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EFFECT OF ELECTROCUTION WITH MAGNETIZED WATER ON SEED GERMINATION AND GROWTH TRAITS OF *ACACIA CYANOPHYLLA* L.

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SUMMARY

This study aimed to determine the effect of electrocution with magnetized water on the seed germination and seedling growth characteristics of *Acacia cyanophylla.* The seeds exposed to electrocution with magnetized water at low magnetic flux levels had different exposure durations using a device designed for this purpose. The parameters were zero × zero, four amps × zero, four amps × 500 gauss, four amps × 850 gauss, and four amps × 1100 gauss, while the exposure durations were four, six, and eight minutes. The experiment occurred in a randomized complete block design (RCBD) with three blocks. The results showed that treating *A. cyanophylla* seeds with an intensity of 4 amperes × 850 watts in all exposure periods displayed a significant increase in the seed germination ratio (60.00%) compared with the control treatment, recorded with the lowest germination ratio (37.77%). For growth characteristics, the treated seedlings with four amps × 850 gauss for four min emerged with the highest seedling height, dry weight, and shoot diameter, compared with the control treatment providing the lowest rates for studied growth traits.

Keywords: *Acacia cyanophylla*, magnetic flux, germination ratio, germination stimuli, seed treatments, dormancy-breaking phase

Key findings: Treating *Acacia cyanophylla* seeds with an intensity of four amps × 850 watts with four min exposure time showed a significant increase in germination percentage. It was excellent over all other interactions in most traits.

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INTRODUCTION

Acacia cyanophylla L. is an evergreen shrub belonging to the family Fabaceae, with dangling, thornless, fast-growing branches that reach a height of seven meters. The leaves are thick, smooth, waxy, and bluish-green. The shrub tolerates less salinity and moderate drought when the trees become large. Reproducing it by seeds is easier; however, propagating it by cuttings is difficult (Adiamo *et al.,* 2020).

Its original habitat is Australia, grown to produce firewood and for environmental purposes, such as stabilization of dunes and windbreaks (Muniandi *et al.,* 2022). Physical treatment is appropriate and safe to enhance seed germination instead of adding chemicals in recent years. One of the methods that has valuable effects in this field is the electrical treatment using the flash method (electric shock). Past findings indicated low energy in the seeds (about 6–26 millivolts), causing the electrical energy treatment for seeds before planting them (Matthes and Boyd, 1968).

Recent applications of electrocution processes to increase plant growth and provide safety to plants from diseases and insects used electric fields with seeds (Tyree and Fensom, 1968). The electric field enhances cell membrane permeability and facilitates nutrient absorption by the crop plant, stimulating cell division, which encourages growth and development (Al-Samarrai and Al-Jubouri, 2011). Magnetism is an effective property on Earth, as the planet is a considerably large magnet. The intensity of its magnetic field is 0.5 gauss, equivalent to 0.00005 Tesla (Fields *et al.,* 2013).

All materials on Earth, including plants, acquire magnetic properties as their internal molecules' arrangement adheres to this magnetic field (Khojaly, 1998). It also provides the magnetic field to manage the plant's physiological responses and their growth and development through seasonal variations that occur in the magnetic field (Hafeez *et al.,* 2023).

The Magnetron treats the magnetized water (Takatchenko, 1997). By treating water magnetically, more variations occur in its chemical and physical properties with surface tension and viscosity, with water polarity increasing and reducing water molecules by breaking up hydrogen bonds that connect these molecules and the degree of water magnetic depends on the exposure duration and the magnet's strength (Brehm *et al.,* 2012). Therefore, it is preferable to encourage forest species with short life cycles and large roots to grow faster.

The pertinent study materialized for improving germination and seedling growth characteristics. Similarly, due to limited research on the effect of electrocution with magnetized water and exposure durations on the *Acacia cyanophylla*, the presented study sought to expose its seeds, which suffer from internal and external dormancy to electrocution with magnetized water and a low magnetic flux at several levels (Ismail *et al.,* 2020). The different exposure durations will reveal the effect of electrocution with magnetic water on Acacia seeds and find low-cost alternatives to increase the germination ratio and stimulate and grow seedlings.

Seed treatment with environmentally friendly physical methods through newly developed methods, such as the magnetic field (MF), is better than other chemical methods (Jamil *et al.,* 2013). Based on the above discussion, the promising study aimed to determine how electrolysis using magnetized water at low flux levels affects seed germination and growth traits of *A. cyanophylla* seeds.

MATERIALS AND METHODS

The practical experiment on *A. cyanophylla* seeds transpired at the nursery site of the University of Mosul, Mosul, Iraq (altitude of 230 masl and at the intersection of longitude 43°07′47″ East and latitude 36°23′19″ North), with woody canopy and shading of 50% of natural lighting intensity. Healthy, clean, and homogeneous seeds collected from *A. cyanophylla* tree pods served as samples in this study. Dividing the seeds into groups depended on the treatments, covering them with perforated cellophane paper and placing them in a glass basin with 110 cm × 30 cm × 25 cm dimensions. The setup also had a device containing two carbon electrodes connected by two wires inside a glass basin to conduct an electrical current (Al-Sahuki, 1992), using a Clamp meter device to control the entering current and a device to measure the temperature of the solution at less than 30 °C (Galliana and Capra, 2012). The wires connected to a voltage electrical switch had a constant 220 volts.

The treatment included magnetizing the water by circulating the water inside the aquarium through a magnetic field of several strengths using a water magnetization device (Magnetron). The *A. cyanophylla* seeds treatment of multiple levels of severity electrocution used magnetized water at low flux levels of magnetization. After treatment, placing three seeds in a black polyethylene bag received all services. Germination ratio recording and monitoring ran for one month after seed planting. The results recorded for the rest of the traits ensued when the experiment ended.

Study factors

The first factor included electrocution with magnetic water at five levels (zero x zero, four amps × zero, four amps × 500 gauss, four amps × 850 gauss, and four amps × 1100 gauss). The second factor included exposure duration (four, six, and eight minutes), as shown in Table 1. Thus, the experiment became factorial, with two factors (5 × 3), and the number of treatments was 15 factorial treatments using an RCBD with three blocks. The number of experimental units in this research was 150 for each block, with 10 observations per treatment per block.

Studied traits

Calculating the germination ratio (%) used the following equation:

$$G.R\% = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seeds\ planted} \times 100$$

Additional studied parameters were the seedling height (cm), stem diameter (mm), the number of leaves per seedling, and dry weight of shoots (g).

Statistical analysis

The results' statistical analysis relied on the analysis of variance (ANOVA) as per the RCBD (Al-Mohammadi and Al-Mohammadi, 2012). The least significant difference ($L.S.D_{0.05}$) test helped compare and separate the means, using the statistical analysis software GenStat12.

Table 1. Planning of experiment.

Treatments	Electrocution levels with magnetized water	Exposure duration/minutes
1	zero × zero	4
2	4 amps × zero	4
3	4 amps × 500 gauss	4
4	4 amps × 850 gauss	4
5	4 amps × 1100 gauss	4
6	zero × zero	6
7	4 amps × zero	6
8	4 amps × 500 gauss	6
9	4 amps × 850 gauss	6
10	4 amps × 1100 gauss	6
11	zero × zero	8
12	4 amps × zero	8
13	4 amps × 500 gauss	8
14	4 amps × 850 gauss	8
15	4 amps × 1100 gauss	8

RESULTS AND DISCUSSION

Germination ratio

The intensity parameters for electrocution with magnetized water showed a significant effect on the germination ratio of the *A. cyanophylla* seeds (Table 2). It was evident that treating the seeds with four amps × 850 gauss provided the highest remarkable increase in the germination ratio, amounting to 60%, and also notably superior over the rest of the treatments. However, the control treatment displayed the lowest germination ratio (38.55%), and influences of other treatments occurred between them.

Exposure durations showed nonsignificant effects on the germination rate. However, as for the interaction between the intensity of the electrocution with magnetized water, the germination ratio of 60% was distinct with the maximum significant increase for treatment of exposing seeds to an intensity of four amps × 850 gauss for all exposure durations of four, six, and eight minutes. Nonetheless, the lowest germination ratio of 37.77% appeared for the control treatment with four minutes of treatment. Past studies revealed that electrocution affects the effectiveness of gibberellins and auxins due to the activity of enzymes that convert complex molecules and materials into simple components (Sharif, 2013). With increased internal energy of the seed, will also boost the activity of most enzymes involved in the germination process (Rasheed, 2018).

Amylase and proteolytic enzymes are considerably crucial and are primary in the metabolic processes during seed germination. The increased activities of these enzymes will be beneficial for rapid germination; hence, it would be highly desirable to find a way to enhance the activities of these enzymes. It was also possible through the development of some physical techniques, such as ionizing radiation, magnetic treatment of the seeds, and laser treatment before sowing (Jamil *et al*., 2013; Perveen *et al.,* 2021). The increased germination ratio was consistent with past findings, which showed that treating seeds with electrocution raises water absorption and softens the seed shell, boosting the germination rate (Gui *et al*., 2003). The presented results were analogous to past observations that increased germination ratio was evident in the seeds of Pine nut, Carob, Robinia, Albizia, and Paulownia, by exposure to electric current (Radu *et al*., 2015; Gätjens-Boniche *et al.*, 2017; Holonec *et al*., 2021; Radif and Al-Hadidi, 2022; Idrees and Omar, 2023).

Seedling height

The results indicated no significant effect of electric shock on the seedling height (Table 3). As for the duration of exposure, significant differences among the treatments appeared, and the exposure duration of four minutes revealed the highest seedling height (66.73 cm) while also excelling in the duration of eight minutes (54.53 cm). On interaction among the intensity of the electrocution with magnetized water and the duration of exposure, it was apparent that the maximum increase in seedling height (82.67 cm) resulted in four amps × 850 gauss for four minutes, with the lowest seedling height recorded in the control

Table 2. Effect of electrocution with magnetized water, the duration of exposure, and their interactions on the germination ratio of the *Acacia cyanophylla* seeds.

Intensity of electrocution with magnetized water	Duration of exposure to electrocution with magnetized water (min)			Means (%)
	4	6	8	
Zero	37.77	38.99	38.88	38.55
4 amps × zero	42.20	43.32	42.21	42.58
4 amps × 500 gauss	44.33	45.33	44.33	44.66
4 amps × 850 gauss	60.00	60.00	60.00	60.00
4 amps × 1100 gauss	41.11	41.11	41.11	38.55
Means (%)	45.08	45.75	45.30	

$LSD_{0.05}$ Electrocution: 2.37, Duration: N.S., Electrocution x Duration: 4.17

Table 3. Effect of electrocution with magnetized water, the duration of exposure, and their interactions on the seedling height of *Acacia cyanophylla* seedlings.

Intensity of electrocution with magnetized water	Duration of exposure to electrocution with magnetized water (min)			Means (cm)
	4	6	8	
Zero	39.33	79.00	44.67	54.33
4 amps × zero	81.00	71.33	54.67	69.00
4 amps × 500 gauss	48.00	69.33	58.33	58.55
4 amps × 850 gauss	82.67	69.33	56.00	69.33
4 amps × 1100 gauss	67.33	44.67	59.00	57.00
Means (cm)	66.73	63.66	54.53	
$LSD_{0.05}$ Electrocution: N.S., Duration: 10.58, Electrocution x Duration: 24.75				

Table 4. Effect of electrocution with magnetized water, the duration of exposure, and their interactions on the stem diameter of *Acacia cyanophylla* seedlings.

Intensity of electrocution with magnetized water	Duration of exposure to electrocution with magnetized water (min)			Means (mm)
	4	6	8	
Zero	6.46	5.84	5.22	5.84
4 amps × zero	6.90	6.66	5.49	6.35
4 amps × 500 gauss	5.42	7.17	5.30	5.96
4 amps × 850 gauss	7.63	6.76	5.80	6.73
4 amps × 1100 gauss	7.37	5.14	5.72	6.07
Means (mm)	6.75	6.31	5.50	
$LSD_{0.05}$ Electrocution: N.S., Duration: 0.94, Electrocution x Duration: N.S.				

with four minutes. The electrocution with magnetized water at low flow levels can show a positive effect on plant height. Exposing plants to low electrical current by adding magnetized water somewhat stimulates plant growth and development. Electric shock also helps the roots and enhances the water and nutrient absorption from the soil. Moreover, electric shock can also quicken the plant's metabolism, increasing the production of chlorophyll and other nutrients that contribute to plant growth and development, positively reflecting on seedling height (Idrees and Omar, 2023).

Stem diameter

For stem diameter in *A. cyanophylla* seedlings, the highest increase was notable in the effect of the intensity of electrocution with magnetized water with treatment (4 amps × 850 gauss), amounting to 6.73 mm and revealed nonsignificant differences with the rest of the treatments (Table 4). However, the comparison treatment gave the tiniest seedling stem diameter (5.84 mm). In exposure durations, the four-minute exposure duration exhibited the utmost increase in stem diameter (6.75 mm), differing significantly from the eight-minute exposure duration (5.50 mm). As for the interaction effects among the intensity of the electrocution with magnetized water and the duration of exposure, the treatment of four amps × 850 gauss for four minutes showed the optimum increase in seedling diameter (7.63 mm) with a nonsignificant difference with the other treatments. Conversely, the lowest diameter was apparent in the control treatment at eight minutes (5.22 mm). Past studies indicated that plants exposed to magnetized water and electric current will grow and develop fast abundantly, as the electric shock promotes growth, cell division, and elongation, which leads to an increase in the efficiency of vital processes within the plant, as reflected positively on plant growth and development (Shareef *et al.,* 2018; Suleiman *et al.,* 2018).

Leaves per seedling

The intensity of electrocution with magnetized water (4 amps × 850 gauss) raised the leaves per seedling (35.44), which also differed nonsignificantly from the rest of the treatments (Table 5). The treatment of four amps × 500 gauss and the comparison treatment provided the lowest leaf numbers (27.66 and 27.88

Table 5. Effect of electrocution with magnetized water, the duration of exposure, and their interactions on the number of leaves of *Acacia cyanophylla* seedlings.

Intensity of electrocution with magnetized water	Duration of exposure to electrocution with magnetized water (min)			Means (leaves seedling^{-1})
	4	6	8	
Zero	17.33	35.67	30.67	27.88
4 amps × zero	36.67	28.33	28.00	31.00
4 amps × 500 gauss	21.00	39.00	23.00	27.66
4 amps × 850 gauss	63.00	24.00	19.33	35.44
4 amps × 1100 gauss	38.00	16.33	30.33	28.22
Means (leaves seedling^{-1})	35.00	a 28.66	26.26	

$LSD_{0.05}$ Electrocution: N.S., Duration: 6.16, Electrocution x Duration: 22.74.

Table 6. Effect of electrocution with magnetized water, the duration of exposure, and their interactions on the dry weight of shoots of *Acacia cyanophylla* seedlings.

Intensity of electrocution with magnetized water	Duration of exposure to electrocution with magnetized water (min)			Means (g)
	4	6	8	
Zero	3.71	14.77	7.82	8.77
4 amps × zero	14.77	10.08	6.91	10.52
4 amps × 500 gauss	7.83	5.73	7.09	6.89
4 amps × 850 gauss	17.93	13.57	6.28	12.59
4 amps × 1100 gauss	13.74	4.71	9.59	9.35
Means (g)	11.60	9.77	7.54	

$LSD_{0.05}$ Electrocution: 2.64, Duration: 1.95, Electrocution x Duration: 3.84.

leaves per seedling, respectively). In the effect of exposure duration, the treatment of four minutes gave a nonsignificant highest increase over the rest for exposure durations for leaves per seedling (35.20), while the eight-minute duration revealed 26.26 leaves seedling^{-1}. The interaction effects of electrocution and its duration markedly increase versus some interaction treatments in the leaves per seedling by treating with four amps × 850 gauss for four minutes (63.00), while the control treatment for four minutes exhibited the lowest number of leaves per seedling (17.33). A belief stated that plants would grow and develop more when exposed to low electric current and magnetized water. The electric shock improves the soil's ability to absorb more water and nutrients, enhancing root growth. The electric shock also enhances the activity of the plant's metabolism, enriching the chlorophyll and nutrient syntheses, which eventually positively affects the plant's growth and development (Radif and Al-Hadidi, 2022).

Dry shoot weight

For dry shoot weight in *A. cyanophylla* seedlings, the maximum dry shoot weight (12.59 g) was evident in the treatment of four amps × 850 gauss, with a nonsignificant difference from its counterparts (Table 6). The treatment of four amps × 500 gauss was notably with the lowest dry shoot weight with a nonsignificant variance. The difference in electrocution with magnetized water and duration of exposure with four minutes gave the dry shoot weight the utmost increase (11.60 g), which was substantially superior to the eight-minute exposure period (7.54 g). In interaction among the intensity of electrocution with magnetized water and the duration of exposure, the treatment with four amps × 850 gauss at four minutes indicated an increase in the dry shoot weight (17.93 g) compared with the values obtained with the eight-minute exposure time. Similarly, other values and the control treatment recorded the lowest dry shoot weight (3.71 g). Eşitken and Turan (2004) stated that exposing plants to a magnetized field causes increased absorption of massive mineral elements and enhances their concentration in the leaves. The magnetized field reduces the resistance of cell walls to cell elongation and, thus, facilitates their growth and development (Zong *et al.,* 2016). It also causes a change in various physical and chemical properties of the water, such as reducing surface tension, viscosity, and density (Ren *et al.,* 2015), hence facilitating the absorption and transfer of water in the plants for an augmented development of wood and phloem tissues (Kathiresan and Rajendran, 2000; Obaid, 2009; Sharif, 2013; Gätjens-Boniche *et al*., 2017).

CONCLUSIONS

Treating the *A. cyanophylla* seeds with electrocution intensity and magnetized water improved the seed germination ratio and increased the seedling height, stem diameter, leaves per seedling, and dry shoot weight. In using safe and environment-friendly physical treatments, electrocution and magnetized water are beneficial for boosting the seed germination rate and stimulating the growth and development of forest tree seeds.

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