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EFFECT OF HOT WATER AND CHILLING TREATMENTS ON THE SEED GERMINATION AND GROWTH OF CHINABERRY TREE (*MELIA AZEDARACH L.*)

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SUMMARY

Summary: The use of silicon is an option for reducing the adverse effects of water deficit conditions. The recent study took place at the Agricultural Research and Experiment Station of the Faculty of Agriculture, Cairo University, Giza, Egypt (30°02' N and 31°13' E, with an altitude of 30 m) in two seasons of 2019 and 2020. The study's chief objective aimed to investigate the effect of water deficit at flowering on maize and its relation to silicon spraying. The study included two water treatments: non-stress (NS) and water stress (WS); three silicon treatments: (0, 3, and 6 mM L⁻¹); and five single-cross hybrids. A split-split plot under the concentration of 6 mM L⁻¹. The most interesting observation in the study showed the noteworthy increase in oil yield/ha for all studied hybrids, ranging from 13.33% (SC-3444) to 29.41% (SC-3433). It resulted from the application of the concentration of 6 mM L⁻¹. The hybrids SC-30N11, SC-3433, and SC-3444 proved the best hybrids, displaying tolerance to water.

Keywords: Maize (*Zea mays L.*), water stress, silicon, yield, carbohydrate, protein, oil, stress-tolerance index

Key findings: The water deficit condition at the flowering stage caused a significant reduction in yield and its components in maize. The silicon treatment 6 mM L⁻¹ concentration notably enhanced the grain and oil yields and carbohydrates.

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INTRODUCTION

The Chinaberry tree (*Melia azedarach* L.) belongs to the family Meliaceae, with its native home in Kashmir and India, which spreads at altitudes of up to 1800 m above sea level. The plant leaves have a pleasant smell and are purple, and the fruits are green, turning yellow when fully ripe (Mahood and Sarropoulou, 2024). The mature tree height reaches 25 m, the tree crown resembles an umbrella, and its feathery leaves reach a length of 90 cm, needing fertile and well-drained soil with low acidity for better growth. Its leaflets are lanceolate, ovate, with a pointed top and serrated edge, and contain a higher percentage of nutrients, with a protein content of 12% (Singh *et al.*, 2020).

The leaves of the Chinaberry tree serve as fodder for animals, especially sheep and goats, and contain insect repellents. The fruits wrinkled in the form of clusters at maturity, with a diameter of 1.5 cm. Each fruit contains a varied number of seeds, often five, and the color of the bark is dark greenish-brown. The fruits and bark may cause complete paralysis in breathing and suffocation, which are toxic to sheep and goats when eating (Qureshi *et al.*, 2021). The flower formation begins in the months of May and June; however, the formed fruits in the summer remain stuck on trees if not eaten by the birds (Sharma and Paul, 2013).

Chinaberry trees are mostly beneficial for decoration in streets and gardens, as well as, windbreakers. The seed oil contains effective medicinal substances that are effective as anti-allergies and healing ulcers, rheumatism, skin diseases, and scabies, while its wood serves as fuel and wood chips (Hossain *et al.*, 2018). If its propagation continued through seeds, it could suffer from dormancy due to seed coat thickness. Several studies progressed to break the dormancy in many plant seeds to identify the best relevant treatment. The seed immersion in hot water is one of the treatments used to break the dormancy in hard seeds (Jangra and Kumari, 2023). Seeds soaked in water either help modify the hard shield of the seed or remove

the materials that prevent germination and shorten the period required to initiate the germination (Nasr *et al.*, 2013).

The treatment of *Melia azedarach* L. seeds with boiling water resulted in the highest rate of germination (Ebeid *et al.*, 2022). Sujatha and Manjappa (2015) mentioned that the treatment of *Melia azedarach* seeds with chilling periods had a significant effect on increasing the germination percentage. Findings of Xu *et al.* (2018) revealed that hot water treatment had a notable influence on the stem length, stem and root diameter, and the number of leaves after the scratching treatment. Thus, the presented study sought to determine the effect of hot water and chilling treatments on the seed germination and growth of the Chinaberry tree (*M. azedarach* L.) seedlings.

MATERIALS AND METHODS

Chinaberry (*Melia azedarach* L.) tree seeds' collection began in February from the trees spread at the University of Mosul, Iraq, and sustained immersion in ordinary water, removing the fleshy layer by the rubbing of hands. The division of seeds into three groups served the purpose of studying the effect of hot water immersion periods. The experiment layout had a randomized complete block design (RCBD) with a factorial arrangement and three replications. The first factor included immersing the seeds in hot water at a temperature of approximately 60 °C–70 °C at three levels (without immersion and immersion for one hour and two hours), while the second factor involved cooling periods at four levels (without cooling and cooling for 10, 20, and 30 days). The process of immersion in hot water and chilling had repetitions according to the above levels, and after 10 days, repeating the water immersion process, and then another repetition for the next 10 days, as per chilling periods. The seed sowing ensued in black plastic bags containing mixed sandy soil. The experiment was continuous for watering and weeding.

Studied traits

The germination percentage calculation proceeded by knowing the number of germinated seeds divided by the total number of seeds $\times 100$. The seedling height (cm) and the main stem diameter (mm) measurement for each seedling used the digital foot (vernier) at a height of one cm from the soil surface. Counting the number of leaves per seedling and the number of branches also ensued.

Statistical analysis

All the recorded data for various parameters underwent the analysis of variance (ANOVA) as per the RCBD. The least significant difference (LSD_{0.05}) test helped compare and separate the means (Al-Rawi and Khalaf-Allah, 2000).

RESULTS AND DISCUSSION

Seeds germination (%)

The results indicated a significant effect of both factors (hot water immersion and chilling periods) on the seeds' germination percentage in *M. azedarach* L. (Table 1). The hot water immersion periods (one and two hours) showed a significant superiority over the control (without water immersion). The two-hour immersion period gave the highest germination rate (70.19%) and caused a significant increase of 21.55% over the lowest rate from the control treatment (55.06%). This may be because the hot water softened the hard covers of the seeds, which increased the percentage of seed germination and formed more developed roots for the seedlings. Past research also revealed the same findings while studying the effects of pre-sowing treatments on seed germination in *M. azedarach* (Azad *et al.*, 2010).

Results further showed remarkable differences between the chilling levels (Table 1). The seedlings produced with chilling of seeds outperformed in germination percentage and provided the highest rate (73.40%), with a significant difference (34.46%) compared with

the control treatment (48.10%). This may be due to cooled seeds causing an increase in the germination rate of seedlings. These results were also consistent with past findings by studying the developmental treatments on the germination and growth of green beans (Benkouachi *et al.*, 2022).

As for the interaction effects of hot water immersion and chilling levels, the outcomes displayed sizable differences (Table 1). The interaction of hot water immersion (two hours) and the chilling period (30 days) provided the ultimate rate of germination (77.33%), with a significant difference of 48.27% compared with the control treatment (without hot water immersion and chilling periods) (40.00%).

Stem diameter

The results indicated that hot water immersion treatments have prominent variations in stem diameter in *M. azedarach* L. (Table 2). The hot water seed immersion period (two hours) outperformed and differed significantly with periods without immersion and gave the highest rate for the stem diameter (3.38 mm), with a significant increase of 19.82% versus the control treatment revealing the minimum average of stem diameter (2.71 mm). The reason may refer to the impregnation and softening of the peel and swelling, which led to the acceleration of germination and the emergence of the lower and upper embryonic peduncle compared with the non-submerged seeds (Huang *et al.*, 2023).

According to chilling levels, the results showed noteworthy alterations between chilling periods in their effect on this trait (Table 2). The chilling period (30 days) exceeded, giving the widest rate of seedling diameter (4.30 mm), with a significant increase of 56.51% compared with non-chilling of the control treatment (1.87 mm). An explanation could be that the chilling period softens and tears the seed coat, hastening the embryonic growth. These results were also greatly analogous to past findings in *M. azedarach* (Gleeson *et al.*, 2022).

Table 1. Effect of hot water immersion and chilling periods and their interactions on the germination percentage in *M. azedarach* L.

Chilling periods	Hot water immersion periods			Means (%)
	Without immersion	Immersion (one hour)	Immersion (two hours)	
without Chilling	40.66	48.11	55.06	48.10
Chilling 10 days	54.32	67.22	72.70	64.74
Chilling 20 days	55.61	68.83	75.20	66.54
Chilling 30 days	69.66	73.22	77.33	73.40
Means (%)	55.06	62.48	70.19	

LSD_{0.05} Chilling periods: 3.20, Immersion periods: 2.11, Interactions: 5.03

Table 2. Effect of hot water immersion and chilling periods and their interactions on the stem diameter in *M. azedarach* L.

Chilling periods	Hot water immersion periods			Means (mm)
	Without immersion	Immersion (one hour)	Immersion (two hours)	
without Chilling	1.53	2.02	2.06	1.87
Chilling 10 days	2.60	2.77	2.88	2.75
Chilling 20 days	3.12	3.32	3.39	3.27
Chilling 30 days	3.61	4.07	5.22	4.30
Means (mm)	2.71	3.04	3.38	

LSD_{0.05} Chilling periods: 0.90, Immersion periods: 0.71, Interactions: 1.53

On effects of interactions between both factors, the results showed significant differences among the interactions for the stem diameter (Table 2). The interaction of hot water immersion (two hours) and the chilling period (30 days) provided the highest rate of stem diameter (5.22 mm), with a significant increase of 70.68% compared with control treatment (1.53 mm).

Seedling height

The results revealed significant differences between hot water immersion periods for seedling height in *M. azedarach* L. (Table 3). The hot water seed immersion period (two hours) outperformed the period of the control treatment; however, it did not differ significantly with the immersion period of one hour. The two-hour immersion gave the tallest rate of seedling height (9.70 cm), with a significant increase of 29.58% versus the control treatment, indicating the lowest rate for the said trait (6.83 cm). This could attribute to the softness of seed covers and the acceleration of the germination process, forming a better root system for seedlings that

helps better absorb nutrients from the soil than the seedlings in the control treatment (AL-Khaffaf and Lazar, 2013).

Regarding the effects of chilling treatments, considerable differences were visible in the seedling height (Table 3). The chilling period (30 days) provided the tallest average of stem length (17.22 cm), which caused a significant increase of 80.02% in seedling height compared with the control treatment (3.44 cm). This may be attributable to chilling causing an acceleration of the germination process and the formation of better seedlings, which further accelerate the longitudinal growth. These results agreed with past findings in studying the pre-sowing treatments on seeds of forest tree species (Kumar *et al.*, 2024).

For the seedling height, the interactions between both factors revealed significant differences (Table 3). The peak seedling height (19.00 cm) resulted from the interaction of hot water immersion (two hours) and chilling period (30 days), with a significant increase of 86.00% by comparing with the chilling control treatment (2.66 cm).

Table 3. Effect of hot water immersion and chilling periods and their interactions on the seedling height in *M. azedarach* L.

Chilling periods	Hot water immersion periods			Means (cm)
	Without immersion	Immersion (one hour)	Immersion (two hours)	
without Chilling	2.66	4.00	6.83	3.44
Chilling 10 days	5.66	5.16	4.83	5.22
Chilling 20 days	3.33	5.16	13.33	7.27
Chilling 30 days	15.66	19.00	17.00	17.22
Means (cm)	6.83	8.33	9.70	

LSD_{0.05} Chilling periods: 0.76, Immersion periods: 0.47, Interactions: 0.92

Table 4. Effect of hot water immersion and chilling periods and their interactions on the leaves per seedling in *M. azedarach* L.

Chilling periods	Hot water immersion periods			Means (leaves seedling ⁻¹)
	Without immersion	Immersion (one hour)	Immersion (two hours)	
without Chilling	7.87	9.67	16.20	11.24
Chilling 10 days	18.89	22.05	22.27	21.07
Chilling 20 days	24.77	32.70	49.77	35.74
Chilling 30 days	40.53	41.00	96.00	59.18
Means (leaves seedling ⁻¹)	23.01	26.35	46.06	

LSD_{0.05} Chilling periods: 9.00, Immersion periods: 6.44, Interactions: 14.06

Leaves per seedling

For leaves per seedling in *M. azedarach* L., the hot water seed immersion treatments exhibited significant differences (Table 4). The immersion period (two hours) showed the most number of leaves (46.06 leaves seedling⁻¹) with a noteworthy increase of 50.04% leaves seedling⁻¹ as compared with the lowest average obtained in the control treatment (23.01 leaves seedling⁻¹). The reason may be because this immersion period worked on softening the seed covers and helped in the process of early germination, which led to forming developed roots, as reflected in the growth of the vegetative parts (Ebeid *et al.*, 2022).

The seed chilling treatments demonstrated noticeable differences for leaves per seedling (Table 4). The chilling period (30 days) gave the maximum number of leaves (59.18 leaves seedling⁻¹), with a significant difference of 81.00% compared with the minimum obtained in the control treatment (11.24 leaves seedling⁻¹). Exposing seeds to low temperatures may stimulate the germination process and grow plants faster. Low temperatures could enhance the activity of

enzymes and metabolic processes within the seed, leading to increased root growth and, thus, an increase in the number of leaves formed during the early stages of plant growth (Palakit *et al.*, 2018).

The interaction effects between the hot water immersion and chilling periods proved significant (Table 4). The hot water treatment (two hours) and the chilling period (30 days) disclosed the most number of leaves per seedling (96.00 leaves seedling⁻¹), with a significant increase of 91.80% leaves seedling⁻¹ versus the lowest average obtained in the control treatment (7.87 leaf seedling⁻¹).

Branches per seedling

The hot water seed immersion levels enunciated substantial differences for branches per plant in *M. azedarach* L. (Table 5). The hot water immersion (two hours) outperformed and showed the ultimate rate of branches (9.66 branches seedling⁻¹), but nonsignificantly differed with the one-hour immersion period, with a notable increase of 25.87%. Meanwhile, the lowest average appeared in the control treatment (7.16 branches seedling⁻¹). The said improvement could be due to the prolonged

Table 5. Effect of hot water immersion and chilling periods and their interactions on the branches per seedling in *M. azedarach* L.

Chilling periods	Hot water immersion periods			
	Without immersion	Immersion (one hour)	Immersion (two hours)	Means (branches seedling ⁻¹)
without Chilling	3.66	6.33	7.16	6.44
Chilling 10 days	8.00	11.00	7.66	8.88
Chilling 20 days	9.00	11.00	10.33	10.11
Chilling 30 days	8.00	9.66	11.33	9.66
Means (branches seedling ⁻¹)	7.16	9.50	9.66	

LSD_{0.05} Chilling periods: 0.32, Immersion periods: 0.11, Interactions: 0.47

seed immersion period, enhancing the softening of the outer crust of seeds and boosting growth. The embryo caused an increase in metabolic activities to accelerate germination and growth (Azad *et al.*, 2010).

For branches per seedling, the chilling factor showed remarkable variations (Table 5). The chilling period (30 days) exceeded all other chilling periods and provided the most number of branches (9.66 branches seedling⁻¹), with a significant increase of 33.33%, with the lowest rate for this trait obtained in the control treatment (6.44 branches seedling⁻¹). This may be because the chilling period affected the dormancy phase by working on cracking and softening the hard crust of seeds and accelerating the germination process. These results were consistent with past findings based on effects of chilling periods on the germination and growth of fruit pine seedlings (Al-Asho, 2004).

The interaction of both factors revealed significant differences for branches per seedling (Table 5). The interaction of hot water seed immersion (two hours) and chilling period (30 days) gave the highest rate of the said trait (11.33 branches seedling⁻¹), with a significant increase of 67.69% branches seedling⁻¹ versus the least number of branches per seedling obtained in the control treatment (3.66 branches seedling⁻¹).

CONCLUSIONS

The results concluded that exposing seeds to different levels of temperature may stimulate the germination process and plant growth. It

could also enhance the activity of various enzymes and metabolic processes within the seeds, which leads to increasing the level of root system growth and, thus, reflecting positively on plant growth and development.

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