Effect of electric shock on germination and seedling growth in henbane species

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ABSTRACT

A laboratory experiment was conducted in 2017 to investigate the effect of electric shock (2, 4, and 6A) with a stable 220V for 5 min, in addition to control treatment (without shock) on germination and seedling growth in henbane species (Hyoscyamus niger and Hyoscyamus muticus). 100 seeds per petri dish for each treatment were placed in the germinator at 25°C with relative humidity of 80% for 12 days. Completely randomized design was applied with four replications. The results showed the supremacy of black henbane in the final germination percentage (FGP), germination speed (GS), germination rate index (GRI), wet and dry seedling weight, chlorophyll index, and leaf area, except mean germination time (MGT). Electric shock (4 A) exceeded other treatments in FGP (48%), wet weight (5.83 g) and dry weight (0.344 g), leaf area (37.62 cm²) and chlorophyll index (89.45), while electric shock (6 A) exceeded in GRI (5.29% day⁻¹) without differing significantly with 4A treatment. Therefore, it can be concluded that the Egyptian henbane have low FGP already, and electric shock can improve germination and seedlings in both henbane species.

Key words: Egyptian henbane, black henbane, Hyoscyamus niger, Hyoscyamus muticus, dormancy, electric shock.

INTRODUCTION

Medicinal plants are considered as an important source of medicine, saving the lives of many people around the world from time immemorial till date. The World Health Organization estimates that approximately 80% of people at present rely mainly on traditional treatments such as herbs for medicine (Abdel-Hady et al., 2008). Henbane which belongs to the Solanaceae family can be considered as one of the important medicinal plants owing to its tropane alkaloids content, mostly as atropine (hyoscine) and hyoscyamine and the rest are considered scopalamine. They are used for multiple medical purposes, such as sedative, antispasmodic, anodyne, and mydriatic, and are also particularly useful against accidents and nervous shocks (Verma et al., 2014). Two species of genus Hyoscyamus Tare are of high economic importance for their tropane alkaloids, which are used for medical purposes. The first species is called European henbane or black henbane (Hyoscyamus niger) grown over South East Europe and Russia. Another species is the Egyptian henbane (Hyoscyamus muticus) grown wildly in many Mediterranean region, West Europe, Iran, India and North Africa especially in Egypt and Libya (Nassar et al., 2016). These henbane species are all cultivated as a crop for medical tropane alkaloid production in drug companies worldwide especially in U.S., Europe, and India. Most henbane seeds from wild origin experience a problem with seed germination (Pareek et al., 1988)

Low germination rates can be a result the effect of several factors such as long dormancy periods which is found in European black henbane and hardened seed coat or both factors which can be found in Egyptian henbane, the famous and widely used species in the medical field (Verma et al., 2014). Many treatments have been used to stimulate seed germination in low viability seeds, such as chemical treatments, hot water, and/or exogenies plant hormones. The gibberline is popularly used in this field (Cheyed et al., 2014), but physical treatments can be safer for use because of their limited effects on human and on the environment.
such as electric shocks treatments which has been widely used in plant science for many years ago. It has been proven the possibility of stimulating plants to increase yield, improve yield quality, and protect plants from disease, insects, and frost by treating seeds, plants, soil, water, and nutrient solutions with electrical field. Nelson (2000) pointed out that seeds treated with electrical shock had higher germination rates and increased yield, and when treated once again with high voltage, a decrease in seed dormancy was found. Steady stable electric was used to give protection to pole negativity which decreases seed death if the treated seeds are kept moist, because dry seeds will lead to seed death, this method increased stimulated germination to 200%.

Numerous researchers have used used electric shock on plants in different ways. Farooq et al. (2006) managed to find a solution to tomato seeds dormancy by applying an electric current at a temperature of 50°C which largely induced germination. Lynikiene et al. (2006), in their study, proved that treating different types of crops with electricity resulted in physical, chemical, and biological changes, as well as a 24% increase in carrot seed germination, a 12% increase in radish and sugar beet seed germination, and 9% increase in barley seeds and an increase in water absorption rate. Thus, respiration and carbon fixation of different plant seedlings were also recorded. Sidaway (1966) observed a large increase in germination rate followed by an increase in growth and dry weight when Avena sativa seeds were treated with electric current. Al-Shamma (2015) studied the effects of electrical shock with different durations (3, 6, and 9 min) on the characteristics of three faba bean cultivars. The results showed an early yield and protein percentage for some cultivars, a significant interaction between treatment duration and cultivar, and response of different cultivars separately to different durations. Based on the importance of these two plants, the present study was conducted to determine the effects of henbane species and electric shock on germination parameters and seedling growth.

**MATERIALS AND METHODS**

The experiment was carried out in the Laboratories of Medical and Aromatic Plants Research Unit/College of Agriculture/University of Baghdad to determine the effects of electric shock treatments on germination parameters and seedling growth of two henbane species: Egyptian henbane *H. muticus* and European henbane *H. niger*. The seeds were imported from Pafny Ltd., an American seed company. Seeds were selected on the basis of validity and homogeneity. Empty seeds were excluded from each species. The selected seeds were divided into groups with 100 seeds per group, treatments were marked, and the seeds were placed in small cloth bags to avoid mixing. They were soaked in NaCl1% for 2 h to allow the solution to penetrate the seed in order to increase electric conductivity during later treatment. An electric shock device with a patent number 3112 dated 20/6/2002 owned by Elshookie and Alsubahi (2001) was released from the central unit for standardization and quality control/Iraq (Figure 1).

The device was used as described by Elshookie and Alsubahi (2001). Different treatments were carried out by placing seeds in the device under different electricity intensities 0, 2, 4, and 6 A with a stable voltage (220 V) for 5 min. Afterwards, seeds were washed with running water for a half an hour for three times to get rid of the remaining salt solution from the seeds. Treatments were named 0, 2, 4, and 6 A, respectively. The 0A was used as control treatment which was treated with all previous conditions except electric shock. The seeds were placed in a drying paper 15 ml petri dishes, 100 seeds per dish, and then placed in an incubator with a temperature set at 25°C and relative humidity of 80% for 12 days with daily checking (Verma et al., 2014). The complete randomized block design was used to include 24 treatments in total resulting from the interaction between two henbane species, as well as four electric shock levels with four replicates. The following parameters of seed germination and seedling growth were measured after six weeks of planting:

1. Final Germination percentage:

\[ \text{FGP(\%)} = \frac{N_g}{N_t} \times 100\% \]

Where \( N_g \): Germinated seeds, and \( N_t \): Total seeds

2. Germination Speed: it was calculated from the following equation:

\[ Gs (\text{seed} \cdot \text{day}^{-1}) = \sum_{i=0}^{i} \frac{N_i}{D_i} \]

3. MGT: The lowest values indicated that the seeds have the highest germination speed (Kader, 2005). It was calculated from the following equation:

\[ \text{MGT (day)} = \sum_{i=0}^{i} \frac{N_i \cdot D_i}{N_t} \]

\( N_i = \) seed germinated on day, \( N_t = \) Total seeds

4. GRI: This parameter reflects the number of germinated seeds(%) for each day of the germination period (Fuller et al., 2012). The results were calculated using the following equation:

\[ \text{GRI (day}^{-1}) = \sum_i \frac{\text{FGP}_i}{i} \]

eg: FGP 3, FGP 6, +...

5. Dry and wet weights(g): After final germination period (FGP), 10, four-weeks-old seedlings after FGP were
randomly chosen, weighed for wet weights using a sensitive digital scale, and seedlings were then dried after being placed in perforated paper bags in an electric drying oven at a temperature of 80°C until a constant weight was obtained to measure the dry weight (AOSA, 1988).

6. Chlorophyll index (SPAD): After the end of the experimental trials, chlorophyll index for all seedlings leaves, as well as the mean for each seedling were measured for 10 randomly chosen seedlings using a (SPAD), a chlorophyll meter.

7. Seedling leaf area: This trait was measured using a Digimizer image 4 analysis program for every plant leaves sample representing each experimental unit.

Data were analyzed statistically at P<0.05. Genstat software was used. Test of least significant differences (LSD) at 5% level of probability was used to compare the calculated averages of traits (Steel et al., 1997).

RESULTS AND DISCUSSION

Final germination percentage (FGP)

The statistical analyzes of results (Table 1) showed significant differences between both species (Egyptian and European henbane) and electric shock treatments, as well as their interaction. Black henbane exceeded Egyptian henbane for this parameter by (578.1%) which is six times higher. Also, shock treatments seemed to exceed the comparison treatment in standard laboratory germination percentage and the increase in germination rates was parallel to the increase in electric shock intensity on seeds, as the control (0A) treatment recorded 33.0%. Thus this percentage gradually increases, reaching the highest percentage (48.0%) recorded at 4A, and then decreases gradually reaching 15.2% while increasing the intensity to 6A.

These results clarify that both henbane species seeds face germination problems at varying rates. Egyptian henbane recorded higher germination problem rates as compared with European henbane. Therefore, this species may be having a thick seed coat, seed coat inhibition compound, and low embryo viable capacity. Cüneyt et al. (2004) reported a double dormancy in black henbane seeds resulting from a hardened seed coat and a partially dormant embryo; this finding was supported by Verma et al. (2014). The henbane seed response to physical treatment with electric shock increased seed germination in both species. In black henbane, the germination percentage increase by 20% when treated with anelectric intensity of 4A recording 79.13% as compared with the no shock treatment (0A) which recorded 52.12% and then decrease to 66.10% in 6A treatment. In the Egyptian henbane an increase from 2.2% with no shock (control) treatment (0A) to 10.30% for 4A with electric shock treatment which recorded the highest germination percentage with only 10% increase (Table 1). On the other hand, the control (0A) recorded the lowest significant values of FGP 52.12 and 2.20 in black and Egyptian henbane, respectively. Plant seeds exposure to electric field may increase the occurrence of genetic variations and the physical, chemical, and biological changes in these seeds such as seed coat softening or an enzyme reaction stimulation, water absorption increase, increase in respiration levels, increase in seed germination by carbon fixation inside the seed, and increase in seed germination of radish and sugarcane by 12% and barley by 9% (Lynikiene et al., 2006). These results are in agreement with the findings of Sidaway(1966) who exposed oat seeds

Figure1: Electric shock device.
Results in Table 2 showed a significant effect for both factors and their interaction on MGT. It can be observed that Egyptian henbane seeds needed less time to germinate (1.47 days), and black henbane seeds needed 9.3 days to complete germination. This trial clarifies the number of days it takes to reach full germination. Thus the Egyptian henbane surpassed European henbane in this regard due to the small number of seeds germinated, which reached 5% as compared with black henbane seeds which reached 70% (Table 1). This indicates that the Egyptian henbane does not require much time to germinate. Electric shock treatment at its highest level 6A in this study gave the lowest significant MGT, reaching 4.3 days followed by the no shock treatment (control) and shock intensity treatment (2A) which did not differ significantly from them, as compared with shock intensity 4A that needed the most time (6.43 days) to complete germination. These results yet again support that electric shock stimulates treated seeds to germinate faster (Table 1). The electric currents influence stimulating enzymatic reactions in seeds and secondary metabolite accumulation. The results in Table 2 show Egyptian henbane which was not treated with electric shock, recording the lowest MGT at 0.85 days. The black henbane treated with electric shock intensities, (2 and 4A) seeds needed the most time to complete germination which reached 11.23 and 10.01 days, respectively.

Germination rate index (% day⁻¹)

The highest GRI number refers to the highest and most rapid germination (Kader, 2005). The results in Table 2 clearly show significant differences between henbane

Table 1: Effect of electric shock on final seed germination percentage (FGP) and germination speed (Gs) for black henbane H. niger and Egyptian henbane H. muticus.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FGP%</th>
<th>GS (Seed day⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Black henbane</td>
<td>Egyptian henbane</td>
</tr>
<tr>
<td></td>
<td>Black henbane</td>
<td>Egyptian henbane</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0A</td>
<td>52.12</td>
<td>2.20</td>
</tr>
<tr>
<td>2A</td>
<td>68.05</td>
<td>12.11</td>
</tr>
<tr>
<td>4A</td>
<td>79.13</td>
<td>11.31</td>
</tr>
<tr>
<td>6A</td>
<td>66.10</td>
<td>10.30</td>
</tr>
<tr>
<td>Mean</td>
<td>71.2</td>
<td>10.5</td>
</tr>
</tbody>
</table>

LSD5% FGP: Shock, species, interaction 5.76, 4.07, and 8.15, respectively. 
LSD5% Gs: Shock, species, interaction 0.39, 0.27, and 0.55, respectively.
species, shock levels, and the interactions between them on GRI. A superiority of black henbane with a large difference reaching 757.6 or seven times more was also observed. The results in Table 2 also clearly show that all levels of electric shock treatments exceeded that of the control (no treatment (0A)). Also, every increase in electric shock levels increased the GRI reaching 5.39 at the highest shock level 6A which did not differ significantly from shock level 4A. The highest interaction rate (9.95) was recorded in black henbane seeds at 6A, while the lowest interaction rate (0.22) was recorded in Egyptian henbane seeds that were not treated with electric current 0A (control). Previous results confirm the large difference in seed viability and germination speed of black henbane in the germination speed index as compared with Egyptian henbane with germination problems faced by the seeds. Electric shock treatments play a role in increasing germination speed index levels for European black henbane, but not in Egyptian henbane seeds because of the endogenous seed problems such as partial dormancy or because of its need to optimum conditions such as temperature and light or dark which required conditions that vary from species to another within the same plant genus or family. This finding was confirmed by Barakat et al. (2013) who reported that Egyptian henbane seeds germinate better under an appropriate interaction between ideal temperature, light and darkness.

**Seedling wet weight (g)**

In general, it can be observed that the difference and the positive effect of electric shock results in improvement of all seedling growth traits of the two henbane species (Figures 2 and 3). The electric shock enhanced the activation of metabolic activity and carbon fixation in seedling stages of plant life or could modify pH value inside and outside cells, which in turn changes membranes transportation characteristics at osmotic equilibrium. The results in Table 3 shows significant differences between both henbane species and electric shock levels and the interaction between them on seedling wet weight. Black henbane gave the highest level of seedling wet weight as 6.12 g with a difference of 414.28% as compared with Egyptian henbane which gave the lowest average reaching 1.19 g. The superiority of black henbane in seedling wet weight is due to the nature of its growth, seedling leaf size of this species and superiority in germination percent (FGP), germination speed (Gs), germination time (MGT), and germination index (GRI) means (Tables 1 and 2) which reflected on seedling growth and development as compared with Egyptian henbane which fell behind in these parameters. It shown in Tables 1 and 2, these increase in electric shock intensity in black henbane is accompanied with an increase in seedling mean wet weight as compared with the control treatment with 1.55 g, followed by 4A treatment with 5.83 g and shock level 6A which gave 4.73 g with no significant differences between the last two treatments. This effect of electric shock intensity on wet weight could be a result of its effect on germination speed and percentage (Table 1) which have effect on the seedling growth of these treatments and eventually increased the wet weight. Significant interactions between both experimental factors can be observed in Table 3. Black henbane seedlings treated with shock levels 4A, 6A were superior to the rest of the interactions with no significant differences between these two treatments. As for Egyptian henbane not treated with electric shock 2, as well as treated seeds with all shock levels recorded the lowest results in seedling wet weight as well as non-treated black henbane seeds with no significant differences between these treatments.

**Seedling dry weight (g)**

The results in Table 3 shows a significant effect for both factors and their interactions on dry weight. Black henbane seedlings gave the highest average for this parameter (0.33 g) as compared with Egyptian henbane seedlings which recorded the lowest average for this parameter at 0.071 g. This can be explained by the nature of vegetative growth in
black henbane and its superiority in seedling wet weight (Table 3). As for the effect of electric shock intensity on this parameter, its action was similar to that on seedling wet weight, as all shock intensities were superior to the control treatment (0.083 g) which gave the least average for this parameter. Meanwhile seedling dry weight increased to achieve the highest average (0.334 g) at 4A which exceeded the average recorded by shock levels at 2A and 6A. These results are in agreement with the report of Sidaway (1966) on *Avena sativa* seeds that an increase in germination speed, a later increase in growth, and dry weight were as a result of exposure to electricity.

Table 3 shows that black henbane treated with shock levels 4A,6A gave the highest values for this parameter. As for black and Egyptian henbane seedlings not exposed to electric shock, as well as Egyptian henbane treated with all shock levels gave the lowest values for interaction treatments between both experimental factors and did not show any significant difference. The similarity between wet and dry weight parameter results affected by the studied factors is as a result of the difference between them, that is, moisture content excluding the dry weight which is mostly stable and can be dried using a heat drying process. The increase in wet and dry weights affected by electric current

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**Table 3:** Effect of electric shock on average seedling wet and dry weights (g) of black henbane *H. niger* and Egyptian henbane *H. muticus.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Wet weight (g)</th>
<th>Dry weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Plant species</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>Black henbane</td>
<td>Egyptian henbane</td>
</tr>
<tr>
<td>0A</td>
<td>2.60</td>
<td>1.50</td>
</tr>
<tr>
<td>2A</td>
<td>3.86</td>
<td>1.16</td>
</tr>
<tr>
<td>4A</td>
<td>9.98</td>
<td>1.68</td>
</tr>
<tr>
<td>6A</td>
<td>8.04</td>
<td>1.41</td>
</tr>
<tr>
<td>Mean</td>
<td>6.12</td>
<td>1.19</td>
</tr>
</tbody>
</table>

LSD5% MGD: Shock, species, interaction 1.33, 0.93, and 1.89, respectively.
LSD5% GRI: Shock, species, interaction 0.073, 0.052, and 0.103, respectively.
treatments can be ascribed to its role in stimulating metabolic cell activities, such as carbon fixation and alteration of cell pH inside and outside the cell which allows transport across cellular membranes resulting in osmotic equilibrium by induction or electric tension. Thus the cells react by accumulating secondary metabolites which play a role in biological synthesis (Zhang et al., 2004).

**Chlorophyll index (SPAD)**

The results of the mean analysis showed that both henbane species had a significant effect on chlorophyll index in seedling leaves. As for the electric shock levels, as well as the interaction between both experimental factors, no significant statistical effect was observed (Table 4). Black henbane gave the highest average for this parameter reaching 40.19 SPAD, as compared with the Egyptian henbane which recorded the lowest average of 32.64 SPAD. This can be attributed to the fact that black henbane seeds recorded the best results for all previous parameters which reflected on the growth and development of leaves and an increase in leaf chlorophyll pigment. This finding was supported by Lynikiene et al. (2006) who treated different crops seeds with electric shock, causing physiological, chemical, and biological changes, which in turn, resulted in an increase in water absorption, increase in respiration levels, and carbon fixation in seedlings of these different plant types.

**Leaf area (cm²)**

The increase in leaves number of henbane was significantly different until six weeks of age, reaching 6.7 leaves in average (Nassar et al., 2016) as shown in Figures 2 and 3. The results in Table 4 show that both studied factors and the interactions between them had a significant effect on henbane seedling leaf area. Black henbane exceeded by 335.7% or three and a half times the leaf area recorded by Egyptian henbane which gave the lowest average leaf area of 23.2 cm². This can be explained by the growth nature of each henbane cultivar and superiority of black henbane in seedling growth and wet and dry weights (Table 3) which refers to its high growth rates as compared with Egyptian henbane. The positive effect of electric shock can be observed in the aforementioned table; thus, the control (0A) treatment recorded 29.2 cm² and gradually increased as the shock intensity increased to 2A and 4A recording 41.2 and 89.4 cm², respectively and 88.8 cm² at 6A which did not differ significantly from 4A treatment. This can be attributed to the fact that as the effect of electric shock increased the germination percentages and speed reflecting on dry weight mass produced, the seedling wet and dry weights increased. The highest interaction level recorded was in black henbane seeds treated with shock levels 4A and 6A (151.2 and 137.4 cm²), while the Egyptian henbane seedlings which were not treated and the treated seeds at all shock levels recorded the lowest interaction values and did not show any significant difference between them (Table 4).

**CONCLUSION**

From the previous results, it may concluded that black henbane faces problems with seed germination at a lower level than the problems facing Egyptian henbane, and better responded to electric shock treatments especially shock level 4A which improved the studies parameters response, as well as seedling characteristics. Although electric shock treatments did increase germination parameters and seedling characteristics in the Egyptian henbane, further studies are needed to overcome seed dormancy in this species.

**REFERENCES**


Sidaway GH (2009). Influence of Electrostatic Fields on seed Germination Department of Botany, University college Cardiff. DOI:10.1038/211303A0.


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