

Germination of Indian Almond (*Terminalia arjuna* Roxb.) Seeds as Affected by Soil Salinity in Presence or Absence of Magnetic Iron

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ABSTRACT

The hard seed coat is the major hindrance in achieving good and uniform germination for Indian almond (*Terminalia arjuna* Roxb.) fruits, especially when large plantations are to be raised under soil salinity stress. The present investigation was therefore, undertaken under the full sun at the nursery of Orman Botanical Garden, Giza during 2016 and 2017 seasons with the objective to find out the role of magnetic iron (Fe_3O_4) on mitigating the hazards of NaCl salinity, when applied at the rates of 0 or 3 g/20-cm-diameter plastic pot containing 10 fruits of arjuna and filled with about 3.5 kg of sand + clay mixture at equal parts (1:1, v/v) salinized with NaCl pure salt at the concentrations of 0, 2000, 4000, 6000 and 8000 ppm. The effect of interactions between Fe_3O_4 application rates and salinity levels was also studied in a complete randomized design experiment with factorial concept replicated thrice. The obtained results indicated that means of germination percentage were descendingly decreased with increasing salinity level to reach less than 50 % by 6000 and 8000 ppm levels, while planting the fruits in a soil mixture free from salt gave the highest germination %, followed by planting in 2000 ppm-salinized soil mixture, and then planting in soil mixture salinized with 4000 ppm concentration. On the other hand, addition of Fe_3O_4 (3 g/pot) significantly raised the mean of this measurement in both seasons. The shortest period to either maximum germination (G.V.) or 50 % germination (MGR) was achieved in both seasons by planting in non salinized control and 2000 ppm-salinized media, whereas increasing salinity level over that (up to 8000 ppm) prolonged these periods with the greatest delay in germination. On the contrary, Fe_3O_4 significantly reduced the means of such two traits causing a marked accelerating in G.V. and MGR. A slight increment was noticed in the means of germination rate index (GRI) by the different salinity concentrations, while Fe_3O_4 caused a trivial decrement. A similar response occurred as well regarding the means of vigour index (V.I.), seed viability (S.V.), hypocotyl length and vegetative and root growth attributes of the resulted seedlings. So, it can be advised to apply magnetic iron (Fe_3O_4) at the rate of 3 g/pot (20-cm-diameter) to improve germination and seedling quality of *Terminalia arjuna* Roxb. fruits planted in either low or medium salinized soil.

Keywords: Indian almond (*Terminalia arjuna* Roxb.), soil salinity, germination characters, magnetic iron (Fe_3O_4).

INTRODUCTION

Indian almond (*Terminalia arjuna* Roxb.) is an evergreen forest tree, belonging to the Family Combretaceae, up to 25 m high with huge trunk. It is found in the tropical and sub-tropical parts of India and plays an important role in the sericulture industry (Orwa *et al.*, 2009). It produces large orthodox seeds as propagules in a dark brown, 5-winged capsule. It is mainly used in the gardens as shade tree. It furnishes a good timber and its leaves form an ideal food for the Tasar silkworms (Dutta, 1995). Its white-to-pinkish-gray bark has been used in Indian's native medicine primarily as a cardiac tonic and also as a potent antioxidant for ischemic heart diseases (Sultana *et al.*, 2007). It has antioxidant, anti-ischemic, antihypertensive and antihypertrophic effects, which have relevance to its therapeutic potential in cardiovascular diseases. Its efficacy, mostly in patients with ischemic heart disease, hypertension and heart failure, besides its potent antibacterial and antimutagenic activities were also reported (Kapoor, 1990; Bone, 1996; Maulik and Talwar, 2012). Naik *et al.* (2010) mentioned that bark of *T. arjuna* is the economic part, which contains arjunolic acid (arjunolitin).

Propagation of *T. arjuna* is difficult by seeds due to poor seed germination and seedling viability. Hence, cuttings and air-layering methods were adopted for this plant (Pandey *et al.*, 2006). However, pre-sowing treatments with chemicals, growth hormones and irradiation were used for enhancing germination. In this regard, Naik *et al.* (2010) found that the propagation of *T. arjuna* through seeds can be practiced by treating the seeds first with concentrated sulphuric acid for 20 minutes and then pre-soaking for 18 hours in GA_3 + BA solution at 150 ppm. Furthermore, Akshatha *et al.* (2013) reported that germination speed of *T. arjuna*

seeds irradiated with gamma ray at 25 Gy was found to be 0.65, which was double compared to the un-irradiated seeds. An increase in germination %, vigour index and relative growth rate, in terms of dry weight was noticed at lower doses of the radiation treatment. The proline content increased with increasing doses. The chlorophyll content was increased to 12.2 mg/g f.w. at 100 Gy compared to control level of 8.4 mg/g f.w. Increased phenolic content and radical scavenging capacity was observed at 25 and 150 Gy.

On other *Terminalia* species, Hossain *et al.* (2005) revealed that depulping the fruits of *T. chebula* and soaking in water for various periods (12, 24 and 48 h.) significantly enhanced seed germination and seedling growth. The highest germination percentage (66.7 %) was observed in the fruits depulped and soaked in cold water for 48 h (T4), followed by 60 % in the depulped seeds soaked in cold water for 24 h (T3). The lowest germination % (48.9 %) was obtained from controlled seeds (T0). The highest germination value (4.41), germination energy (58.9) and vigour index (5291) were also obtained in T4. Shoot length, root length, collar diameter and leaf number followed the same trend of higher value for T4, T5 and T3, respectively (T5: depulped seeds and soaking in hot water for 2 min.). Likewise, Michael *et al.* (2008) observed that nicking and soaking *T. sericea* seeds in cold water for 12 h. gave the highest germination % (51 %) for the first collection (when 60 % of the fruits were deep-green to brown) and appears to be the most feasible and suitable pretreatment method for small scale farmers than use of H_2SO_4 . Soaking in hot water for 15 and 20 min. and immersion in concentrated H_2SO_4 for 3 and 4 h. gave poorest germination percentage (0 %).

However, information in the literature about the germination and seedling growth of *Terminalia* spp under

salt stress are very rare, except for Tomar and Gupta (1985) who mentioned that *Acacia nilotica*, *Pongamia pinnata* and *Prosopis juliflora* have been categorized as salinity tolerant tree species at the germination and seedling stages, while *Terminalia arjuna* has not been. In the areas where salinity is associated with high water table conditions, *Tamarix*, *Prosopis* and *Casuarina* species can be subsurface planted with success, while *Acacia auriculiformis*, *A. nilotica* and *Terminalia arjuna* can be grown in such areas if planted on the ridges. They also added that if salinity is associated with waterlogging, *Terminalia arjuna* can be grown up to a salinity of ECe = 7-10 mmhos/cm.

Overcoming the deleterious effects of salinity on germination and seedling growth through applying magnetic iron was studied before by Moustafa *et al.* (2017) who postulated that amending the soil texture with 2g/pot which contained 10 seeds of *Moringa oleifera* raised germination percentage to 100 % for seeds sown in soil mixture salinized with 2000 ppm of NaCl salt, while those sown in soil mixture salinized with 4000 and 8000 ppm NaCl salt, Fe₃O₄ rose their germination percentage to 50 % or more. Magnetic iron accelerated germination speed when applied only to 2000 ppm salinized soil mixture. The means of vigour index, seed viability, epicotyl length, seedling length, No. leaves/seedling, root length, No. roots/seedling, top growth and roots fresh and dry weights, as well as leaf contents of pigments, total soluble sugars and total indoles were greatly improved by applying of Fe₃O₄ (2g/pot) irrespective of salinity level. Similar observations were also reported by Abdel-Fattah (2014) on *Jacaranda acutifolia* and Ahmed *et al.* (2016) on *Acalypha wilkesiana*.

Table a. The physical and chemical properties of the sand and clay used in 2016 and 2017 seasons

Soil type	Particle size distribution (%):				S.P.	E.C. (dS/m)	pH	Cations (meq/l)				Anions (Meq/l)		
	Coarse sand	Fine sand	Silt	Clay				Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻
Sandy	84.76	6.30	1.49	7.45	21.87	3.78	7.90	19.42	8.33	7.20	0.75	1.60	7.80	26.30
Clayey	7.64	22.50	30.15	39.71	52.38	2.33	8.10	7.50	2.21	15.49	0.75	6.78	8.02	11.15

In addition, fruits sown in salinized soil mixture at the previously mentioned concentrations were drenched with magnetic iron (Fe₃O₄, 22.5 %), obtained from Alahram Mining Co., Giza at the rates of 0 or 3 g/pot. Each level of salinity was combined factorially with each one of the magnetic iron to create ten interaction treatments. A factorial in complete randomized design experiment with 3 replicates was adopted in both seasons, as each pot contained 10 seeds stands for one replicate (Mead *et al.*, 1993). All agricultural practices necessary for seed care were done as usually grower did. The germination was recorded daily from date of sowing and continued till the germination ceased. The seed germination criterion was visible protrusion on the surface of soil at least 0.5 cm of the cotyledon and hypocotyle of the seedlings. Seedlings were then allowed to grow altogether under the same environmental conditions till end of the season (on October, 30th), as the following data were recorded:

A. Germination characteristics:

1- Germination percentage (G %) was calculated after completion of germination using the equation below:

$$G. \% = \text{No. germinated seeds} / \text{Total No. sown seeds} \times 100.$$

The current work aims to study the effect of magnetite on germination of arjuna seeds and on the first growth stages of the resulted seedlings when sown in a salinity affected soil.

MATERIALS AND METHODS

A pot experiment was carried out under the full sun at the nursery of Orman Botanical Garden, Giza, Egypt during the two consecutive seasons of 2016 and 2017 to detect the effects of different salinity concentrations on germination and seedling growth attributes of the hard seed-coated fruits of Indian almond tree (arjuna) and the role of magnetite on reducing the harmful effects of such salinity.

Therefore, mature fruits of *Terminalia arjuna* Roxb. known as arjuna and Indian almond, were collected from strong-build and healthy mother trees grown in Orman Botanical Garden on June, 1st for each season. The fruits are 5-winged capsules, as each fruit contained only one seed (Das and Alam, 2001). All fruits were dried in sunlight and stored in a paper sac till the treatments were applied.

Uniform fruits (its long ranged between 2.9-3.1 cm, diameter between 2.2-2.4 cm and weight between 2.0-2.2 g) were soaked in tap water for 48 hours on June, 20th for every season as recommended by Gomaa (1998), then were sown in 20-cm-diameter plastic pots (10 fruits/pot) filled with about 3.5 kg of sand + clay soil mixture at equal parts by volume (1:1, v/v) salinized with NaCl pure salt at the concentrations of 0, 2000, 4000, 6000 and 8000 ppm. The physical and chemical properties of the sand and clay used in the two seasons were determined and listed in Table (a).

2- Germination velocity in days (G.V.), which equal average number of days from sowing till emergence of the final hypocotyle.

3- Mean germination rate in days (MGR) = mean No. days till 50 % germination (Odetola, 1987).

4- Germination rate index (GRI), which was calculated from Bartled equation indicated by Hartmann and Kester (1983):

$$GRI = A + (A + B) + (A + B + C) + \dots / N(A + B + C \dots).$$

Where: A, B, C, etc: are No. germinated seeds counted at different times, and N: No. times at which the germinated seeds were counted.

5- Vigour index (VI) = G % x mean length of hypocotyle (Selvaraju and Selvaraj, 1994).

6- Seed viability (SV) = No. survived seedlings in each treatment after excluding the deteriorated and dead ones (Odetola, 1987).

B. Seedling growth parameters:

Samples from the produced seedlings under each treatment were randomly selected and uprooted very carefully to estimate: seedling length (cm), hypocotyle length (cm), number of leaves/seedling, leaf area (cm²),

root length (cm), as well as aerial parts and roots fresh and dry weights (g).

Data were then tabulated and subjected to analysis of variance using program of SAS Institute (2009), while the mean values were compared according to Duncan's New Multiple Range Test at 5 % level of probability (Steele and Torrie, 1980).

RESULTS AND DISCUSSION

- Effect of salinity level, magnetite application and their interactions on:

1- Germination characters and hypocotyle length:

Data presented in Table (1a) exhibit that means of germination percentage were gradually decreased with increasing NaCl salt concentration to be less than 50 % by 6000 and 8000 ppm levels in the two seasons, while 4000 ppm level gave germination percent slightly more than 50 % (52.88 % in the 1st season and 56.87 % in the 2nd one). However the highest records were attained in both seasons by sowing in a soil mixture free from salts (control), followed by sowing in 2000 ppm-salinized soil mixture.

The reduction in germination % by high salt levels may be due to that excess of soluble salts causes a reduction in soil-water potential leading to less water availability to be absorbed by seeds. This water potential reduction and the toxic effect of salt interfere with water absorption process influencing germination (Fahey, 2005). The salt may cause changes in functions of the cell membranes and the cell walls, and may affect the water potential of the cytosol and cellular extensibility, and consequently may affect seed germination and seedling growth (Santos *et al.*, 2011). Moreover, Lobato *et al.*

(2009) suggested that the progressive decrease in the available water under salt stress may interfere in hydrolytic enzymes activity affecting the supplement and velocity of water assimilation. In this regard, Tomar and Gupta (1985) stated that *Terminalia arjuna* can tolerate salinity of ECe ranged between 7-10 mmhos/cm (4000-6000 ppm) if salinity was associated with high water table conditions. However, the seedlings are not able to tolerate these levels like the mature plants.

On the other side, germination percentage was slightly higher than 40 % for fruits planted in the soil mixture not treated with Fe₃O₄, while adding it at 3 g/pot significantly raised the mean of germination to more than 60 % in both seasons. However, the greatest percent of germination was attained in the two seasons by planting the fruits in soil mixture free from salinity and amended with 3 g/pot magnetic iron, as this combination elevated means of such trait to 93.89 and 96.45 % in the first and second seasons, respectively, and followed by 78.83 and 83.25 % for the two seasons by the combination of planting in 2000 ppm-salinized soil mixture + 3 g /pot Fe₃O₄. Magnetic applying caused also a significant increment in germination % for fruits sown in 4000 ppm salinized soil mixture from 50 to 55.76 % in the 1st season and from 54.33 to 59.40 % in the second one. This may indicate the role of magnetic iron in reducing soil salinity through decreasing the hydration of salt ions and colloids, having a positive effect on salt solubility and finally leading to leaching of the salts. Thus, it is successfully used to reclaim soils with high cations and anions, such as Ca, Na, Cl and HCO₃ (Mostafazadeh *et al.*, 2012).

Table 1a. Effect of salinity level, magnetite application and their interactions on some germination traits of *Terminalia arjuna* Roxb. seeds during 2016 and 2017 seasons

Magnetite (3 g/pot) Salinity level (ppm)	Germination (%)			Germination velocity (day)			Mean germination rate (MGR) (day)			Germination rate index (GRI)		
	0	3	Mean	0	3	Mean	0	3	Mean	0	3	Mean
First season: 2016												
0	67.50c	93.89a	80.70a	28.80f	31.67e	30.24c	28.00d	30.33d	29.17b	0.60b	0.63b	0.62a
2000	55.65d	78.83b	67.24b	30.00e	32.38e	31.19c	33.76c	26.50d	30.13b	0.67ab	0.63b	0.65a
4000	50.00e	55.76d	52.88c	56.50b	41.71d	49.11b	56.50a	43.50b	50.00a	0.75a	0.63b	0.69a
6000	30.50g	40.33f	35.42d	63.72a	47.25cd	55.49a	-	-	-	0.76a	0.65b	0.71a
8000	0.00	33.35g	16.68e	-	50.33c	50.33b	-	-	-	-	0.68ab	0.68a
Mean	40.73b	60.43a		44.75a	40.67b		39.42a	33.44b		0.70a	0.65a	
Second season: 2017												
0	58.00cd	96.45a	77.23a	31.83f	32.60e	32.22c	31.00d	31.00d	31.00b	0.63b	0.65b	0.64a
2000	60.12c	83.25b	71.69b	33.50e	34.85e	34.18c	37.16c	29.75d	33.46b	0.70ab	0.65b	0.68a
4000	54.33d	59.40c	56.87c	57.11b	45.04d	51.08b	55.50a	46.35b	50.93a	0.75a	0.67b	0.71a
6000	32.41f	43.21e	37.81d	67.48a	50.50c	58.99a	-	-	-	0.77a	0.67b	0.72a
8000	0.00	33.31f	16.66e	-	56.33b	56.33a	-	-	-	-	0.69ab	0.69a
Mean	40.97b	63.13a		47.48a	43.87b		41.22a	35.70b		0.71a	0.67a	

Means followed by the same letter in a column or row do not differ significantly according to Duncan's New Multiple Range Test at 5 % level.

The shortest period to either maximum germination (G.V.) or 50 % germination (MGR) was recorded in the two seasons by control and 2000 ppm salinity treatments, as these two treatments registered the least No. days to such two criteria with non-significant differences in between. Increasing salinity level to 4000 ppm significantly prolonged the periods of these two characters in both seasons, and that was true also for 6000 and 8000 ppm levels which induced the

greatest delay in G.V., and failed to increase germination to 50 % or more. On the contrary, magnetic iron significantly reduced means of these two traits in both seasons inducing a marked accelerating in G.V. and MGR. A slight increment was observed in the means of germination rate index (GRI) by the different salinity concentrations, but tenuously decreased by application of Fe₃O₄ with non-significant differences compared to control in the two seasons.

In addition, data presented in Table (1b) clear that means of vigour index, seed viability and hypocotyl length (cm) were progressively diminished as the salinity concentration was increased with significant differences relative to means of control in most cases of both seasons.

This may be ascribed to the hazards of salinity on germination attributes. The opposite was the right regarding the effect of Fe₃O₄ application that caused a significant improvement in these characters over control in the two seasons regardless of salinity level.

Table 1b. Effect of salinity level, magnetite application and their interactions on some germination traits of *Terminalia arjuna* Roxb. seeds during 2016 and 2017 seasons

Magnetite (g/pot)	Vigour index (VI)			Seed viability (SV)			Hypocotyle length (cm)		
	Salinity level (ppm)			Salinity level (ppm)			Salinity level (ppm)		
	0	3	Mean	0	3	Mean	0	3	Mean
First season: 2016									
0	67.50c	138.96a	103.23a	4.00b	8.33a	6.17a	1.00b	1.48a	1.24a
2000	52.20d	99.33b	75.27b	1.76c	3.50b	2.63b	0.92b	1.25ab	1.09ab
4000	42.00e	52.97d	47.49c	0.00d	2.00c	1.00c	0.84b	0.95b	0.90b
6000	17.69h	33.48f	25.59d	0.00d	1.10c	0.55c	0.58c	0.83b	0.71b
8000	-	26.01g	26.01d	-	0.00d	0.00d	-	0.78bc	0.78b
Mean	44.60b	70.15a		1.44b	3.73a		0.84b	1.06a	
Second season: 2017									
0	54.2c	136.00a	95.26a	4.33b	9.00a	6.67a	0.94b	1.41a	1.18a
2000	54.11c	104.06b	49.09b	1.91c	3.76b	2.84b	0.90b	1.25ab	1.08ab
4000	44.01d	55.24c	49.63c	0.00d	2.15c	1.08c	0.81b	0.93b	0.87b
6000	19.45f	33.71e	26.58d	0.00d	1.17c	0.59c	0.60c	0.78bc	0.69b
8000	-	22.32f	22.32d	-	0.00d	0.00d	-	0.67bc	0.67b
Mean	43.02b	70.27a		1.56b	4.02a		0.81b	1.01a	

Means followed by the same letter in a column or row do not differ significantly according to Duncan's New Multiple Range Test at 5 % level.

2- Vegetative and root growth parameters of the resulted seedlings:

A similar trend to that of germination characteristics was also obtained concerning vegetative and root growth parameters of the resulted seedlings, where data averaged in Tables (2 and 3) showed that the means of seedling length (cm), hypocotyle length (cm), No. leaves/seedling, leaf area (cm²), root length (cm), as well as aerial parts and roots fresh and dry weights (g) were descendingly decreased in response to the progressive increment of salinity concentrations to reach the minimal values by 6000 and 8000 ppm levels comparing with control in the first and second seasons. This deleterious effect of salinity may be attributed to the lower rate of cell division and ethylene production

in seedlings subjected to this type of stress. This hormone is a consequence for decreasing of seedling size (Lobato *et al.*, 2009). Further, Allen (1995) affirmed that the decrease in biomass production of many plants under salt stress is mainly referred to generation of reactive oxygen species (ROS) in chloroplast, which diminishes the plant growth in the absence of any protective system like antioxidant system. In this concern, Moustafa *et al.* (2017) on *Moringa*, concluded that a gradual decrement was observed in the means of seedling length, No. leaves/seedling, root length, No. roots / seedling, as well as top growth and roots fresh and dry weights with the gradual increment in salinity level up to 4000 ppm.

Table 2. Effect of salinity level, magnetite application and their interactions on growth traits of *Terminalia arjuna* Roxb. seeds during 2016 and 2017 seasons

Magnetite (g/pot)	Seedling length (cm)			Hypocotyle length (cm)			No. leaves/seedling			Leaf area (cm ²)			Root length (cm)		
	Salinity level (ppm)			Salinity level (ppm)			Salinity level (ppm)			Salinity level (ppm)			Salinity level (ppm)		
	0	3	Mean	0	3	Mean	0	3	Mean	0	3	Mean	0	3	Mean
First season: 2016															
0	52.50a	55.20a	53.85a	5.6ab	6.00a	5.8a	22.00b	24.00a	23.0a	25.1a	25.5a	25.3a	28.7b	32.6a	30.7a
2000	37.10bc	41.23b	39.17b	4.5b	4.8b	4.7b	18.00c	22.00b	20.0b	24.5a	25.3a	24.9a	22.4c	27.0b	24.7b
4000	29.50cd	32.99c	31.25c	3.6c	3.8c	3.7c	15.33d	17.67c	16.50c	21.5b	24.5a	23.0b	17.3d	21.5c	19.4c
6000	18.52de	24.40d	21.46d	2.9d	3.1d	3.0d	9.67f	12.26e	11.0d	17.3c	18.5bc	17.9c	13.8e	15.9de	14.9d
8000	-	13.50e	13.50e	-	3.0d	3.0d	-	5.33g	5.3e	-	8.2d	8.2d	-	12.3e	12.3d
Mean	34.41a	33.47a		4.15a	4.14a		16.25a	16.25a		22.1a	20.4b		20.6b	21.9a	
Second season: 2017															
0	55.10a	58.76a	56.93a	5.9b	6.5a	6.20a	23.10b	26.10a	24.60a	26.3a	27.0a	26.7a	26.5b	33.5a	30.0a
2000	38.96bc	43.58b	41.27b	4.7cd	5.1c	4.9b	19.00c	23.00b	21.00b	25.7a	26.6a	26.2a	23.1c	28.4b	25.8b
4000	30.41cd	34.00c	32.21c	3.8de	4.1d	4.0c	16.10d	18.60c	17.35c	21.3b	25.5a	23.4b	17.8d	22.0c	19.9c
6000	19.43de	25.50d	22.47d	3.0e	3.3e	3.2d	9.50f	13.00e	11.25d	16.9c	18.2bc	17.6c	14.6de	16.8d	15.7d
8000	-	13.97e	13.97e	-	3.0e	3.0d	-	6.00g	6.00e	-	9.1d	9.1d	-	13.1e	13.1e
Mean	35.99a	35.16a		4.40a	4.4a		16.93a	17.34a		22.6a	21.3b		20.5b	22.8a	

Means followed by the same letter in a column or row do not differ significantly according to Duncan's New Multiple Range Test at 5 % level.

On the other hand, amending the soil mixture with 3 g/pot of Fe₃O₄ markedly improved all the aforementioned growth parameters under the various salinity levels. This may explain the role of magnetic iron in mitigating the harmful effects of salinity through creating an electromagnetic field which helps the passage of useful nutrients to the roots of plants plus shocks nematodes and microbes on the roots, improving the water balance of the soil, increasing root growth, rising salts washing efficiency in the soil, and finally separating chlorine, sodium and toxic gasses magnetically from the soil (Mostafazadeh *et al.*, 2012).

The interaction between the used two factors indicated that combining between salinity at any level

and applying of magnetic iron caused noticeable improvements in the abovenamed growth traits, especially at the low levels of salinity. These gains can be supported by those revealed by Santos (2011) and Moustafa *et al.* (2017) on *Moringa oleifera*, Abdel-Fattah (2014) on *Jacaranda acutifolia* and Ahmed *et al.* (2016) on *Acalypha wilkesiana*.

Hence, the results of this experiment enable us to use magnetic field for alleviating the determinatal effects of salinity on germination of *Terminalia arjuna* seeds and the initial growth performance of the produced seedlings.

Table 3. Effect of salinity level, magnetite application and their interactions on aerial parts and roots fresh and dry weights of *Terminalia arjuna* Roxb. seedlings during 2016 and 2017 seasons

Magnetite (g/pot) Salinity level (ppm)	Aerial parts						Roots					
	Fresh weight (g)			Dry weight (g)			Fresh weight (g)			Dry weight (g)		
	0	3	Mean	0	3	Mean	0	3	Mean	0	3	Mean
First season: 2016												
0	11.55ab	12.69a	12.12a	2.91ab	3.17a	3.04a	2.63cd	4.85a	3.74a	1.15cd	2.18a	1.67a
2000	8.71b	11.50ab	10.11b	2.18b	2.90ab	2.54b	2.38d	4.02b	3.20ab	1.07d	1.83b	1.45b
4000	6.89c	9.28b	8.09c	1.73c	2.33b	2.03c	1.91de	3.18c	2.55c	0.86de	1.42c	1.14b
6000	5.13d	6.42c	5.78d	1.30d	1.58c	1.44d	1.27e	2.31d	1.79d	0.55e	1.03d	0.79bc
8000	-	1.86e	1.86e	-	0.43e	0.43e	-	1.39e	1.39d	-	0.57e	0.57c
Mean	8.07a	8.35a		2.03a	2.08a		2.05b	3.15a		0.91b	1.41a	
Second season: 2017												
0	12.41ab	13.71a	13.06a	3.12ab	3.45a	3.29a	2.81cd	5.26a	4.04a	1.20cd	2.38a	1.79a
2000	9.50b	12.33ab	10.92b	2.36b	3.13ab	2.75b	2.57d	4.33b	3.45b	1.10d	1.97b	1.54b
4000	7.45c	10.00b	8.73c	1.87c	2.50b	2.19c	2.05de	3.41c	2.73c	0.92de	1.51c	1.22b
6000	5.54d	6.93c	6.24d	1.39d	1.71c	1.55d	1.40e	2.50d	1.95d	0.60e	1.12d	0.86bc
8000	-	2.01e	2.01e	-	0.75d	0.75e	-	1.43e	1.43d	-	0.60e	0.60c
Mean	8.73a	9.00a		2.19a	2.31a		2.21b	3.39a		0.96b	1.52a	

Means followed by the same letter in a column or row do not differ significantly according to Duncan's New Multiple Range Test at 5 % level.

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إنبات بذور شجرة اللوز الهندي (*Terminalia arjuna* Roxb.) المتأثرة بملوحة التربة في وجود أو غياب الحديد الممغنط

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تعتبر أغلفة البذرة الصلبة الإعاقة الأساسية لتحقيق إنبات جيد ومتماثل لثمار شجرة اللوز الهندية (*Terminalia arjuna* Roxb.)، خاصة عند زراعتها على نطاق واسع تحت إجهاد ملوحة التربة. لذلك، أجري هذا البحث تحت الشمس الساطعة بمشغل حديقة الأورمان النباتية، الجيزة خلال موسمي 2016، 2017 بهدف معرفة دور الحديد الممغنط (ح₃) في تخفيف أضرار ملوحة كلوريد الصوديوم عند إضافته بمعدلات: صفر، 3 جم/أصيص قطره 20 سم منزرع به عشرة ثمار من التيرميناليا وملوء بحوالي 3.5 كجم مخلوط متساوي من الرمل + الطين (1:1 حجماً) تم تملیحه بملح كلوريد الصوديوم بتركيزات: صفر، 2000، 4000، 6000، 8000 جزء في المليون. تم أيضاً دراسة تأثير التفاعلات المشتركة بين معدلات إضافة الحديد الممغنط ومستويات الملوحة المختلفة على الإنبات وصفات النمو الخضري والجذري للشتلات الناتجة في تجربة عاملية تامة العشوائية ذات ثلاث مكررات. أوضحت النتائج المتحصل عليها أن متوسطات نسبة الإنبات قد انخفضت تنازلياً بزيادة مستوى الملوحة لتصل إلى أقل من 50 % بمستويات 8000، 6000، 2000 جزء في المليون، بينما أعطت الزراعة في مخلوط تربة خالي من الأملاح أعلى نسبة إنبات على الإطلاق، تلتها الزراعة في مخلوط تربة ملوحته 2000 جزء في المليون، ثم الزراعة في مخلوط تربة تركيز الأملاح فيه 4000 جزء في المليون. على الجانب الآخر، فقد أدت إضافة الحديد الممغنط (3 جم/أصيص) إلى إحداث زيادة معنوية في متوسطات هذا القياس بكلا الموسمين مقارنة بعدم إضافته. أما أقصر فترة لتحقيق أعلى نسبة للإنبات (سرعة الإنبات) أو لتحقيق نسبة 50 % إنبات (معدل متوسط الإنبات)، فقد تحققت في كلا الموسمين بالزراعة في بيئة خالية من الأملاح أو ملوحتها 2000 جزء في المليون، بينما أدت زيادة تركيز الملوحة لأكثر من ذلك (إلى 6000 أو 8000 جزء في المليون) إلى إبطاء هذه الفترات وبالتالي تأخير الإنبات بدرجة كبيرة. على النقيض من ذلك، فقد أحدثت إضافة الحديد الممغنط انخفاضاً معنوياً في متوسطات هاتين المختلفتين، مما أدى إلى إسراع الإنبات بشكل ملحوظ. لوحظ أيضاً حدوث زيادة طفيفة في متوسطات دليل معدل الإنبات (GRI) متأثرة بالتركيزات المختلفة للملوحة، بينما أحدث الحديد الممغنط انخفاضاً طفيفاً في هذه المتوسطات. ولقد أمكن الحصول على اتجاه مشابه فيما يتعلق بمتوسطات: دليل قوة الإنبات (V.I.)، حيوية البذور (S.V.)، طول السويقة الجنينية السفلى وجميع صفات النمو الخضري والجذري للشتلات الناتجة. وعليه، يمكن النصح بإضافة الحديد الممغنط (ح₃) بمعدل 3 جم/أصيص قطره 20 سم ومنزرع به عشرة ثمار لتحسين إنبات وجودة الشتلات الناتجة من ثمار شجرة اللوز الهندية (*Terminalia arjuna* Roxb.) عند زراعتها في تربة منخفضة أو متوسطة الملوحة.