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Improving ability to germinate and produce vigorous seedlings of tamarind (*Tamarindus indica*) trees

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Abstract

This study was conducted during the two successive seasons of 2022 and 2023 at Al-Marashda Agricultural Research Station, Qena Governorate in Upper Egypt. The objective of study was to improve tamarind (*Tamarindus indica*) germination and seedlings growth by using pre-sowing treatments including; untreated seeds, soaking seeds in tap water for 24, 48 and 72 hours, soaking in boiled water for 24 hours, mechanical scarification and concentrated sulphuric acid (H_2SO_4) for 10 sec. Two separate experiments were carried out where the first was in laboratory and the second was in field. The highest values of germination parameters and growth performance (stem length, root length, seedling fresh and dry weight and vigor index) were recorded with mechanical scarification followed by concentrated H_2SO_4 and soaking in tap water for 72 hours compared to the control under both laboratory and field conditions for both seasons. Water imbibition and germination of tamarind seeds was observed to be increased by the effect of mechanical scarification that disrupting the seed coats. Therefore, to produce higher germination and vigor seedlings, this study recommended treating seeds with mechanical scarification by sandpaper, concentrated H_2SO_4 for 10 seconds or soaking seeds for 72 hours in tap water.

Keywords: *Tamarindus indica*, germination, seedling growth, water imbibition

Introduction

Tamarind tree (*Tamarindus indica* L.) is an indigenous tree belonging to Fabaceae family and native of the Tropical Africa. It is a multipurpose tree that has specific uses for medicinal, food, wood, ornamental, firewood, excellent charcoal, shelter, windbreaks, as well as se forage **[1].** Moreover, almost parts of the tree use in chemical, pharmaceutical and textile industries **[2].** Seeds of tamarind contain a variety of active phytochemical compounds i.e. phenolic, flavonoids, anthocyanin, vitamin C as well as carotenoids, which indicate high antioxidant activity **[3].** It grows well over a wide range of soils and climate **[4].** Egypt lacks such high valuable trees, although the climatic conditions allow it to grow well. Aswan Governorate is distinguished by the fact that this tree species can grow well and produce fruits, as in Aswan Botanical Garden and Kom-Ombo.

Although tamarind seed is often take a long time to germinate, it is necessary to identify the most appropriate method for sowing seeds under different seed treatments **[5].** Freshly harvested tamarind' seeds exhibit low germination even if exposed to favorable conditions owing to the hard impermeable seed coat. Many studies reported that pre-germination treatments improved the seed germination in tamarind. In this regard, it was revealed that scarified seeds and seeds treated with 60% concentrated H_2SO_4 for 10 minutes germinated in first five days after sowing, while those untreated germinated after nine days **[6]**. Also, it was noticed that soaking tamarind seeds in 50 % concentration of H_2SO_4 for 60 minutes increased germination percentage compared to the control **[7]**. Also, another results indicated that concentrated H_2SO_4 treatment gave the highest seed germination percentage (95%) within 3–19 days **[8]**.

Although numerous studies investigated seed germination in the legumes species, few of these have specifically investigated the water imbibition **[9-13]**. In some cases, a time course for cumulative seed germination after different pre-sowing treatments was given **[14]**. Many studies have usually shown that manual scarification by nicking or sandpapering

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resulted in accelerate seeds germination after a few days of water entry. Moreover, numerous studies indicated that pre- sowing treatments of tamarind seeds had a significant impact on the growth and quality of the resulting seedlings. In this regard, it was reported that concentrated H_2SO_4 gave higher leaf number and seedling height than that of hot water and untreated seeds **[15]**. Meanwhile, a study on the effects of different pre-germination treatments on the seedling growth of tamarind pointed out that maximum growth parameters as plant height, number of leaves, stem diameter, root length, seedling vigor index as well as fresh and dry weights of shoots and roots were due to seeds treated by GA_3 at 150 ppm **[16]**. Another study on the effect of some pre-sowing treatments on germination and growth performance of *T. indica* and showed that the pre-germination treatments have a significant effect on the growth performance of seedlings **[4]**. They demonstrated that *T. indica* seeds, when treated with the different treatments i.e. mechanical scarification, soaking in concentrated H_2SO_4 for 15 minutes and soaking in tap water for 24 hours resulted in better growth parameters. Therefore, the main purpose of this study was to examine the effects of some pre-sowing treatments on germination and growth performance of tamarind under laboratory and field conditions.

Materials and methods

The present study was carried out during two successive seasons of 2022 and 2023 at Al- Marashda Agricultural Research Station, Qena Governorate, ARC, Egypt (26° 9' N, 32° 42’ E.). The main objective of this research was to study the effect of some pre-sowing treatments on seed germination and seedling growth of tamarind. For this purpose, two separate experiments were carried out, the 1st in the laboratory and the 2nd in the field.

The first experiment (under laboratory conditions):

Tamarind seeds were obtained from the Aswan Medicinal plant Market. From 28th March to 12th April during the two growing seasons, seeds were sown in 10 cm petri dishes after lining them with cotton at a rate of 10 seeds per dish. Uniform and healthy tamarind seeds were selected and treated with the different pre-germination treatments, which were untreated seeds as control, soaking seeds in tap water for 24, 48 and 72 h, soaking in previously boiled water for 24 h, mechanical scarification (seeds were scarified by nicking the seed coat with sand paper) as well as rapid immersing seeds in concentrated sulphuric acid (H_2SO_4 98%) for 10 sec with rapid washing with tap water. The dishes were irrigated with tap water at a rate of 10 ml every two days until the end of the experiment. Seeds germination was recorded periodically every day until germination was stable. Germination parameters were:

$$Germination\ percentage\ (G\%) = \frac{number\ of\ germinated\ seeds}{number\ of\ total\ seeds} \times 100$$

Mean Daily Germination (MDG) was recorded according to **[17]**,

$$MDG = \frac{final\ germination\ percentage}{number\ of\ days\ to\ final\ germination}$$

The germination rate index (GRI): was recorded according to **[18]**, it reflects the percentage of germination on each day of the germination period.

$$GRI\ (\%) = \sum number\ of\ germinated\ seeds \div number\ of\ days$$

Water imbibition:

Since the mechanical scarification treatment resulted in the best germination parameters, this treatment was compared with the untreated seeds for water imbibition characteristic. Tamarind seeds, whether scarified or untreated one, were soaked after weighting them in a poly cup and adding 10 ml tap water with the daily water change. Seeds weight was calculated after 24, 48, 72, 96 and 120 hours to measure the water imbibition percentage.

The second experiment (under field condition):

This experiment was done from 28th March to 6th May during the two growing seasons, in the same way as in the laboratory experiment. Meanwhile, after imposing the same treatments, tamarind seeds were sown in poly pots size of 18 × 24 cm, previously filled with prepared medium of clay loamy soil, its chemical and physical properties was shown in Table (1). Treated tamarind seeds were sown in pots filled with the prepared clay loamy soil. Fifteen seeds were sown per pot, about 2 cm deep into the pot, seeds were lightly covered with sand soil and to maintain adequate moisture, watering was done daily until the seeds start to germinate. Observations for germination parameters were daily recorded as in the first experiment. Moreover, the growth parameters like stem length, seedling fresh and dry weight as well as vigor index were recorded at 40 days after seed sowing as following: $Vigor\ index\ (g) = dry\ weight\ of\ seedling\ \times germination\ \%$ **[19]**.

Table (1): Physical and chemical analysis of the experimental soil.

Physical properties	Soil texture	Sand (%)		Silt (%)	Clay (%)	
	Clay loam	17.00		36.35	46.65	
Chemical properties	Organic Matter %	HCO_3 (meq/100 g)	SO_4^{--} (meq/100 g)	Soil pH	E.C. (mmhose/cm)	$CaCO_3$ %
	1.85	0.82	3.86	7.81	1.42	2.31

Statistical analysis:

The layout of the experiment was a randomized complete blocks design including three replicates, each replicate contained three petri dishes for laboratory experiment, or poly pots for the field experiment. The data were statistically analyzed for each season according to the procedure outlined by **[20]**. The least significant difference (L.S.D.) at 5% was used for comparing the treatments means.

Results and discussion

Germination parameters under laboratory conditions:

Obtained results in Table (2) and Figures (1-3) showed that the mechanical scarification and concentrated H_2SO_4 caused noticeable and increment in seed germination percentage, mean daily germination and germination rate index of tamarind seeds over those of untreated seeds under laboratory conditions, in the two seasons, over those of untreated seeds. However, such increase in germination parameters was significant due to all tested treatments compared to the control in both seasons. These results may due to the positive effect of scarification and H_2SO_4 treatments in facilitating the water entry to the seed, which speeds up and increases germination parameters. Our results can be compared favorably with the finding of **[8]** who reported that concentrated H_2SO_4 improved seed germination of *T. indica*. The assessment also tallies with the findings of **[1, 7, 15, 21]**. On the other hand, it was pointed out that tamarind seeds treated with concentrated H_2S0_4 for 10 minutes had highest germination percentage, followed by mechanically scarification treatment **[22]**.

Table (2): Effect of some pre-germination treatments on seed germination percentage (G%), mean daily germination (MDG%) and germination rate index (GRI %) of tamarind under laboratory conditions during 2022 and 2023 seasons.

Treatments	**G (%)**		**MDG (%)**		**GRI (%)**	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	**33.67**	**37.67**	**2.10**	**2.35**	**21.04**	**23.54**
Tap water for 24 h	43.00	46.67	2.69	2.92	26.88	29.17
Tap water for 48 h	47.50	52.00	2.97	3.25	29.69	32.50
Tap water for 72 h	51.83	57.00	3.24	3.56	32.40	35.63
Boiled water for 24 h	41.30	42.33	2.58	2.65	25.81	26.46
Scarification	**78.00**	**82.00**	**4.88**	**5.13**	**48.75**	**51.25**
H_2SO_4 for 10 sec.	**62.00**	**68.00**	**3.88**	**4.25**	**38.75**	**42.50**
Mean	51.04	55.10	3.19	3.44	31.90	34.43
LSD 5%	5.70	4.61	0.36	0.29	3.56	2.88

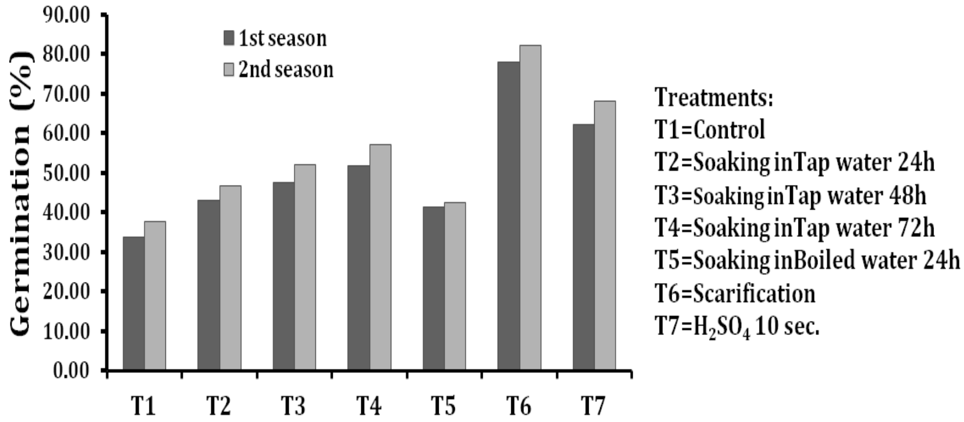

Figure (1): The effect of pre-germination treatments on germination percentage of tamarind under laboratory conditions during 2022 and 2023 seasons.

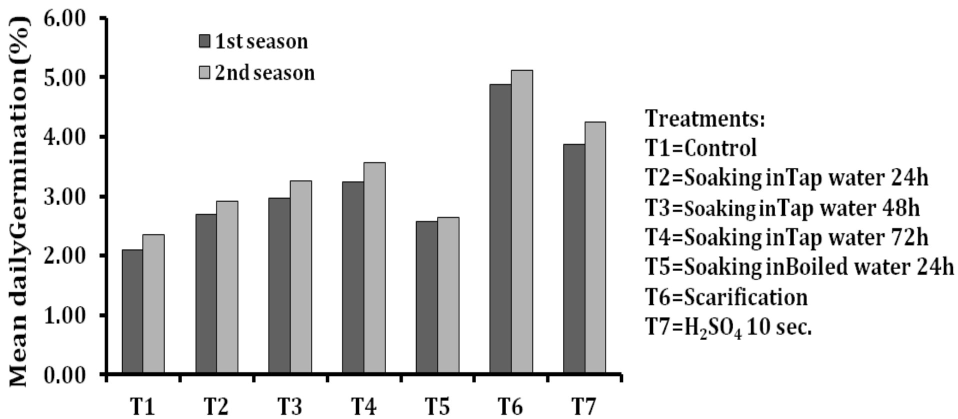

Figure (2): The effect of pre-germination treatments on mean daily germination percentage of tamarind under laboratory conditions during 2022 and 2023 seasons.

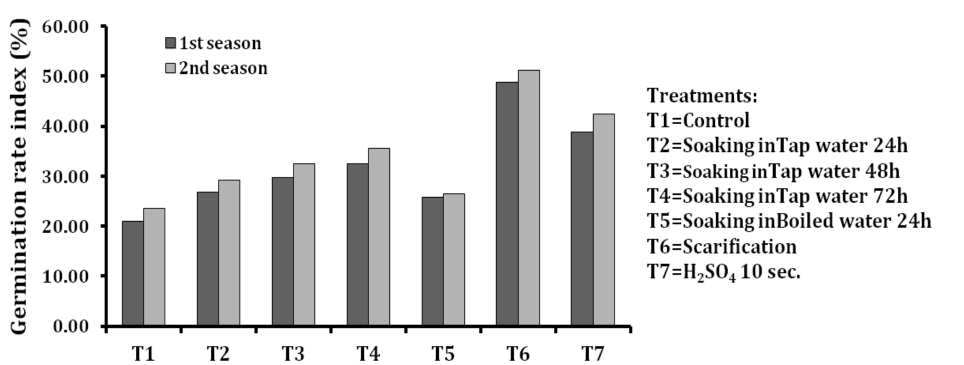

Figure (3): The effect of pre-germination treatments on germination rate index percentage of tamarind under laboratory conditions during 2022 and 2023 seasons.

Water imbibition (%):

Water imbibition percentages were gradually increased parallel to the increase in the soaking time in tap water, in both seasons. Within the five times both 120 and 96 hours gave significantly higher values of imbibition % than the other times as shown in Table (3) and Figure (4). Moreover, the response of scarified seed to water imbibition is clearly higher than that of untreated one in both seasons. Numerically, scarified seeds were increased by 66.00, 83.02, 91.71, 96.33 and 100 % in the first season and 74.00, 85.79, 96.41 and 105.76 % in the second one due to soaking in tap water at 24, 48, 72, 96 and 120 hours, respectively. The low percentage of water imbibition in control seeds may be due to the hardness of seed coat, which impedes the entry of water. Legume species which fail to imbibe water at a reasonable time (18-24 h) are called hard seed or hard-shell species. Meanwhile, species that do imbibe water, but its seed coat fail to soften even when fully hydrated and cooked are called hard-to-cook species **[23]**. Another results revealed that scarified seeds of *Serianthes nelsonii* absorbed water for the duration of 24 h, but control seeds stopped absorbing water after an hour **[24]**. Our results were in agree with previous researchers who revealed that seeds of *Acacia species* have a physical dormancy due to a water impermeable epidermal layer of seed **[25]**.

Table (3): Water imbibition percentage for the scarified and untreated seeds of tamarind during 2022 and 2023 seasons.

Treatments	**1st season**		**2nd season**	
	Untreated seeds	Scarified seeds	Untreated seeds	Scarified seeds
Tap water for 24 h	7.80	66.00	10.19	74.00
Tap water for 48 h	16.01	83.02	17.83	85.79
Tap water for 72 h	17.76	91.71	23.85	96.41
Tap water for 96 h	24.06	96.33	32.08	97.80
Tap water for 120 h	38.08	100.00	39.87	105.76
Mean	20. 74	**87.41**	24.76	**91.95**
LSD 5%	1.56	4.16	2.46	3.47

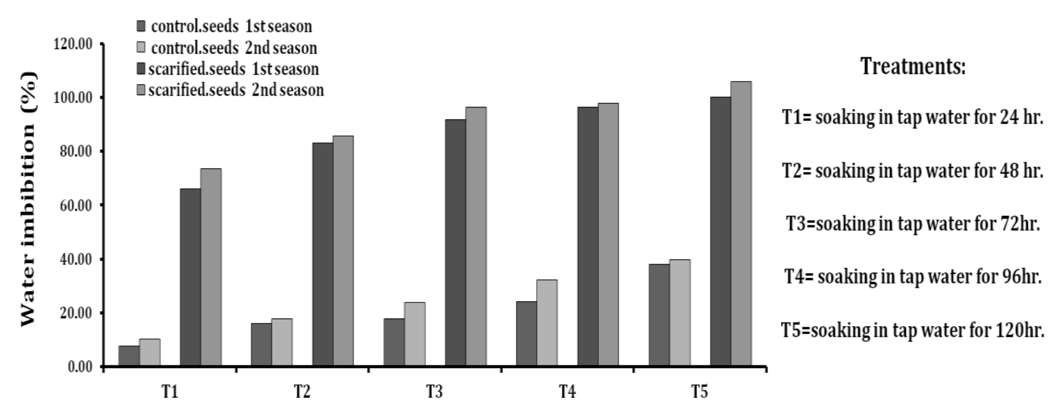

Figure (4): percentage of seed increases after soaking for 24, 48, 72, 96 and 120 h of untreated and scarified seeds of tamarind during 2022 and 2023 seasons.

Germination parameters under field conditions:

The germination parameters i.e. germination percentage, mean daily germination and germination rat index of *T. indica* seeds treated with different methods for breaking their dormancy were shown in Table (4) and Figures (5, 6 and 7). Mechanical scarification showed highest germination parameters followed by immersing in concentrated $H_2SO_4$and the least was untreated seeds followed by soaking in boiled water for 24 h. However, obtained results evidently showed that all the pre-sowing treatments have significant effects in improving germination in the two seasons compared to the control. Germination parameters were improved may be due to seed coat ruptures as a result of pre-treating of seeds with mechanical scarification, concentrated H_2SO_4, boiled water as well as cold water. These results were in agree with previous findings **[26, 27]** and also support the finding of **[4]** who postulated that germination of tamarind was enhanced by mechanical scarification followed by concentrated H_2SO_4. Also, it was revealed that that hot water and concentrated H_2SO_4 treatments of tamarind increased germination rate and the germination improved with increasing of water temperature and the time of soaking **[28]**. In this respect, it was stated that most of pre-germination treatments significantly reduced hard seed content and increased germination percentage **[29]**.

Table (4): Effect of some pre-germination treatments on germination percentage, mean daily germination (%) and germination rate index (%) of tamarind under felid conditions during 2022 and 2023 seasons.

Treatments	G(%)		MDG (%)		GRI (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	**41.56**	**50.22**	**2.08**	**2.51**	**31.17**	**37.67**
Tap water for 24 h	61.33	70.22	3.07	3.51	46.00	52.67
Tap water for 48 h	74.67	77.78	3.73	3.89	56.00	58.33
Tap water for 72 h	75.33	80.67	3.77	4.03	56.50	60.50
Boiled water for 24 h	55.78	60.67	2.79	3.03	41.83	45.50
Scarification	**83.78**	**93.56**	**4.19**	**4.68**	**62.83**	**70.17**
H_2SO_4 for 10 sec.	**78.22**	**87.11**	**3.91**	**4.36**	**58.67**	**65.33**
Mean	67.24	74.32	3.36	3.72	50.43	55.74
LSD 5%	2.09	2.89	0.11	0.15	1.57	2.17

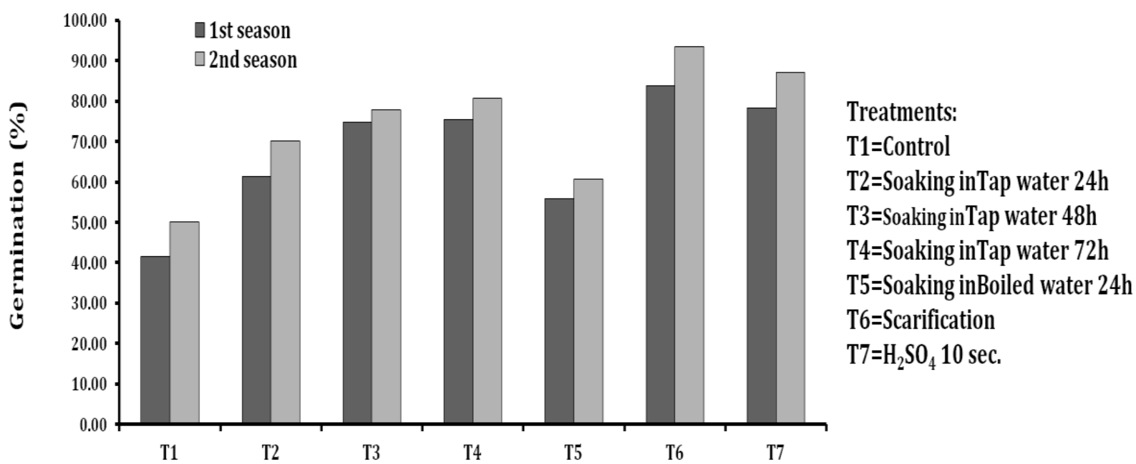

Figure (5): The effect of pre-germination treatments on germination percentage of tamarind under field conditions during 2022and 2023 seasons.

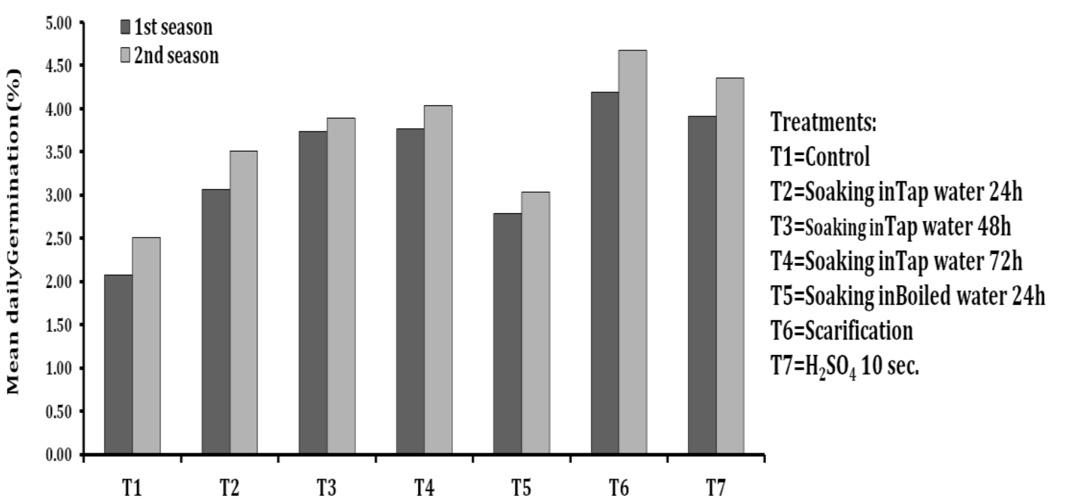

Figure (6): The effect of pre-germination treatments on mean daily germination percentage of tamarind under field conditions during 2022 and 2023 seasons.

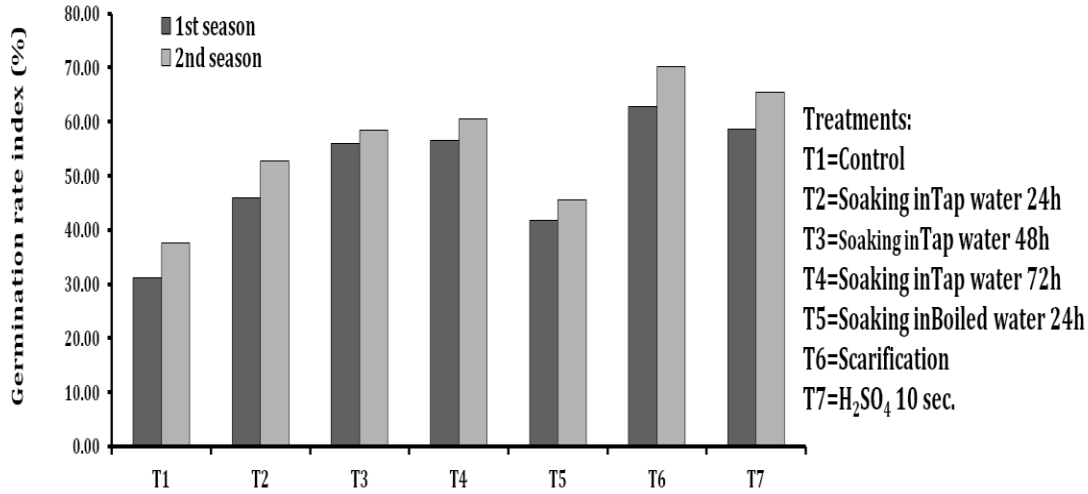

Figure (7): The effect of pre-germination treatments on germination rate index percentage of tamarind under field conditions during 2022and 2023 seasons.

The growth parameters:

Table (5) and Figures (8-13) showed the effects of pre-sowing treatments on the growth parameters of tamarind during both seasons of 2022 and 2023. There were significant differences between treatments for these growth characteristics and mechanical scarification, concentrated H_2SO_4 and soaking in tap water for 72 hours gave the highest values, respectively. Stem length of 21.33 and 25.77 cm, root length of 11.50 and 12.77 cm, seedling FW of 1.07 and 1.89 g, seedling DW of 0.58 and 0.61 g and vigor index of 48.58 and 55.28 g were recorded from mechanical scarification treatment in the 1st and 2nd seasons, respectively. Meanwhile, the lowest values in both seasons were noticed with untreated tamarind seeds. Through the results, it is noted that the growth characteristics were in agreement with those of the germination parameters as a result of pre- sowing treatments. The obtained results in this study agreed with the finding of **[4].** The reason for this result may be due to pre-germination treatments that led to an increase and speed of water imbibition, softening the seed coat and the occurrence of faster germination and thus an increase in the growth parameters compared to the control. These findings were in agreed with previous findings **[27, 30, 31].**

Table (5): Effect of some pre-germination treatments on the growth parameters of tamarind under filed conditions during 2022 and 2023 seasons.

Treatments	**Stem length (cm)**		**Root length (cm)**		**Seedling FW (G)**		**Seedling DW(G)**		**Vigor index (G)**	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	13.67	16.27	5.70	6.50	0.65	0.70	0.23	0.26	9.40	11.39
Tap water for 24 h	16.67	19.33	7.47	8.27	0.78	0.82	0.32	0.35	19.64	22.48
Tap water for 48 h	17.43	20.73	8.23	9.50	0.80	0.90	0.36	0.40	26.87	28.02
Tap water for 72 h	**18.50**	**22.03**	**9.60**	**10.47**	**0.89**	**0.94**	**0.40**	**0.44**	**30.15**	**32.29**
Boiled water for 24h	16.50	18.20	7.23	8.00	0.75	0.80	0.29	0.33	16.37	17.79
Scarification	**21.33**	**25.77**	**11.50**	**12.77**	**1.07**	**1.89**	**0.58**	**0.61**	**48.58**	**55.28**
H_2SO_4 for 10 sec.	**19.00**	**23.17**	**10.77**	**11.53**	**0.90**	**1.11**	**0.47**	**0.50**	**36.76**	**41.69**
Mean	17.59	20.79	8.64	9.58	0.83	1.02	0.38	0.41	26.82	29.85
LSD at 5%	1.94	1.10	0.51	0.47	0.013	0.06	0.04	0.03	2.76	3.70

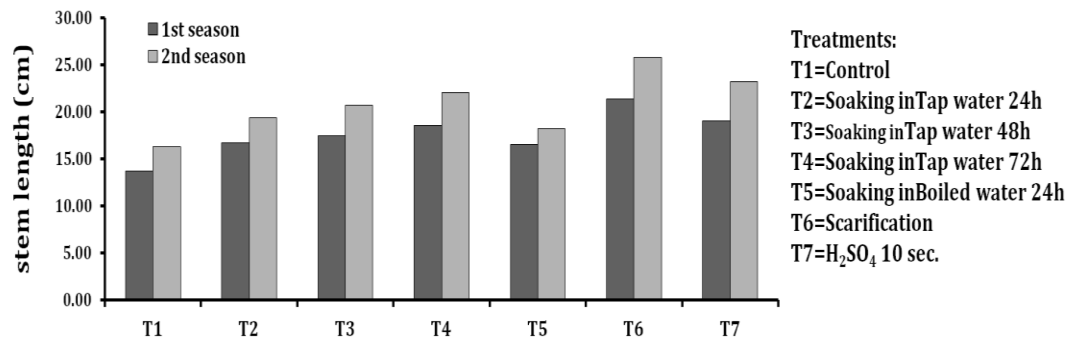

Figure (8): The effect of pre-germination treatments on stem length (cm) of tamarind 40 days after sowing during 2022 and 2023seasons.

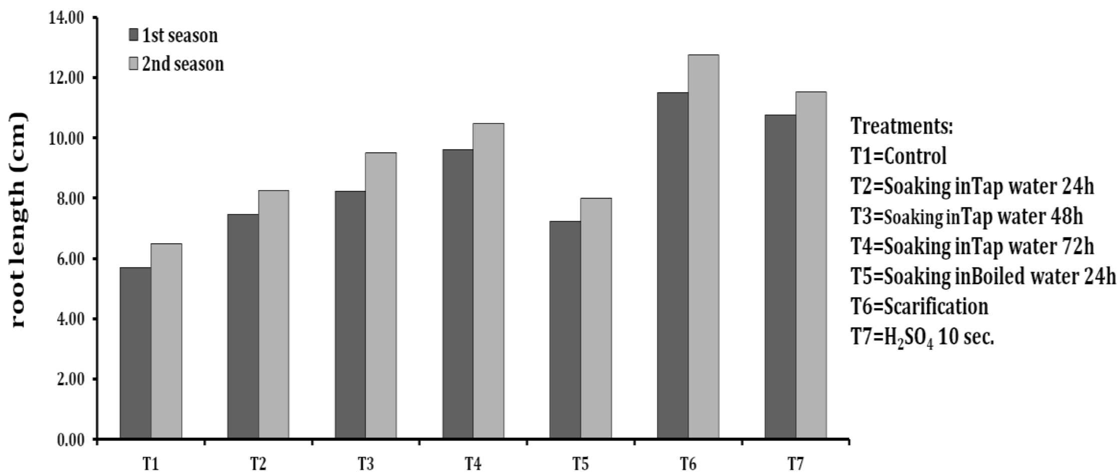

Figure (9): The effect of pre-germination treatments on root length (cm) of tamarind 40 days after sowing during 2022 and 2023 seasons.

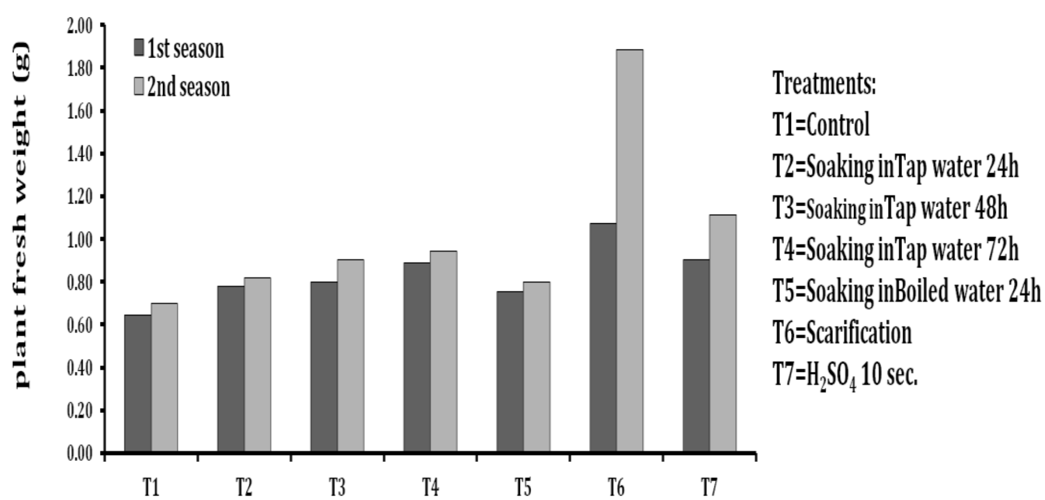

Figure (10): The effect of pre-germination treatments on plant fresh weight (g) of tamarind 40 days after sowing during 2022 and 2023 seasons.

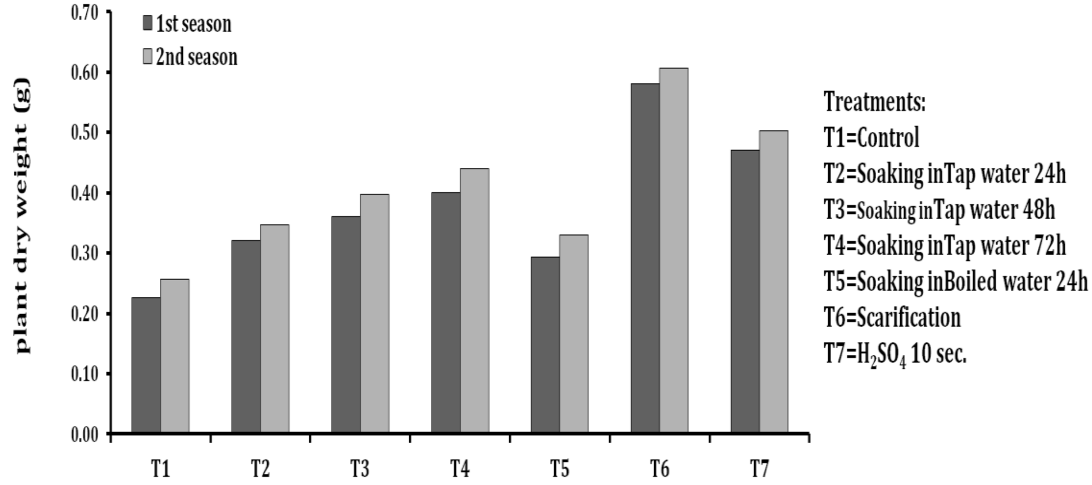

Figure (11): The effect of pre-germination treatments on plant dry weight (g) of tamarind 40 days after sowing during 2022 and 2023 seasons.

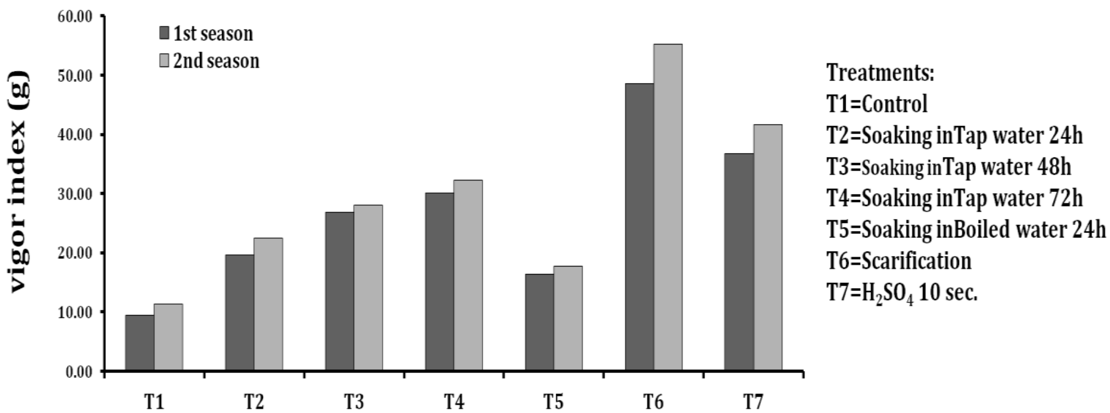

Figure (12): The effect of pre-germination treatments on vigor index (g) of tamarind 40 days after sowing during 2022 and 2023 seasons.

Treatments:
T1=control.
T2= soaking in tap water for 24 hr.
T3= soaking in tap water for 48 hr.
T4=soaking in tap water for 72hr.
T5= soaking in boiled for 24 hr.
T6=scarification.
T7=$H_2SO_4 10_{Sec}$

Figure (13): The effect of different pre-germination treatments on seedling growth of tamarind.

Conclusion

From the results of this study, it is concluded that treating seeds with mechanical scarification by sandpaper, concentrated H_2SO_4 for 10 seconds or soaking seeds for 72 hours in tap water led to produce higher germination and vigor seedlings.

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