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RESTORING ARID-REGION: OPTIMIZING PRE- GERMINATION TREATMENT AND ENHANCING FORAGE POTENTIAL OF *PROSOPIS CINERARIA* IN NURSERY CONDITION

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SUMMARY

Prosopis cineraria, commonly known as the Khejri or Ghaf tree is a drought-tolerant species in arid regions of Asia. *P. cineraia* is valued for its forage potential, particularly with limited options. This abstracts provides an overview of pre-germination treatments techniques that enhance germination rates and forage potential under nursery condition. The study was conducted by taking four sources of seed collection i.e. two from Haryana (Hisar and Bhiwani) and two from Rajasthan (Churu and Hanumangarh) with two types of pre-treatments; (1) mechanical scarification with scarifier (1, 1.5, 2.0, 2.5 and 3.0 minutes) and (2) chemical scarification with hot water (20, 25, 30, 35, 40 and 45 minutes), sulphuric and hydrochloric acid for 5,15,20,25 and 30 minutes duration. Results showed that the maximum seedlings were germinated on 3rd day of sowing and minimum on 7th days of sowing. Highest value of speed of germination, seedling establishment, growth and biomass were recorded in seedlings treated with scarifier for 1.5 minute followed by H_2SO_4 for 15 minutes and hot water for 30 minutes.

Key words: *Prosopis cineraria*, pre-germination, nursery, seedling establishment, forage

Genus *Prosopi*s belongs to family Fabaceae, has more than 45 species ranging from shrubs to spiny trees. In arid regions where other plant species find it difficult to survive, it is the only source of leaf fodder for cattle, camels and goats (Rani *et al.,* 2013). It offers nutritious supplementary food (pod flour, fruits, seed etc), top feed (leaves and pods) and protection – cum-shelter for the benefit of human and livestock during all the seasons (Majumder *et al*., 2015). Its pods contain 6-16 percent sugar and 9-4 percent crude protein (Singh *et al.,* 2021). The unripe pods are used as a feed supplement (Brown, 19920) where mature pods are fed to livestock. Due to its great ability to fix nitrogen, it is well known to improve soil conditions through the addition of organic matter (Khatri *et al*., 2010). Prosopis cineraria trees (girth >75 cms) can be lopped annually to gain maximum fodder and fuel wood yield (Singh and Bishnoi 2014). Kaushik and kumar (2003) reported that the fodder and grain crops grown in Khejri based agri-silvicultural system earned more profit than sole croppping. Therefore nursery propagation of *Prosopis cineraria* plays a crucial role in ensuring the availability of healthy seedlings for large scale restoration projects.

To optimize the success of nursery propagation, pre germination treatments are employed to enhance germination rates, seedling establishment and subsequent growth (Purohit *et al*., 2009). These treatments aim to overcome the inherent challenges associated with the species, such as the hard seed coats and physiological dormancy and to expedite the germination process. This article aims to explore four pre-germination treatment approaches and their impact on the speed of germination, seedling establishment, growth and biomass parameters of *Prosopis cineraia* in nursery conditions. By understanding and optimizing these factors, successful nursery propagation can be achieved, contributing to the restoration of arid regions and forage utilization through the widespread cultivation of *Prosopis cineraria*.

MATERIALS AND METHODS

Two sites each in Haryana and Rajasthan making total of four geographical locations were identified and surveyed for quality pod collection of *Prosopis cineraria.* Additionally, trees that had better morphological indicators (plant height, DBH, bole length, and crown diameter) were chosen. By preserving isolation of 200 m in accordance with the current standard methods for seed harvesting in tree stands, the trees were chosen at random to have a true representation from each chosen provenance. The latitude (°N) and longitude (°E) points of the sites were Hisar (29.09, 75.043), Bhiwani (28.77, Churu (28.32, 74.40) and Hanumangarh (29.58, 74.32) respectively from where the pod collection were done. Six distinct trees from each provenance were used to collect the physiologically mature pods, which were preserved individually in paper bags. For source variations and pre-treatment experiments, the gathered pods from all six trees at each provenance were composited to create four lots from four different sites. For detailed nursery research, the seeds were manually removed from the pods and left at room temperature. According to the established standard methods, pods were measured and found to range in length from 12 to 45.5 cm, in width from 0.6 to 0.7 mm, and in the number of seeds they contain from 7 to 13.7. Similar measurements were made on seeds that had been removed from their pods, including weight per 100 seeds (76-145.3g), length, width, and thickness measurements (4.4-4.7mm, 2.2-2.4mm, and S/cm/ seed, respectively).

Treatment details

The pre-germination treatment were given to phenotypically selected seed to remove dormancy were (1) mechanical scarification with scarifier for 1.0, 1.5, 2.0, 2.5 and 3.0 minutes; (2) hot water immersion for 20, 25, 30, 35, 40 and 45 minutes soaking time; and (3) acid scarification with concentrated sulfuric (H_2SO_4-98%) and hydrochloric acid (HCl-98%) for 5.0,10,15,20, 25 and 30 minutes duration. A three replicates of each treatment was made and experiment was laid out in Completely Randomized Design (CRD).

Observation recorded

Days to germinate, Speed of germination, Seedling establishment, Growth and Biomass parameters

Fifty seeds of each treatment in three replicates were sown in plastic bags filled with mixture of FYM, sand and soil. Days to germination include the number of days taken to emergence and number of days to complete germination. Speed of germination was calculated by following formula give by Heydecker (1969).

Germination rate = (G1/t1 + G2/t2 +.........+ Gn/Tn)

Where,

G1= Number of seeds germinated on first day

G2 = Number of seeds germinated on second day

Gn = Number of seeds germinated on nth day

T1 = Day one, T2 = Day two, Tn = nth Day

The seedling establishment was determined by counting the total number of seedlings when the emergence was completed or where there was no further addition in the total emergence i.e on 15th day. The height of the seedling was measured from the collar to the growing tip from 10 seedlings and average is taken and expressed in centimeters. The collar diameter was measured at collar region where root and shoot separate slightly above the ground level using digital caliper and was expressed in millimeters. The number of leaves was counted in 10 seedlings per replication and average was computed as the number of leaves per seedling. Destructive sampling assessed the root dry weight. Five seedlings from each treatment were selected for every observation. The plant was uprooted from the poly bag and the roots were separated and are washed thoroughly in tap water. The fresh weight was taken and the average was recorded as fresh weight per seedling. The samples were oven dried at 60 – 80 degree Celsius for 72 hours and dry weight was recorded and expressed as dry weight per seedling in milligrams.

RESULTS AND DISCUSSION

Mechanical scarification is important in arid regions, involves physically altering the seed coat to allow water and oxygen to penetrate in seed. This process significantly enhances the germination rate of seeds. For Prosopis species, improved germination count or days to germination means more young plants can sprout early, contributing to the overall forage potential. It is evident in Fig 1. that treatment duration of scarification treatment had a significant effect on the *Prosopis cineraria* seedling days to germination. The maximum seedling germination was initiated on 3rd day of sowing in comparison to control in which germination initiated on 7th day of sowing whereas germination completed at different rate from 8th to 13th day in treatment duration as well as in control conditions. Similar results were recorded by Morgan *et al.,* 2017 where germination increased during the first five days.

The treatment of *Prosopis cineraria* seeds with sulphuric acid enhance their germination potential and germination count, thereby increasing the forage supply

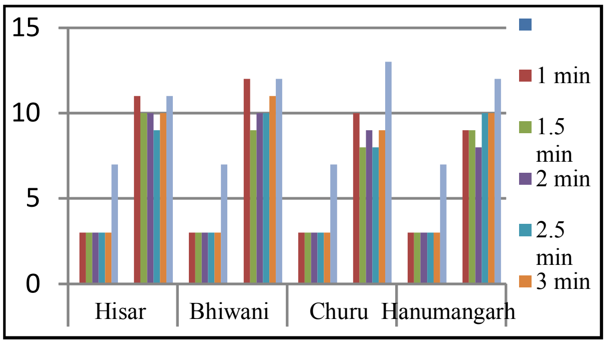

Fig. 1. Effect of seed scarification on days to germination of *P. cineraria* seedlings.

from these hard seeded plants. It is clearly seen in Fig 2. that days to germination of *Prosopis cineraria* seedling was significantly affected by the treatment duration of sulphuric acid treatment. The seedlings germination were initiated on 3rd day of sowing in 5, 10, 15 and 20 minutes treatment duration whereas in 25 and 30 minute, seedling emergence occurred on 4th and 5th day respectively in comparison to control in which seedling germinated on 7th day of sowing. Like scarification treatment germination was completed from 8th to 13th days. The results are in line with the Ramesh et al., 2016, showed that seeds of *P. pallida* scarified with 30 percent sulphuric acid results in 6.4 day of mean germination time.

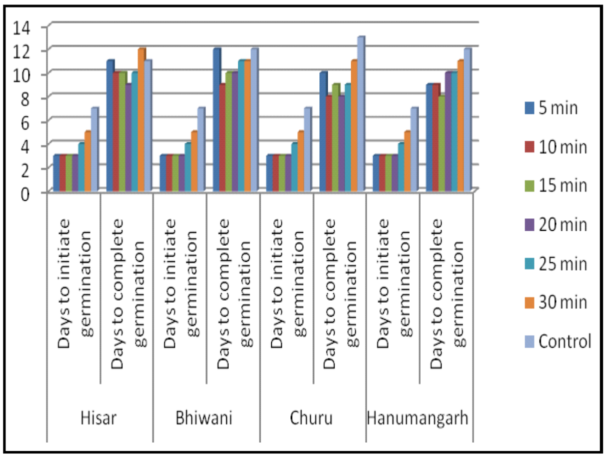

Fig. 2. Effect of H_2SO_4 on days to germination of *P. cineraria* seedlings.

Prosopis cineraria has significant forage potential due to its drought resistant and nutrient rich foliage. Seed coat imposed dormancy in seeds of leguminous forage *P. cineraria* is an important impediment to rapid uniform and high germination and thus germination count. Hot water treatment plays a vital role in breaking seed dormancy and enhancing germination, essential for successful cultivation of this tree in arid regions. It is noticeable in fig 3 that treatment duration of hot water had a significant effect on days to germination. It was observed that the germination of seedlings were initiated on 3rd day of sowing at treatment duration of 20, 25, 30 and 35 minutes whereas in treatment duration (40 and 45 minute) of hot water treatment, germination initiated on 4th and 5th day of sowing in comparison to control where germination started on 7th day. Days of germination was completed from 8th to 14th day in treatment duration of hot water. koobonye et al., 2018 also reported 14 percent of germination count by 4 days.

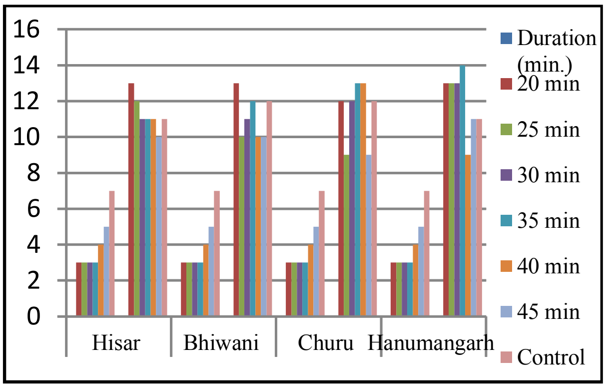

Fig. 3. Effect of hot water on days to germination of *P. cineraria* seedlings.

The number of days to germination depends on factors such as seed quality and environmental conditions but treatment with HCl significantly expedite the germination process. With proper care and management, we can ensure the successful establishment of *P. cineraria* for forage production. Fig 4, clearly show that in hydrochloric acid treatment among the pre-germination treatment of *Prosopis cineraria* seeds had a significant effect on the seedling germination. It was recorded that in treatment duration (5 to 20 minute) of HCl treatment, the germination started on 3rd day of sowing whereas in treatment

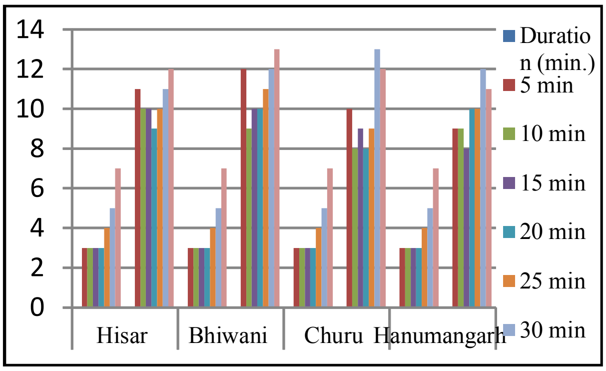

Fig. 4. Effect of HCl on days to germination of *P. cineraria* seedlings.

TABLE 1
Effect of mechanical scarification on speed of germination, seedling establishment, growth, and biomass parameters of seedlings of *Prosopis cineraria*

Scarification time (minutes)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves seedling	Shoot dry weight (g)	Root dry weight (g)
T_1:1.0	5.8	74.0	75.2	2.0	16.5	117.9	107.6
T_2:1.5	8.3	98.0	86.6	2.3	20.6	133.3	110.7
T_3:2.0	6.8	81.9	81.8	2.1	19.1	128.6	109.4
T_4:2.5	5.7	65.7	72.6	1.8	14.2	115.9	105.9
T_5:3.0	4.8	62.5	62.1	1.8	11.6	104.7	98.9
T_6:Control	1.3	45.0	59.2	0.9	7.5	88.7	86.4
LSD ($p<0.05$)	0.22	1.1	0.75	0.9	0.44	0.91	0.79

duration (25 and 30 minute), germination initiated on 4th and 5th of sowing in comparison to control. Germination was completed from 8th to 13th day.

Scarification can speed up the establishment, growth and biomass of Prosopis forage resources by increasing the number of plants, it become possible to support large populations of livestock and contribute to sustainable forage production. These benefits are valuable in arid and semi-arid regions where access to forage resources is limited. The data presented in the Table 1 shows that scarification treatment had a significant effect on the speed of germination, seedling establishment, growth and biomass. The maximum value (8.3, 98.0%, 86.6cm, 2.3mm, 20.6, 133.3g and 110.7g) of speed of germination, seedling, establishment, total height, number of leaves/seedling, shoot dry and root dry weight respectively were recorded when seeds were scarified for 1.5 minutes respectively. All the treatments were observed to be at par for collar diameter except T_6 (control). Minimum value of the speed of germination, seedling establishment, total height, number of leaves/seedling, shoot dry and root dry weight (4.8, 62.5%, 62.1cm, 1.8mm, 11.6, 104.7g and 98.9g) were recorded in T_5 (3.0 min) treatment when compared to control. The results were in line with Oyebamiji et al., 2022 revealed that mechanical scarified seeds had consistent significantly higher values (6.54cm, 13.79cm, 19.90cm, 25.13cm and 29.15cm, 0.15cm, 0.19cm, 0.21cm, 0.25cm and 0.29cm, and 0.14, 0.16, 0.19, 0.20 and 0.23) on SH, CD, and LA at 2-10 WAS respectively and found that mechanical scarification was the best best pre-sowing treatment.

The data in the Table 2 depicts that speed of germination, seedling establishment percent, growth and biomass were significantly affected by chemical treatment of H_2SO_4. The seedlings were observed with maximum speed of germination, seedling establishment percent, total height, collar diameter, number of leaves/seedling, shoot dry weight and root dry weight (6.8, 83.2%, 74.7cm, 2.0mm, 16.9, 119.6 g and 100.7g) when treated with H_2SO_4 for 15 minutes. T_{10} and T_{15} (73.4 and 74.7 cm) were recorded to be at par for total height. The lowest value of all the parameters (2.1, 31.7%, 55.3cm, 0.9mm, 6.9, 88.2g and 85.5g) respectively were found in seeds treated with H_2SO_4 acid for 30 minutes as compared to control.The results were supported by Zare *et al.,* 2011in which seeds

TABLE 2
Effect of chemical scarification (H_2SO_4) on speed of germination, seedling establishment, growth, and biomass parameters of seedlings of Prosopis cineraria

H_2SO_4 (minutes)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves/ seedling	Shoot dry weight (g)	Root dry weight (g)
T_1: 0.5	4.4	62.5	67.3	1.2	14.1	111.5	92.0
T_2: 10	6.1	78.1	73.4	1.7	15.4	116.5	96.3
T_3: 15	6.8	83.2	74.7	2.0	16.9	119.6	100.7
T_4: 20	4.8	60.1	68.6	1.5	12.4	110.3	90.9
T_5: 25	3.5	49.2	61.6	1.3	10.3	97.2	87.7
T_6: 30	2.1	31.7	55.3	0.9	6.9	88.2	85.5
T_7: Control	1.3	44.9	59.1	0.9	7.7	88.7	86.4
LSD ($p<0.05$)	0.18	0.97	0.78	0.19	0.22	0.73	0.95

treated with sulphuric acid within 15 mintues increased germination percentage from 48.21% to 85.01% For P. juliflora and from 22.7% to 74.26% for P. koelziana. Sikiratu et al., also revealed that seeds soaked in 50% concentrated sulphuric acid was found to had 89 percent germination with mean germination time of 4.0. Ramesh et al., 2016, showed that seeds of *P. pallida* scarified with 30 percent sulphuric acid along with hot water results in mean germination rate of 0.16/ day.

The data presented in the Table 3 shows that six treatment of hot water namely $T_{1;}$20, $T_{2;}$25, $T_{3;}$30, $T_{4;}$35 $T_{5;}$40 $T_{6;}$45 and $T_{7;}$control significantly affected the speed of germination, seedling establishment, growth and biomass. Hot water treatment significantly enhances the forage potential of *Prosopis cineraria*. By softening the hard seed coat and improving germination rates, it facilitates the establishment, growth and biomass of *P. cineraria* , making it valuable resource for livestock feed in areas with limited water resources. 5.8, 75.7%, 71.0 cm,1.8 mm, 15.2, 116.9g and 98.1g were the highest values of speed of germination, seedling establishment percent, total height, collar diameter, number of leaves/seedling, shoot dry weight and root dry weight of *P. cineraria* seedling when treated with hot water for 30 minutes. Values of T_2 and T_3 (5.6 and 5.8) were found to be at par for speed of germination. The lowest value (2.5, 28.6%, 55.0cm, 0.8mm, 6.0, 96.8g and 81.8g) of attributes in the table below were recorded in the seedlings treated with hot water for 45 minutes as compared to control. Koobonye et al., 2018 also reported the germination of 84.3% when seeds of *Leucaena leucocephala* treated with hot water Pre-germination treatment with HCl significantly enhance the forage potential of *Prosopis cineraria*. This treatment not only accelerates the speed of germination but also promotes establishment, growth and biomass parameters. Consequently, it offers reliable source of nutrient rich foliage, making *Prosopis cineraria* an invaluable source for livestock in arid regions. The data in the table 4 shows that pre-germination treatment of HCl had a significant effect on speed of establishment, seedling establishment, growth and biomass parameters. The maximum value for speed of germination, seedling establishment, total height,

TABLE 3

Effect of hot water on speed of germination, seedling establishment, growth, and biomass parameters of seedlings of Prosopis cineraria

Hot water (minutes)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves/ seedling	Shoot dry weight (g)	Root dry weight (g)
T_1: 20	4.5	64.4	65.9	1.3	12.5	106.9	90.0
T2: 25	5.6	65.0	68.9	1.6	13.9	112.8	95.4
T_3: 30	5.8	75.7	71.0	1.8	15.2	116.9	98.1
T_4: 35	4.7	60.8	66.5	1.3	12.2	111.9	87.5
T_5: 40	3.7	46.3	60.6	1.1	9.7	105.5	84.3
T_6: 45	2.5	28.6	55.0	0.8	6.0	96.8	81.8
T_7: Control	1.3	46.0	58.8	0.9	7.4	88.7	86.4
LSD ($p<0.05$)	0.2	1.2	0.83	0.10	0.43	1.73	0.79

TABLE 4

Effect of chemical scarification (HCl) on speed of germination, seedling establishment, growth, and biomass parameters of seedlings of Prosopis cineraria.

HCl (minutes)	Speed of germination	Seedling establishment (%)	Total height (cm)	Collar diameter (mm)	No. of leaves/ seedling	Shoot dry weight (g)	Root dry weight (g)
T_1: 05	3.4	46.8	62.1	1.5	-	98.0	84.1
T_2: 10	4.9	61.1	67.0	1.7	-	97.4	91.4
T_3: 15	5.8	70.0	67.5	1.8	-	106.5	94.2
T_4: 20	4.2	51.6	62.4	1.7	-	100.1	86.9
T_5: 25	3.5	41.0	59.5	1.5	-	96.8	78.1
T_6: 30	2.4	30.5	55.4	1.4	-	88.6	73.7
T_7: Control	1.3	45.2	59.3	0.9	-	88.7	86.4
LSD ($p<0.05$)	0.21	0.79	0.92	0.2	NS	1.45	0.78

collar diameter, number of leaves/seedling, shoot dry and root dry weight (5.8, 70.0%, 67.5cm, 1.8mm, 13.9, 106.5 and 94.2g) were exhibited by T_{15} HCL treatment of *P. cineraria* seedlings. T_{10} and T_{15} were found to be at par for total height with value of 67.0 and 67.5cm). Number of leaves/seedling was found to be non-significant among the six treatment of HCl. The minimum value (2.4, 30.5%, 55.4cm, 1.4mm, 7.7, 88.6 and 73.7g) were observed for the respective parameters in the table below when treated with T_6 as compared to control.

CONCLUSION

In conclusion, the pre-germination treatment of *Prosopis cineraria* (also known as Khejri) in a nursery condition, with scarification as the best treatment followed by sulphuric acid and hot water, has proven to be effective in promoting seed germination and enhancing seedling establishment. As scarification has demonstrated the highest success rate, it may require more labor and specialized equipment. Sulphuric acid treatment should be handled with care due to safety concerns, and hot water treatment may be a more accessible alternative with satisfactory results. The forage potential of *Prosopis cineraria* makes it a valuable crop in areas where alternative forage options are limited. Livestock can benefit from its leaves, pods, and green branches as a source of nutrition. In conclusion, scarification is the recommended pre-germination treatment for Prosopis cineraria seeds in a nursery setting, followed by sulphuric acid and hot water treatments. These treatments can significantly enhance seed germination and forage production, ultimately contributing to the successful propagation of *Prosopis cineraria* in a nursery.

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