

***In vitro* germination of the argan (*Argania spinosa* (L.) Skeels) from Algeria.**Germinação *in vitro* do argan (*Argania spinosa* (L.) Skeels) da Argélia.[Imane Haouame](#)¹, [Nadjim Semcheddine](#)^{1,2}, Salima Guerrouj³, Hanane Khalfa^{1,5}, Fatima Zohra Hechaichi¹, [Abdelkader Morsli](#)⁴, [Hamdi Bendif](#)^{1,5*}¹ Biodiversity and Biotechnological Techniques for Plant Resources Valorization Laboratory (BTB_VRV), Department of Natural and Life Sciences, Faculty of Sciences, University of M'sila, University Pole, Road Bourdj Bou Arreiridj, 28000 M'sila, Algeria. E-mail: imane.haouame@univ-msila.dz² Department of Agronomy, Faculty of Nature and Life Sciences, University of Setif, Algeria. E-mail: semcheddinenadjim@gmail.com³ Department of Biology, Université Amar Telidji Laghouat, 3000 Laghouat, Algeria. E-mail: guerroudj.s.dz34@gmail.com⁴ Laboratory of Genetic Resources and Biotechnologies (LRGB), Ecole Nationale Supérieure Agronomique (ENSA), Avenue Hassan Badi, El Harrach, Algiers, Algeria.^{5*} Laboratory of Ethnobotany and Natural Substances, Department of Natural and Life Sciences, ENS Kouba, Alger. E-mail: hamdi.bendif@univ-msila.dz**Abstract**

Argania spinosa, is an endangered tree species native to North Africa, primarily found in Algeria and Morocco. The objective of this work is to determine the optimal culture medium and conditions that maximize germination rates and promote healthy growth in *A. spinosa* seeds from two regions. Seeds from both regions were germinated on three types of media: Murashige and Skoog (MS) medium, Knop medium, and gelled water, both with and without activated charcoal. We evaluated germination rates, germination speed, leaf count, root length, and aerial growth. Tindouf seeds showed superior germination rates, reaching up to 90% in Knop and gelled water media, whereas Mostaganem seeds reached a maximum of 41%. Activated charcoal improved root and aerial growth in Tindouf seeds more significantly than in Mostaganem seeds. Gelled water medium provided the best germination rates for Mostaganem seeds. These insights are useful for improving *in vitro* germination techniques and aiding in conservation efforts for *A. spinosa*.

Keywords: Germination Rate. Culture Media. Seed Provenance. Activated Charcoal.**Resumo**

Argania spinosa (L.), também conhecida como Skeels, é uma espécie de árvore ameaçada de extinção nativa do Norte da África, encontrada principalmente na Argélia e Marrocos. O objetivo deste trabalho é determinar o meio de cultura ideal e as condições que maximizam as taxas de germinação e promovem o crescimento saudável em sementes de *A. spinosa* de duas regiões. Sementes de ambas as regiões foram germinadas em três tipos de meios: meio Murashige e Skoog (MS), meio Knop e água gelificada, com e sem carvão ativado. Avaliamos as taxas de germinação, velocidade de germinação, contagem de folhas, comprimento da raiz e crescimento aéreo. As sementes de Tindouf apresentaram taxas de germinação superiores, atingindo até 90% em meios Knop e água gelificada, enquanto as sementes de Mostaganem atingiram um máximo de 41%. O carvão ativado melhorou o crescimento da raiz e da parte aérea em sementes de Tindouf de forma mais significativa do que em sementes de Mostaganem. O meio de água gelificada forneceu as melhores taxas de germinação para sementes de Mostaganem. Esses insights são úteis para melhorar as técnicas de germinação *in vitro* e auxiliar nos esforços de conservação de *A. spinosa*.

Palavras-chave: Taxa de germinação. Meio de cultura. Proveniência da semente. Carvão ativado.

Introduction

A. spinosa (L.), Skeels, is a threatened tree species endemic to North Africa, specifically Algeria and Morocco (PUMAREDA et al., 2006). It is the sole representative of the Sapotaceae family in North Africa. This species is adapted to high temperatures, making it a thermo-xerophytic species. The argan tree can withstand temperatures ranging from 3°C to 50°C (CHARROUF et al., 2007), thanks to its root system, which includes endomycorrhizal symbiosis that plays a role in its resistance.

In Algeria, its geographical range covers a relatively large area in the northwest of the Tindouf Province, where it constitutes the second most important forest species. The Tindouf argan forest likely originally formed a single ecological unit with that of Morocco, covering extensive territories. It now occupies about 800,000 hectares (MSANDA et al., 1993) and consists of dispersed populations grouped in contact zones, such as along riverbanks and wadis, where water compensation is available (BAUMER and ZERAIA, 1999). The distribution of argan trees shifted southward in Morocco due to the last glaciation (Würm glaciation), which reduced its range towards the south. The argan tree is known for its unique climate, characterized by warm winters, high humidity, and fog (BENABID and FENNANE, 1994), and it exhibits drought resistance and adaptation to various soil types (RADI, 2003). *Sideroxylon spinosum* L., the initial name given by Linnaeus in 1737, belonged to the genus *Rhamnus* (Sapotaceae). Later, the argan tree was renamed by Roemer and Schultes as *A. sideroxylon*, based on its Arabic and Berber name, "argan." The name "Sideroxylon" refers to the tree's extremely hard wood. It is endemic to western Algeria and southwestern Morocco. The argan tree can appear as a shrub or a more upright form, with thorny branches. It can grow to a height of 8 to 10 meters and has a slow growth rate. It is the only species of this family that thrives in an intertropical zone. The structure of the argan tree presents a challenge in determining its age. It features a short, twisted, and robust trunk, with a very dense, rounded, and spreading crown. The tree's habit can vary from upright to weeping, and it is often twisted. The tree is formed by several intertwined stems. The argan tree's wood is very hard and highly branched from the base. *A. spinosa*, also known as "spinosa" due to its thorny branches, has thorny branches with small leaves around them. Some branches transform into thorns, forming new branches. The thorns serve a defensive role. According to Bellefontaine et al. (2010), the leaves of the argan tree are very small, simple, green, persistent, and coriaceous, arranged in fascicles.

Although the leaves remain on the tree during the dry season, they may fall off during extremely high temperatures as part of a physiological process. New leaves begin to emerge a few weeks later, sometimes before the winter season (EMBERGER, 1938). Flavonoids are one of the prominent phenolic compounds found in argan leaves (LÓPEZ-SÁEZ and ALBA-SÁNCHEZ, 2009). The flowers of the argan tree are crucial for fruit development. Blooming occurs around May and June, with fruit maturation by September. The argan flower is hermaphroditic, measuring 2 to 4 mm in size and colored white or yellowish-green. They are gathered in clusters of about fifteen flowers (RADI, 2003). Several studies have been conducted on in vitro culture to obtain or produce plantlets, involving multiple stages such as germination, micropropagation, rooting, and acclimatization.

According to Aizer et al. (2019) once the seeds have germinated in culture chambers, the resulting vitro-plants are cut into micro-cuttings of 0.5 cm to 2 cm in length and cultured. This process, known as micropropagation, is carried out in a culture chamber maintained at 25°C with a photoperiod of 16 hours light and 8 hours darkness. Various pretreatment methods have been investigated to improve seed germination of the argan tree. Mechanical scarification, as reported by

Ouallal et al. (2013), helps facilitate water entry into the seed. Amghar et al. (2021) explored the effects of soaking seeds in gibberellic acid (GA3), although specific results were not detailed. Germination is typically achieved using MS medium (MEZGHENNI et al., 2014).

Micropropagation of in vitro plants, focusing on bud break, involves MS medium with various concentrations of phytohormones such as auxins and cytokinins, for elongation during micropropagation, MS medium enriched with GA3 is used (AIZER et al., 2019). Rooting is facilitated using MS medium with 5 mg/l of AIB and ANA, activated charcoal, and coconut fiber substrate. Acclimatization has been conducted using several substrates: a nutrient solution-saturated calcined clay (NOUAIM et al., 2002), a peat and sand mixture (LAMAOUÏ et al., 2019), and peat alone (AMGHAR et al., 2021).

The objective of this study is to identify the optimal culture medium and conditions that maximize germination and growth in *A. spinosa* seeds from two regions. By comparing different media types, with and without activated charcoal, we aim to enhance germination success and support conservation efforts for this endangered species.

Materials and methods

Plant material

Almond seeds of *A. spinosa* were harvested In July 2022. Two distinct samples were collected from separate locations: one from Hamada in the Tindouf region of southwestern Algeria, and the other from Mostaganem in the Stidia commune, situated to the west of the Wilaya (Figure 1).



Figure 1 - Plant material from two different regions (seeds and almonds of *A. spinosa*) A - seeds of Mostaganem; B-seed of Tindouf.

Applications

Germination tests

The initial step involves preparing the plant material, which consists of almond seeds collected from Mostaganem and Tindouf in July 2022. Next, it is essential to sterilize both the plant material and the equipment. The sterilization process for the plant material is carried out in several stages. First, the argan almonds are soaked and rinsed in a 32% sodium hypochlorite solution for 10 minutes. They are then thoroughly rinsed with sterile distilled water (autoclaved). After this, the almonds are dried using sterile filter paper placed on Petri dishes.

The culture media used in the experiment include MS (MURASHIGE and SKOOG, 1962), KNOP solution (1865), and gelified water (PRENDERGAST, 1991). The Knop and MS solutions

are prepared separately, with each medium being solidified using 7 grams of agar. The pH of the media is adjusted to 5.6 before autoclaving at 121°C for 20 minutes.

The culture experiment was conducted in test tubes, each containing 20 ml of the prepared solutions and a single almond seed. The tubes were placed in a culture chamber with a light regimen of 16 hours light and 8 hours dark, and maintained at a temperature of 25°C. The experiment was carried out over a period of 4 weeks, during which various parameters such as stem length, number of leaves, and root length were measured.

Results and discussion

1. Germination rate and speed

The germination rates of *A. spinosa* seeds from Tindouf, depending on the culture media, are illustrated in Figure 2. Over the weeks, the germination rate increases progressively, with the highest rates achieved using gelled water, MS medium, and Knop medium, reaching nearly 92%. This is followed by Knop medium with charcoal and MS medium with charcoal, which exhibit germination rates of 87.5% and 81%, respectively. In contrast, for *A. spinosa* seeds from Mostaganem (Figure 2), the gelled water medium yields the highest germination rate at 41%, followed by Knop medium with a 25% germination rate, and finally MS medium with a rate of 6%. To assess the effect of "seed provenance," seeds from two different regions, Tindouf and Mostaganem, were cultivated.

The results after 4 weeks (Figures 3 and 4) reveal a notable difference in seed reactivity between the two sources. Seeds from Tindouf achieved a 90% germination rate across all three tested media, whereas seeds from Mostaganem showed germination rates of 6% for MS, 25% for Knop, and 41% for gelled water (Figures 2). Germination is a crucial vegetative stage in a plant's development cycle. Our results indicate that the in vitro germination of *A. spinosa* is influenced by the provenance of the plant material used: Tindouf seeds germinate better than those from Mostaganem. Furthermore, germination rates for seeds of the same provenance vary depending on the culture medium. Tindouf seeds show higher germinative capacity compared to Mostaganem seeds, but the composition of the culture medium does not significantly affect in vitro germination. Knop medium and gelled water, despite being low in minerals, yield good results.

To study the effects of seed provenance and culture media, seeds from Tindouf and Mostaganem were germinated using MS medium, Knop medium, and gelled water, as well as MS and Knop with charcoal. After four weeks (Figure 2), a difference in germination speed was observed between seeds from the two regions. Tindouf seeds exhibited the highest germination speed in Knop and gelled water media, with a 90% germination rate within the first week, followed by 73% in MS medium. Conversely, Mostaganem seeds showed slower germination rates, ranging from 0% to 33% in the first week and reaching a maximum of 10% to 40% by the second week across all media tested.

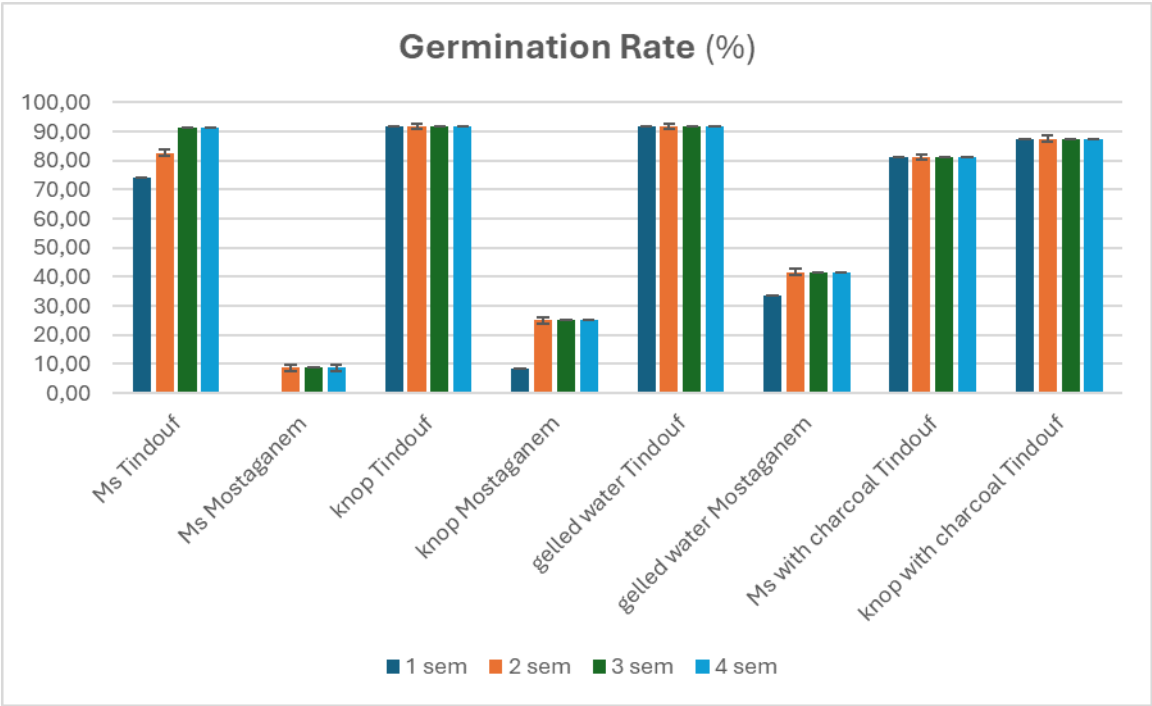


Figure 2 - Germination rate of *A. spinosa* seeds based on culture media and region.



Figure 3 - Germination of *A. spinosa* seeds from Tindouf in relation to the culture media after 4 weeks.

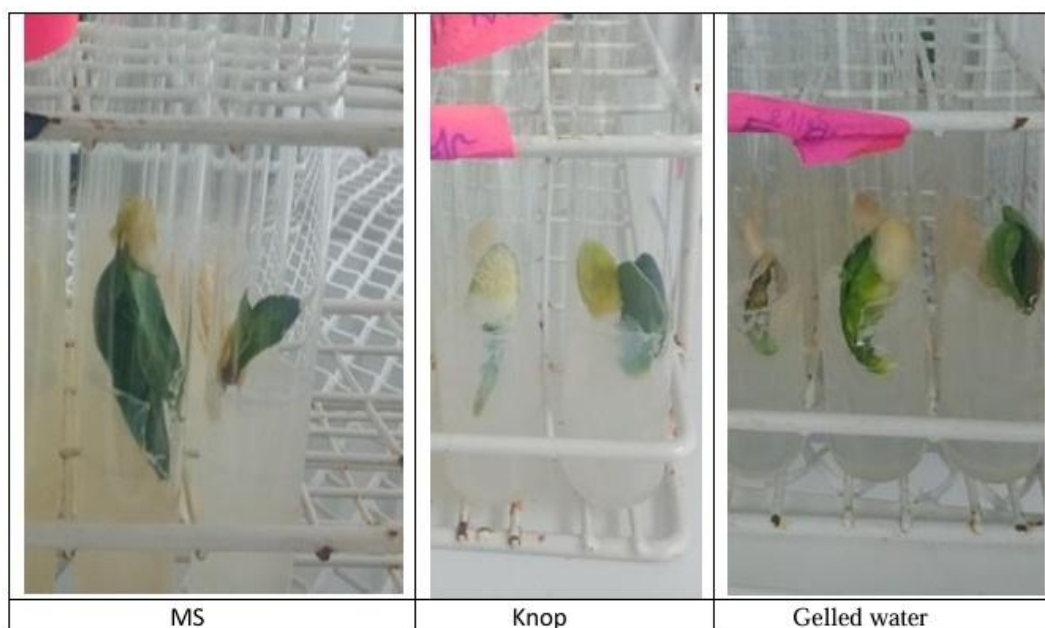


Figure 4 - Germination of *A. spinosa* seeds from Mostaganem in relation to the culture media after 4 weeks.

2. Number of leaves, aerial portion length, and root length

Analysis of the number of leaves after germination of *A. spinosa* seeds from Tindouf, as a function of the culture media (Figure 3), indicates no significant differences in seed behavior across the media used, except for MS medium and Knop medium with charcoal, where a higher number of leaves is observed after 3 and 4 weeks (Figure 3). However, regarding seed provenance, both regions (Mostaganem and Tindouf) exhibited similar explant behaviors. For root length, the results (Figure 5) reveal varying responses depending on the type of culture medium and the presence of activated charcoal. Root length was significantly affected by the presence of activated charcoal, regardless of the medium used. Data show that the addition of activated charcoal, whether in MS or Knop medium, positively impacts root length (Figure 5). Consequently, root length increased over time for seeds from both Mostaganem and Tindouf across all media used, although seed provenance did not significantly affect root length. The addition of activated charcoal to the culture medium (MS and Knop) significantly enhances the aerial growth of Tindouf seeds. With activated charcoal, the average length of the aerial portion reached 26 cm and 33 cm, compared to 36 cm and 49 cm for MS and Knop after 3 and 4 weeks, respectively. Regarding the aerial portion length, MS and Knop media with charcoal show high growth after 3 and 4 weeks for Tindouf seeds (Figure 6). In contrast, other media show low aerial growth for seeds from both Mostaganem and Tindouf (Figures 3 and 4). These results confirm the beneficial effect of activated charcoal compared to other media, significantly promoting the development of the aerial part.

Our findings indicate that the highest germination rates are observed in gelled water, MS, and Knop media, followed by Knop medium with charcoal and MS medium with charcoal. Notably, *A. spinosa* seeds from Mostaganem exhibit the best germination rates in gelled water. Germination tests demonstrate that Tindouf seeds have a superior germination speed compared to Mostaganem seeds, regardless of the medium used. Regarding the number of leaves after germination of *A. spinosa* seeds from Tindouf (Figure 7), different culture media did not show significant differences in reaction, except for MS and Knop media with charcoal, where an increased number of leaves was observed after 3 and 4 weeks. Nonetheless, both regions (Mostaganem and Tindouf) display similar behaviors. Root length responses vary according to culture media and the presence of activated charcoal. Activated charcoal significantly improves root growth.

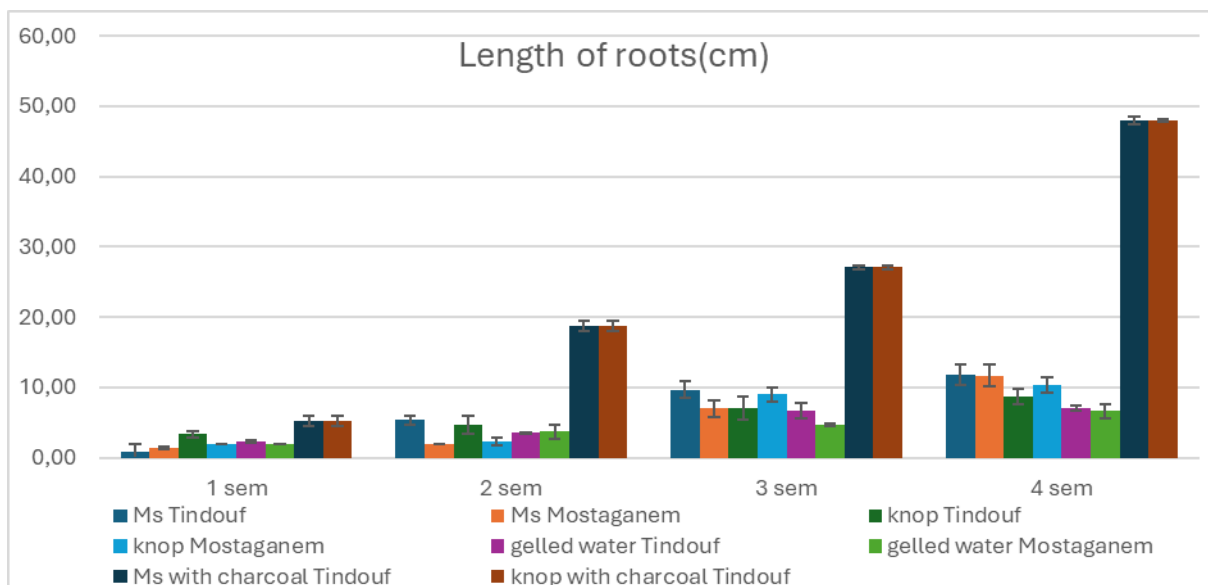


Figure 5 - Root length (cm) after germination of *A. spinosa* seeds according to the culture media and region.

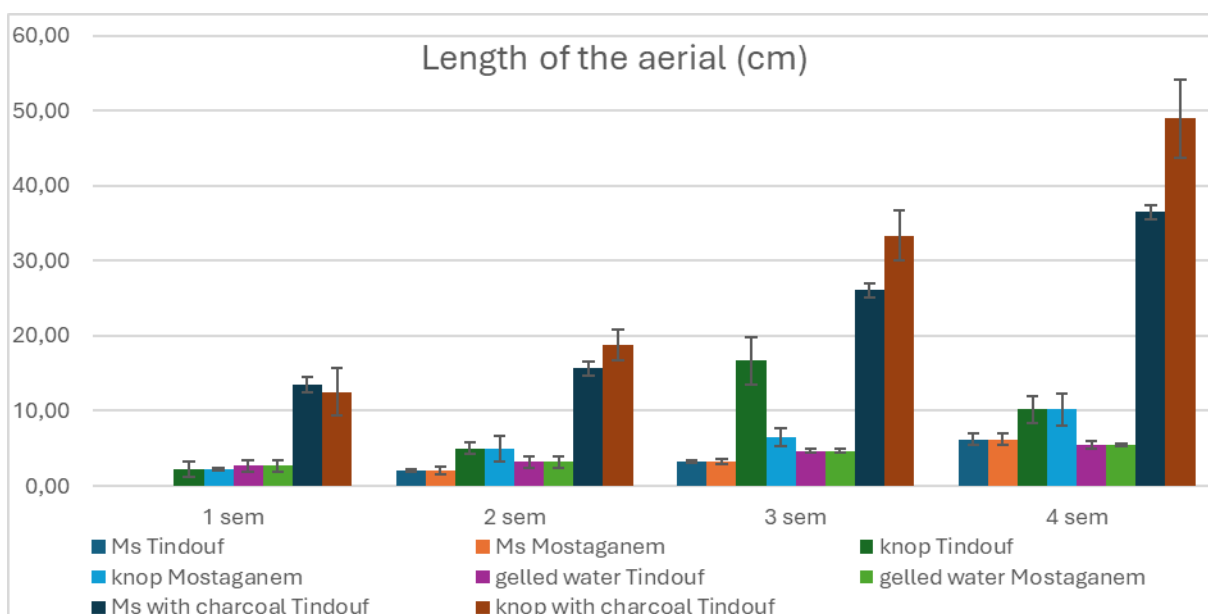


Figure 6 - Length of the aerial portion (cm) after germination of *A. spinosa* seeds according to the culture media and region.

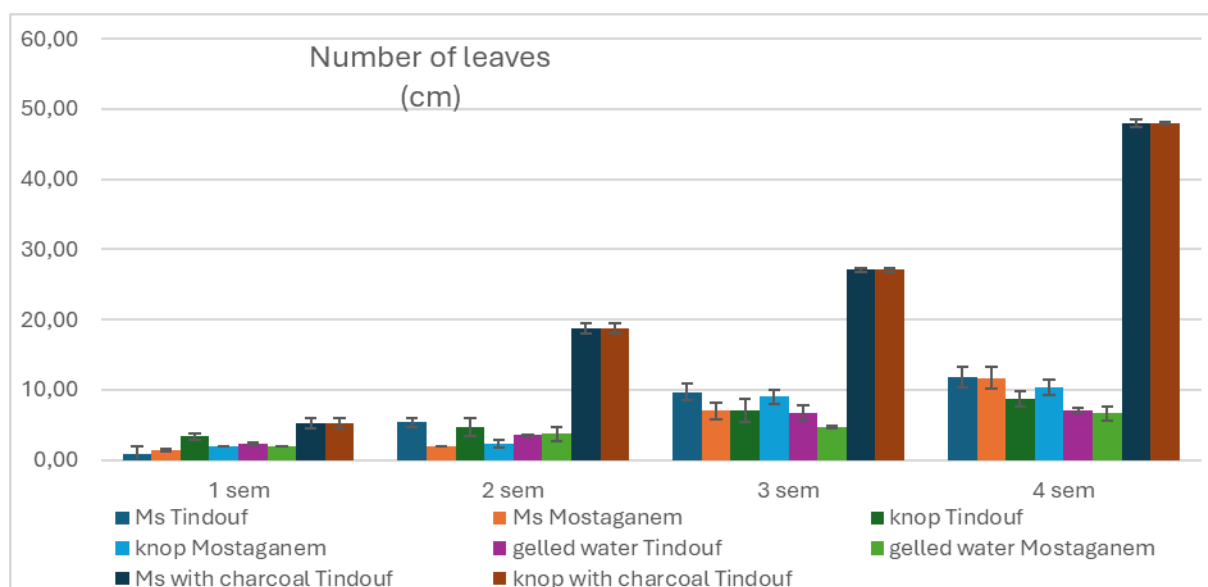


Figure 7 - Number of leaves after germination of *A. spinosa* seeds according to the culture media and region.

No prior studies have specifically examined the germination and in vitro micropropagation of *A. spinosa* seeds from different regions. Research by Ziani (2014) used seeds from Mostaganem and explored various micropropagation methods, including seeding, microcuttings, micrografting, organogenesis, and/or somatic embryogenesis. Additionally, Zohra et al. (2014) tested germination of seeds from two different sources of *A. spinosa* in the semi-arid western region of Algeria. Germination is a critical initial step for reforestation, whether through natural or artificial means. Seeds from different locations or species exhibit varied germination responses, which is essential for understanding planting programs. Environmental factors such as temperature, oxygen, and light, as well as genetic factors like seed size and weight, influence germination (CHAUSSAT and CHAPON, 1981). The success of germination depends on treatment type, seed nature, and provenance.

Conclusion

The study of *A. spinosa* seed germination from Tindouf and Mostaganem reveals significant insights into the effects of culture media and seed provenance on germination rates and growth parameters. Seeds from Tindouf exhibited a higher overall germination rate and faster germination speed compared to those from Mostaganem. In particular, Tindouf seeds achieved a 90% germination rate across Knop and gelled water media, while Mostaganem seeds showed significantly lower rates, with a maximum of 41% in gelled water. The germination speed was notably higher for Tindouf seeds in both Knop and gelled water media, reflecting their superior germinative capacity. Gelled water, MS medium, and Knop medium were most effective in promoting germination, with Knop and MS media supplemented with charcoal yielding slightly lower but still significant rates. Despite variations in mineral content, these media provided optimal conditions for germination, particularly for Tindouf seeds. The presence of activated charcoal in the culture media (MS and Knop) had a substantial positive effect on root length and aerial growth.

Seeds from Tindouf showed considerable improvements in the length of both roots and aerial parts when activated charcoal was included, although the aerial growth was generally higher in the MS and Knop media. Conversely, seeds from Mostaganem did not benefit as significantly from the activated charcoal, showing generally lower growth metrics across all media. The provenance of the seeds plays a crucial role in germination success. Tindouf seeds consistently demonstrated better

germination rates and faster germination speeds than Mostaganem seeds, suggesting regional differences in seed quality or inherent viability. *A. spinosa* seeds from Tindouf have a higher germination potential compared to those from Mostaganem, with specific culture media enhancing germination rates and growth. Activated charcoal positively influences root and aerial growth, but its effects vary depending on seed provenance. These findings are critical for optimizing in vitro germination and micropropagation protocols for *A. spinosa*, especially for reforestation and conservation efforts in different environmental contexts. Further research could provide deeper insights into the genetic and environmental factors influencing seed performance and help refine cultivation techniques for this important species.

Conflicts of interest

The authors declare no conflict of interest.

Authors' contributions

Methodology and conception or design of the study: I.H. and H.B. Acquisition of data: I.H. and A.M. and H.K. Analysis and/or interpretation of data: I.H. and S.G. Drafting the manuscript: I.H. and F.Z.H. Review and editing: N.S. and H.B. Critical revision of the manuscript: H.B. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

We extend our gratitude to the staff of the Laboratory of Genetic Resources and Biotechnologies (LRGB), Ecole Nationale Supérieure Agronomique (ENSA), Avenue Hassan Badi, El Harrach, Algiers, Algeria, Algiers, for his permission and support in allowing us to conduct this study within the laboratory facilities.

References

- AIZER, N.; ABDELLATIF, N.; SAIDI, F.; CHAOUIA, C. Initiation a la micropropagation par microbouturage de l'arganier (*Argania spinosa* L. Skeels). **Revue Agrobiologia**, v. 9, n. 2, p. 1628-1635, 2019. <https://agrobiologia.net/online/initiation-a-la-micropropagation-par-microbouturage-de-larganier-argania-spinosa-l-skeels/>
- AMGHAR, I.; IBRIZ, M.; IBRAHIMI, M.; BOUDRA, A.; GABOUN, F.; MEZIANI, R.; IRAQI, D.; MAZRI, M. A.; DIRIA, G.; ABDELWAHD, R. *In vitro* root induction from argan (*Argania spinosa* (L.) Skeels) adventitious shoots: influence of ammonium nitrate, auxins, silver nitrate and putrescine, and evaluation of plantlet acclimatization. **Plants**, v. 10, n. 6, p. 1-15, 2021. <https://doi.org/10.3390/plants10061062>
- BAUMER, M.; ZERAIA, L. The most continental of argania sites in North Africa. **Geology**, p. 446-452, 1999. <https://www.semanticscholar.org/paper/The-most-continental-of-the-argan-sites-in-North-Baumer-Zeraia/a2c7dbf0678da8b6eda7f3d4081029e32f108c49>
- BELLEFONTAINE, R. De la domestication à l'amélioration variétale de l'arganier (*Argania spinosa* L. Skeels)? **Sécheresse**, v. 21, n. 1, p. 42-53, 2010. <https://doi.org/10.1684/sec.2010.0226>
- BENABID, A.; FENNANE, M. Connaissances sur la végétation du Maroc: phytogéographie, phytosociologie et séries de végétation. **Lazaroa**, v. 14, p. 21-97, 1994.

https://www.researchgate.net/publication/39287046_Connaissances_sur_la_vegetation_du_Maroc_phytogeographie_phytodociologie_et_series_de_vegetation

CHARROUF, Z.; GUILLAUME, D. Argan oil: occurrence, composition and impact on human health. **European Journal of Lipid Science and Technology**, v. 110, n. 7, p. 632-636, 2008. <https://doi.org/10.1002/ejlt.200700220>

CHAUSSAT, R.; CHAPON, M. Etude comparative des poids et des propriétés germinatives des grains de l'épillet de quelques *Triticum sauvages* et cultivés. **Bulletin de la Société d'Ecophysiologie**, v. 6, n. 1-2, p. 15-21, 1981.

EMBERGER, L. Contribution à la connaissance des Cèdres et en particulier du Deodar et du Cèdre de l'Atlas. **Revue de Botanique Appliquée et d'Agriculture Coloniale**, v. 18, n. 198, p. 77-92, 1938. https://www.persee.fr/doc/jatba_0370-3681_1938_num_18_198_5828

KNOP, W. Quantitative Untersuchungen über die Ernährungsprozesse der Pflanzen. **Landwirtschaftliche Versuchs-Stationen**, v. 7, p. 93-107, 1865.

LAMAOU, M.; CHAKHCHAR, A.; BENLAOUANE, R.; EL KHARRASSI, Y.; FARISSI, M.; WAHBI, S.; EL MODAFAR, C. Uprising the antioxidant power of *Argania spinosa* L. callus through abiotic elicitation. **Comptes Rendus Biologies**, v. 342, n. 1-2, p. 7-17, 2019. <https://doi.org/10.1016/j.crvi.2018.11.001>

LÓPEZ-SÁEZ, J. A.; ALBA-SÁNCHEZ, F. Ecología, etnobotánica y etnofarmacología del argán (*Argania spinosa*). **Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas**, v. 8, n. 5, p. 323-341, 2009. <https://digital.csic.es/bitstream/10261/85522/1/2009-1-Lopez%20Saez%20Argania%20BLACPMMA.pdf>

MEZGHENNI, H.; HAMROUNI, L.; HANANA, M.; JAMOSSI, B.; BOUZID, S.; KHOUJA M. L. Multiplication de l'Arganier *Argania spinosa* (L.) Skeels. **Journal of New Sciences**, v. 10, n. 2, p. 6-17, 2014. <https://www.jnsiences.org/agri-biotech/18-volume-10/39-multiplication-de-l-arganier-argania-spinosa-l-skeels.html>

MSANDA, F. **Ecologie et cartographie des groupements végétaux d'Anzi (anti-atlas occidental, Maroc) et contribution à l'étude de la diversité génétique de l'arganier (*Argania spinosa* (L.) Skeels)**. Thèse (Doctorat) – Université Joseph Fourier, 1993. <https://theses.fr/1993GRE10084>

MURASHIGE, T.; SKOOG, F. A revised medium for rapid growth and bioassays with tobacco tissue culture. **Physiologia Plantarum**, v. 15, n. 3, p. 473-497, 1962. <https://doi.org/10.1111/j.1399-3054.1962.tb08052.x>

NOUAIM, R.; MANGIN, G.; BREUIL, M. C.; CHAUSSOD, R. The argan tree (*Argania spinosa*) in Morocco: propagation by seeds, cuttings and *in-vitro* techniques. **Agroforestry Systems**, v. 54, p. 71-81, 2002. <https://doi.org/10.1023/A:1014236025396>

OUALLAL, I.; OUAJDI, M.; KERDOUH, B.; SANGUIN, H.; ROCHDI, A.; ABBAS, Y. Caractérisation des ressources mycorhiziennes pour la sauvegarde de l'écosystème arganeraie: un outil de la biotechnologie moderne pour la régénération de l'arganier (*Argania spinosa* L.). In: Congrès International de l'Arganier, 5., Actes... Agadir (Maroc), p. 179-183, 2013. https://www.researchgate.net/publication/286443957_Caracterisation_des_ressources_mycorhiziennes_pour_la_sauvegarde_de_l_ecosysteme_arganeraie_un_outil_de_la_biotechnologie_moderne_pour_la_regeneration_de_l_arganier_Argania_spinosa_L

PRENDERGAST, H. D. V. **Conservation à long terme des semences de l'arganier, *Argania spinosa***. In: Colloque International L'arganier: recherche et perspectives. Agadir (Maroc), p. 11-15, 1991.

PUMAREDA, L.; HENRY, F.; CHARROUF, Z.; PAULY, G.; FALCONNET, G. Valorisation des feuilles d'arganier: impacto ambiental. **Bois & Forêts des Tropiques**, v. 287, n. 1, p. 35-44, 2006. <https://doi.org/10.19182/bft2006.287.a20321>

RADI, N. **L'arganier: arbre du sud-ouest Marocain, en péril, à protéger**. Thèse (Doctorat) – Université de Nantes, 2003. <https://www.sudoc.fr/147149746>

ZIANI, S. **Multiplication de l'arganier (*Argania spinosa* L. Skeels) par vitro semis, microbouturage, microgreffage, organogenèse et/ou embryogenèse somatique**. Mémoires (Magister) – Institut des Sciences Agronomiques, Université Hassiba Ben Bouali Chlef, 2014. <https://theses-algerie.com/9086588547930906/memoire-de-magister/universite-hassiba-ben-bouali---chlef/multiplication-de-l-arganier-argania-spinosa-l-skeels-par-vitro-semis-microbouturage-microgreffage-organogenese-et-ou-embryogenese-somatique>

ZOHRA, B.; ALI, M.; MOULAY, B. Germination tests of seeds of argan tree (*Argania spinosa* (L.) Skeels) of two sources (Tindouf and Mostaganem) in the semi-arid western Algerian. **African Journal of Plant Science**, v. 8, n. 6, p. 260-270, 2014. <https://doi.org/10.5897/AJPS2014.1171>

Received on September 17, 2024

Returned for adjustments on November 8, 2024

Received with adjustments on November 8, 2024

Accepted on January 6, 2025