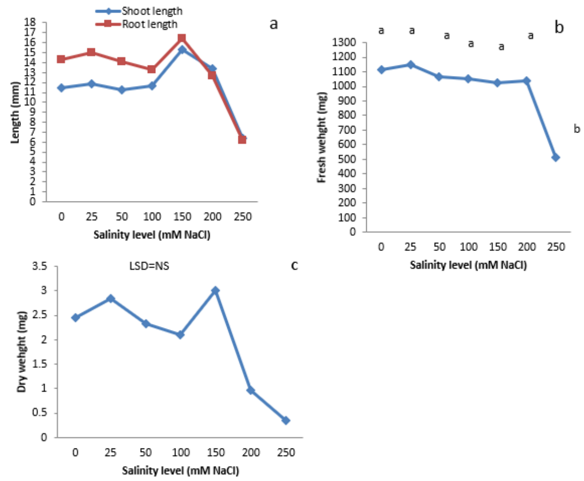
**LSD not significant for all traits*
Figure 4: Effect of different pH level *C. memphitica* growth.
a: Shoot and root length; b: Fresh dry weigh of seedling, c: dry weight of seedling

Effect of salinity on germination

The results demonstrate that up to a salinity level of 50 mM, the seeds of *C. memphitica* were not influenced significantly by salinity compared to the control, but beyond that, the germination percentage significantly and steadily reduced as the salt level increased. The germination percentage increased insignificantly from 82.5% in the control treatment to 89.16% and 85.00% at 25 and 50 mM salinity levels, respectively. The lowest significant germination percentage was recorded at 250 mM, with 10.83. Meanwhile, germination percentages at 100, 150 and 200 mM levels were 58.33, 43.33, and 37.50 percent, respectively, with statistically significant variations. These outcomes propose that *C. memphitica* seeds could germinate in extraordinary saline circumstances, which could be an important characteristic of this weed species allowing it to settle saline zones.

Effect of salinity on growth

The results of the salinity effect on length of *C. memphitica* shoot and root are presented in Figure (5,a) and demonstrated that, with the exception of 250 mM, all salinity levels evaluated had no significant influence on shoot and root length when compared to control or among them. The shoot length was 6.36 mm and the root length was 6.16 mm under the salinity treatment of 250 mM, which was significantly lower than all other levels studied. Also, the root length in the control treatment was 14.31 mm and the shoot length was 11.48 mm, but when the salinity was increased to 250 mM, the root length was decreased to 6.16 mm and the shoot length was lowered to 6.36 mm. As a result, roots are more influenced by salt than shoots. Salinity at 250 mM considerably reduced the fresh weight of *C. memphitica* seedlings from 1115.75 mg in control to 512.22 mg, as shown in figure (5, b). Meanwhile, there was no significant difference in any salinity levels when compared to the control. Although there is a huge variation in the dry weight of *C. memphitica* seedlings between salinity at 250 mM and control, statistical analysis revealed that salinity at all levels investigated had no significant influence on seedling dry weight.



a: Shoot and root length; b: fresh weight of seedling; c: dry weight of seedling.
Figure 5: Effect of different salinity level on growth of *C. memphitica* seedling.

Discussion

The responses of weed seeds to germination at different temperatures differ between weed species. No study was found on the germination of *C. memphitica* at different temperatures. The temperature role in the weed seeds germination is a complex matter. The opinion that changing temperature is an important factor moving weed seed germination has been before documented. For instance, it has been shown that *Eclipta prostrata* germinates over a variety of temperatures [14]. In a study, it was observed that the germination temperature of tall morningglory (*Ipomoea purpurea*) plant was in a wide range. The ultimate germination (86% to 89%) was perceived at day/night temperatures of 25/15°C to 30/20 °C. The germination rate of the plant decreased to 67% and 74%, respectively, at 35/25°C [8]. The effect of temperature on eclipta (*Eclipta prostrata*) plants was also investigated. The germination of seeds was significantly higher in the day and night temperatures of 30°C and 20°C, respectively. Considering the germination temperature, it was thought that the plant can be seen in tropical countries and low altitude field [16]. Generally, considerably of the literature undertakes an inverse relationship between duration and temperature [17]. In order to know the weed seed responses to alterations in the thermal surroundings below the crop canopy shall permit us to progress weed control approaches in operating crop canopy characteristics [18].

The mechanism by which light affects certain seeds and leads them to be ready for germination while also preventing other seeds from germinating is complicated. The raised germination in darkness vs. that in light be likely owing to the induction of secondary dormancy in a part of the seed sample. Sensitivity to light varies among species in weeds. Some weeds may increase germination in daylight, while others may decrease. Light-induced dormancy in wild oat (*Avena fatua* L.), and parallel outcome were acquired for other species, such as monkey flower (*Mimulus ringens* L.) [19].

In field environments, the light setting of the weed seeds, which is apparent mostly by photoreceptors of the phytochrome family, offers vital knowledge for prompting germination in the appropriate ecological condition. Numerous weed species germinate once incubated in darkness. This shows that phytochrome is previously existing in the seeds and/or that germination does not need phytochrome. From an agronomical opinion, the germination control by light represents a potentially beneficial phase in the lifecycle of weeds for evolving effective management practices [20].

The fact that most seedlings emerge out of seed at the soil surface indicates the possible for this species to be a problematic weed in agricultural applications such as zero or minimal tillage systems that permit most of the weed seeds to remain at or near the soil surface [21]. Although one study found that light is not required for seed germination, it may be important for seedling emergence because a high seedling rate was revealed when planted 2 cm deep. Among the small-seeded weeds, American sloughgrass seeds are quite small and may contain limited amounts of stored nutrients to support germinated seedling growth [22, 23].

In this study showed that *C. memphitica* is a cosmopolitan species that can be found in soils with very different pH values. Similarly Some other researchers have also obtained similar results in different weed species. For example, oriental mustard germination was found to be more than 50% in the pH range of 4 to 10, but optimum germination occurred between pH 7 and 9 [24]. Similarly, germination was observed between pH 4 and 10 in American sloughgrass [22].

In studies, the difference in germination and growth due to the difference in pH level, which is one of the environmental stress factors, is seen in plants. When we look at the studies, it is seen that the demands of weeds in terms of pH level for the germination and development of their seeds are different [25].

Salinity is significant abiotic stress to agricultural production international, with the inclusion of Middle East. It is considered that soils with higher than 100 mM NaCl are have high salt contents. In addition to weed competition soil salinity may effect crop production. Like seeds of *H. tridactylites* and *M. invisa* germinated at very loud salt concentrations [21].

Rigid ryegrass seeds germination was greater than 50% up to a concentration of 40 mM NaCl and some germination appeared even if at 160 mM NaCl. However, germination was totally inhibited by 320 mM NaCl [24]. Germination of seed did not change up to 20 mM NaCl concentration (51-53%) in Oriental mustard (*Sisymbrium orientale*) seeds, there was a decrease in germination with the rise in concentration and no germination at 160 mM NaCl [26].

Salinity, which is one of the environmental stress factors, is an important factor affecting the growth of plants. In addition to changing the physiological functions of plants, salinity also causes stress on the plant's nutrient and water intake [26]. Salinity can reduce the biosynthesis of gibberellic acid, which is necessary for the growth of plants, even if the climatic conditions are suitable [25].

This results of this study highlight for the first time the effect of environmental factors on *C. memphitica* seed biology. We concluded that the optimum germination temperature of seeds of this species is between 20-25°C. and if available, they can germinate within 3 days. Seeds of this species do not germinate at a temperature of 30 or higher for at least 28 days. And it delays germination at low temperatures. The study's findings also revealed that the seeds of this species germinated better in the dark than in the light, indicating that they may germinate in deep depths of soil, while their growth was better in the light than in the dark. This suggests that this weed prefers to thrive in the desert and not in the shade of other plants. This species has exhibited little sensitivity to pH changes during germination or subsequent growth, indicating that it may germinate and develop in a variety of soils. According to the findings of seed germination and seed growth, this species is very salt resistant and can survive salt up to 250 mM sodium chloride level but performs best at 200 mM level or less.

Author Contributions

Ammar H. Faraj: Collected data, performed experiments, did data analysis and reviewing manuscript, assign in computational analysis.

Ender Sahin Colak: Collected data, performed experiments, did data analysis and reviewed manuscript, assigned in computational analysis.
Dogan Isik: Conceptualized and supervised the study, assign in computational analysis, proofreading and editing the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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