الجمهورية الجزائرية الديمقراطية الشعبية

وزارة التعليم العالي و البحث العلمي

جامعة عمار ثليجي بالأغواط

كلية العلوم

Department of agricultural sciences

Specialty: plant protection

GERMINATION TEST OF CHERIMOYA (*ANNONA CHERIMOLA* Mill.) UNDER ABIOTIC CONSTRAINTS IN LAGHOUAT REGION

A Dissertation Submitted to the Department of Agricultural sciences

in Practical Fulfillment of the Requirements for the Degree of ***Master in Protection of plant****.*

Candidate: **Mr.Mohammed iftissane MOKHTARI**

Board of examiners:

President :	Dr.Zineb Bourakna	M.A.B	University of Amar Telidji Laghouat
Supervisor :	Dr.A.Boukoftane-Ameur	M.A.B	University of Amar Telidji Laghouat
Examiner:	Dr.Delel Mekhaldi	M.A.B	University of Amar Telidji Laghouat

June 2024

Acknowledgements

First, I am extremely grateful to Allah who helped me to finish this work.

I would like to thank my supervisor Dr. Abla Boukoftane -Ameur for her patience, guidance, and assistance throughout my work.

Special thanks go for both examiners Dr.Zineb Bourakna and Dr. Delel Mekhaldi who accepted to read my modest work.

I thank the teachers, laboratory engineers and administrators.

I dedicate this work to my beloved family, my father and mother who were always guiding me to go through the right path. I also dedicate this work to my small family.

Without forgetting to strongly thank my dearest brother who always giving me support, et all persons who shared me difficult times all around the making of this works.

Abstract

Germination Test of Cherimoya (*Annona cherimola* Mill.)

Under abiotic constraints in Laghouat region

The main objective of this work was to study the germination and emergence of *Annona cherimola* Mill in Laghouat region. It was interested in the study of primary dormancy in the first time, but also on seed germination behavior to cope with some abiotic factors, in emergence, as well as in the conservation of their viability. We used physical methods and evaluated the results by the parameters of germination and modeling as well as states for carrying out this study.

The final germination percentage (FGP): for Storage seeds (FGP Floationg= 0% and FGP= 3.34% Soaking), for Fresh seeds (FGP Floationg = 10% and FGP Soaking= 60%). The results of the Effect of storage of cherimoya seeds on germination show that the storage duration of *A.cherimola* seeds does not exceed 4 years.

The results of germination fresh seeds: germination of 50 % seeds soaking and 20% seeds floating in box. Germination 75% of seeds soaking and 15% seeds floating in soil. Germination of 80% seeds soaking and 50% seeds floating in compost. The first seeds germinated in compost after 10 days, The first seeds germinated in soil after 18 days. The first seeds germinated in box after 15 days.

The results of the parameters germination test were measured over an incubation period of 25 days during the experimental period are (FGP=50%), (MGT= 16.45 days), (CVG= 5.88%), time to 50% germination (T50=17.73 days) of *A. cherimola.* on box. On soil the final germination percentage (FGP=80%), Final germination percentage (FGP=75%), mean germination time (MGT= 4.58 days), coefficient of velocity of germination (CVG= 7.14%), time to 50% germination (T50=6.25 days) of *A. cherimola.* Mean germination time (MGT= 8 days), coefficient of velocity of germination (CVG= 4.54%), time to 50% germination (T50=7.78 days) of *A. cherimola* on compost.

The results of the effect temperature parameters on germination in box: A first period of latency (Tmin=10 to13°C. Tmax=25.4°C), a second exponential period where germination is accelerated (Tmin=10 to18°C. Tmax°C=33.8°C) and a stationary phase (Tmin=10 to 22°C. Tmax= 35°C). Germination in soil: A first period of latency (Tmin=10 to 20°C. Tmax= 30.1°C), a second exponential period where germination is accelerated (Tmin=22°C. Tmax=31°C) and a stationary phase (Tmin=21°C. Tmax= 32.2°C).

Germination in compost: A first period of latency (Tmin= 10 to 19°C Tmax=33°C), a second exponential period where germination is accelerated (Tmin=12.8°C. Tmax=22.5°C) and a short and limited stationary phase (Tmin=23°C. Tmax= 33°C). We use the mathematical formula of YAN and HUNT (1999). The results of the non-linear regression of temperatures applied to the number of germinations in the different cherimoya germination trays of the period (May 1 to June 6, 2024) are Tmin=10°C a Tmax=38°C. Fresh seeds exhibit variable behaviors ($P<0.0001$) at minimum temperature and ($p<0.0001$) at maximum temperature at room temperature.

Key words: *A.cherimola.* Fresh seeds. Storage seeds. Test Germination. Soaking. Temperature. Soil. Water. Abiotic constraints.Laghouat region. Saharan environment.

ملخص

اختبار إنبات القشطة (*Annona cherimola Mill.*)

في ظل القيود اللاحيوية. بمنطقة الأغواط

تم استهلاك ثمار شجرة الشيريمويا "فاكهة القشطة" (*Annona cherimola Mill*) من قبل القبائل المحلية في أمريكا الوسطى، ومن هناك تم نشر المحصول إلى أمريكا الجنوبية. إلا أن الشيريمويا لا يزال محصولًا غير مستغل بالقدر الكافي في حين يشهد وفرة في الانتاج في اسبانيا. ومحاولات الإنبات الناجحة في مناطق مختلفة بالجزائر ونظرا لفوائد القشطة الصحية واستعمال مستخلص بذورها في مكافحة الآفات الزراعية من جهة والمناخ القاري للجزائر من جهة اخرى اقترحنا هذه الدراسة المبدئية.

تظهر البذور المجهزة إنبات مبكر وموحد كما يتيح تحضير البذور البقاء على قيد الحياة للنباتات في الظروف البيئية الصعبة ويعطي إنتاجًا مناسبًا. لقد ناقشنا في هذه الأطروحة معالجة البذور بمركبات طبيعية وتقنيات بسيطة قبل إنباتها وذلك لبدء حالة فسيولوجية محددة في النباتات.

تم إجراء محاولة الإنبات للقشطة في جامعة عمار ثليجي (الأغواط) كلية العلوم بقسم العلوم الفلاحية لأول مرة حسب المعطيات والمراجع العلمية والتاريخية. تم تأسيسه في جزأين. الأول في المختبر، في العلب، والثاني عن طريق البذر مباشرة في التربة والسماد (في صواني البذور)، ووضعها في غرفة جيدة التهوية تحت الظروف المحيطة الموجودة في منطقة الخنق. خلال إجراء هذه الاختبارات استخدمنا المياه من المصادر الطبيعية والصنابير. أجريت التجربة في الفترة الممتدة من فيفري إلى يونيو 2024 في درجة حرارة الغرفة متفاوتة. لتحديد تأثير درجة الحرارة أثناء الإنبات.

تختلف طريقة نقع البذور ومدة نقع البذور من محصول إلى آخر، نسبة الإنبات النهائية تساوي 0 من المئة و متوسط وقت الإنباتMGT = 0.66يوم ومعامل سرعة الإنبات(CVG = 8.33) ، الوقت حتى 50٪ إنبات (T50 = 0) تم قياس هذه المعلمات خلال فترة حضانة قدرها 25 يوماً، واستمر زراعة البذور المخزنة حتى منتصف يونيو 2024، أي ما يعادل 14 أسبوعاً ولكن لم نلاحظ أي إنبات. التفسير الأرجح للنتيجة السلبية حول تأثير التقسيم الطبقي البارد على إنبات البذور المخزنة لنبات الشيريمويا هو مدة التخزين الطويلة .أظهرت نتائج تأثير تخزين بذور الشيريمويا على الإنبات أن مدة تخزين بذورها لا تتجاوز 4 سنوات.

بالنسبة لنتائج نقع البذور الطازجة أعطت إنبات 50% من البذور المنقوعة و20% من البذور الطافية في العلب. نسبة الانبات في التربة هي 75% من البذور المنقوعة و15% من البذور الطافية. نسبة الانبات في السماد هي80 % البذور المنقوعة و50% من البذور الطافية.

تم قياس نتائج اختبار الإنبات خلال فترة حضانة قدرها 25 يوما خلال الفترة التجريبية .نسبة الإنبات النهائية (FGP=50% متوسط زمن الإنبات (MGT= 16.45 يوم)، معامل سرعة الإنبات(% (CVG= 5.88 ، بخصوص 50% من الوقت الاجمالي حتى إنبات لدينا T50 = 17.73 يومًا في الصندوق.

نسبة الإنبات النهائية 75٪، متوسط وقت الإنبات هو 4.85يوم، معامل سرعة الإنبات7.14% = CVG) والوقت حتى 50٪ إنبات 6.25 = T50) يوم في التربة.

نسبة الإنبات النهائية(80% = FGP) ، متوسط وقت الإنبات 8 = MGT) أيام)، معامل سرعة الإنبات = CVG) (4.54%، الوقت حتى 50% إنبات 7.78 = T50) يوم) .*Annona cherimola* على شتلات علبة السماد.

النتائج التي تم الحصول عليها من الاختلافات في سرعة الإنبات بسبب شتلات الصواني والظروف اللاحيوية هي: إنبات البذور الأولى في شتلات صينية السماد بسرعة بعد 10 أيام .نبتت البذور الأولى في شتلات صينية التربة بسرعة بعد 18 يومًا .نبتت البذور الأولى في شتلات العلب بسرعة بعد 15 يومًا.

استخدمنا الصيغة الرياضية لـ .(1999) YAN HUNT نتائج الانحدار غير الخطي لدرجات الحرارة المطبقة على عدد الانبتات في صواني إنبات الشيريمويا المختلفة للفترة (من 1 مايو إلى 6 يونيو 2024) هيT_{min}=10°C وT_{max}=38°C.اعطت نتيجة إجراء تحليل التباين (ANOVA) لتحديد تأثير المعالجات الفيزيائية المختلفة المطبقة لكسر السكون وعلى إنبات بذور صنف *A.cherimoya.* اعتمادا على تباين العوامل اللاحيوية المدروسة($P<0.0001$)

الكلمات الدالة. شيريمويا. القشطة. الحبوب الطازجة. الحبوب المخزنة. اختبار الإنبات. درجة حرارة. التربة. الماء. موانع اللاحيوية. المعالجة بالنقع. منطقة الاغواط. البيئة الصحراوية.

RESUME

TEST DE GERMINATION DE CHERIMOYE (*ANNONA CHERIMOLA* Mill.) SOUS LES CONDITIONS ABIOTIQUES DANS LA REGION DE LAGHOUAT

Les fruits du cherimoya (*Annona cherimola* Mill) connaissent une production abondante en Espagne et des tentatives de germination réussies dans différentes régions d'Algérie. La préparation des graines permet aux plantes de survivre dans des conditions environnementales difficiles et donne une production adéquate. Dans cette étude, nous avons discuté le traitement des graines avec des composés naturels et des techniques simples avant la germination afin d'initier un état physiologique spécifique chez les plantes.

Une tentative de germination *de A.cherimoya* Mill a été réalisée pour la première fois à l'Université Ammar Telidji (Laghouat), Faculté des Sciences, Département des Sciences Agronomiques. L'expérience a été menée de février à juin 2024 à différentes températures ambiantes. Déterminer l'effet de la température pendant la germination.

Les résultats des tests de germination ont été mesurés pendant une période d'incubation de 25 jours pendant la période expérimentale. Pourcentage final de germination (FGP=50%). Temps de germination moyen (MGT=16,45 jours), coefficient de vitesse de germination (CVG=5,88%), pour 50% du temps total de germination nous avons T50=17,73 jours dans la boîte. Le taux de germination final est de 75%, le temps moyen de germination est de 4,85 jours, le coefficient de vitesse de germination (CVG = 7,14%) et le temps jusqu'à 50% de germination (T50 = 6,25 jours dans le sol.

Le taux de germination était de 50 % des graines trempées et de 20 % des graines flottant dans les boîtes. Le taux de germination dans sol est de 75 % pour les graines trempées et de 15 % pour les graines flottantes. Le taux de germination dans l'engrais est de 80 % des graines trempées et de 50 % des graines flottantes.

Le Pourcentage final de germination FGP=50%) et le Temps de germination moyen (MGT=16,45 jours), le coefficient de vitesse de germination est de (CVG=5,88%), pour 50% du temps total de germination nous avons T50=17,73 jours dans la boîte.

Le taux de germination final est de 75%, le temps moyen de germination est de 4,85 jours, le coefficient de vitesse de germination (CVG = 7,14%) et le temps jusqu'à 50% de germination (T50 = 6,25 jours dans le sol. Pourcentage de germination finale (FGP = 80%), temps de germination moyen (MGT = 8 jours), coefficient de vitesse de germination (CVG = 4,54%), temps jusqu'à 50% de germination (T50 = 7,78 jours) dans le compost. Nous avons utilisé la formulation mathématique de YAN et HUNT (1999). Les résultats de la régression non linéaire des températures appliquée au nombre de germinations dans différents plateaux de germination de chérimoya pour la période (du 1er mai au 6 juin 2024) sont Tmin = 10°C et Tmax = 38°C. avec ($P<0,0001$).

Mots clés. *Annona cherimola*. Graines fraîches. Graines stockées. Test de germination. Température. Le sol. Eau. Conditions abiotiques. Traitement par trempage. Région de Laghouat. Milieu saharien.

List of Abbreviations

APG IV: An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants

1 inch: 1 inch (in) = 2,54 (cm),

ATP: adenosine triphosphate (ATP), energy-carrying molecule found in the cells of all living things.

AFLPs: Amplified fragment length polymorphism (AFLP) is a PCR-based technique that uses selective amplification of a subset of digested DNA fragments.

CVG: coefficient of velocity of germination.

FGP: Final germination percentage

FGPC: the final germination percentage in Compost trays.

FGPS: The final germination percentage in (mixed soil and compost).

FSP: Fresh Seeds on Pitri or box.

FSS: Fresh Seeds on Soil.

FSC: Fresh Seeds on Compost

T50: time to 50% germination.

MGT: mean germination time.

NADH: Nicotinamide Adenine Dinucleotide.

USD: 1 EUR = 1,10 USD (14 /1/2024).

r: is the daily rate of growth (or development) at any temperature.

Topt: is the optimum temperature.

TDMAX (°C): is the maximum temperature of growth or development at (Tmax).

R max: is the maximum rate of growth or development at (Topt).

Tmin: Temperature minimum

Dmax (Tinf) is the maximum rate of growth or development at (Tinf).

List of figures

List of tables

Table of Contents

Introduction

Introduction

According to the scientific literature *Annona cherimoya* was cultivated in Algeria but we do not find the production of this species despite the favorable conditions. as well a few studies about cherimoya in Algeria.

The *Annonaceae* family besides its commercial value (*Annona cherimola*, ext.) also produces several active secondary metabolites. Among these metabolites, Annonaceous acetogenins which are exclusive in this family, are reported with insecticidal activity on various species of insects that are crop pests and disease vectors. Annonaceous acetogenins are toxic at low concentrations, considering evaluation standards and comparison with commercial insecticides, and are active at various stages of insect development (Azucena Durán-Ruiz et al., 2024).

Presently, a variety of approaches are being used to overcome abiotic stresses in plants. Recently, seed soaking with various priming agents has emerged as a promising strategy to induce tolerance in plants against abiotic stresses. In seed priming, seeds are treated with synthetic or natural compounds prior to germination so as to initiate specific physiological state in plants (Ashraf et al., 2018).

Seed priming could also be defined as physiological state which enables plants to more quickly respond to abiotic stresses. Plants raised from seeds treated with various priming agents tend to show greater abiotic stress tolerance over unprimed seeds. Induction of abiotic stress tolerance through priming is an intricate process that involves various metabolic events. Primed seeds show early and uniform germination and seedling emergence. Seed priming enables plants to survive adverse environmental conditions and gives appropriate yield (Ashraf et al., 2018).

Promoting this information will be useful for research about the cherimoya because of the lack of scientific studies on the different stages of its forms of germination. In addition, improving germination times and rates could increase the number of studies related to cherimoya seedlings, which is of great interest due to the increasing demand for the introduction of new rootstocks. Through this study, we aim to develop knowledge of the different stages of cherimoya germination after sowing and test an optimized, vigor-promoting seed germination technique to be used on a large scale.

The objective of this study is oriented towards knowledge of the biology of *A.Cherimola* through the study of different axes:

Axis 1. Primary dormancy in *A. cherimoya*: Studying the effect of some treatments to determine the germinative capacity of cherimoya and breaking dormancy.

Axis 2. The resistance of seeds to the abiotic factors of the Saharan environment: The study of the germinative behavior of seeds with respect to temperature.

The work will be structured around the following three chapters: The first chapter addresses a presentation of the *A. cherimoya* species. The second chapter is devoted to the methodology followed for carrying out germination tests. The third chapter presents commented results and discussions.

General information on *Annona cherimola Mill.*

Section I

General information on *Annona cherimola Mill.*

The first documented report on cherimoya was by Jose de Acosta, a sixteenth-century Spanish Jesuit missionary, who wrote that "*all the flesh inside is soft and tender as butter and white and of an exquisite taste and some believe that it is the best fruit in the Indies*" (Acosta, 1590). In the 18th century, the Italian capuchin friar Ilarione da Bergamo, who traveled to Mexico (1727–1778), wrote "*the chirimolla has a mild flavor and is also highly esteemed by locals. The centre is very white and is often eaten with a spoon, given that its consistency is like that of curdled milk*" (Almeida et al, 2017). A young Charles Darwin also praised the cherimoya during the Beagle's stopover on the South American continent in Lima (Peru) in 1835: "*There are two things in Lima which all travelers have discussed; the ladies 'tapadas', or concealed in the saya and manta, and a fruit called chilimoya. To my mind the former is as beautiful as the latter is delicious*" (Darwin et al., (1831–1836)). Mark Twain declared the cherimoya to be "*deliciousness itself*!" [97] and wrote from the Hawaii Islands: "*We had an abundance of mangoes, papayas, and bananas here, but the pride of the islands, the most delicious fruit known to men, cherimoya, was not in season. It has a soft pulp, like pawpaw, and is eaten with a spoon*" (Popenoen, 1989).

I.1. Introduction *to Annona cherimola Mill.*

Fruits of the cherimoya tree *A.cherimola* were consumed by native cultures in Central America, from where the crop was disseminated to South America in pre-Columbian times. Despite its historical significance and cultivation in subtropical regions worldwide, cherimoya remains an underutilized crop, particularly in its area of origin where the conservation of its genetic diversity is under threat.

I.2. Taxonomy and Botanical Characteristics

The cherimoya (*Annona cherimola Mill.*) belongs to the *Annonaceae*, a pantropical family that includes approximately 107 genera and 2400 species of flowering trees, shrubs and lianas (Guo et al., 2017) distributed worldwide. According to the APGIV classification (Linn, 2016), this family is included in the Magnoliales order, along with five other families (*Myristicaceae,* *Degeneriaceae, Himantandraceae, Magnoliaceae* and *Eupomatiaceae*), which collectively represent three-quarters of the species within the order. Together with the Canellales, Laurales and Piperales form the Magnoliid complex (Zanis et al., 2002), considered a sister to the eudicot and monocot clades of angiosperms (Soltis et al., 2005).

The *Annonaceae* family is believed to have originated in the upper Cretaceous period, about 82–98 million years ago when taxa were distributed between Laurasia and northern Gondwana (Doyle et al., 1997). A division from the Laurasian lineage gave rise to the genus *Anaxagorea* (present in the Neotropics and tropical Asia), while the Gondwana lineage gave rise to the rest of the genera in the family. Since the morphological-based classification of Fries (Fries et al., 1959), several studies have focused on the systematics of this family and its genera, based on reproductive (Doyle et al.,1994 and Goodrich, 2012), morphological (Maas et al., 1985 and Couvreur et al,2009) and molecular characters, using chloroplastic sequences (Richardson et al., 2004 and Chatrou et al.,2012) and nuclear markers such as RAPDs and RFLPs (van Zuilen et al., 1996).

Asimina triloba, native to North America, is the most interesting from an agronomic perspective and has been the subject of numerous molecular studies using isoenzymes, RAPDs, AFLPs and ISSRs (Huang et al., 1997 and Wang et a.l, 2005). In addition, the interaction between the pistil and pollen has been characterized (Losada et al., 2017), its phenology has been studied and its genome is currently being sequenced (Ferrer et al., 2022).

The genus Annona includes about 160 species (Richardson et al., 2004) and is mainly distributed throughout tropical regions of the Americas, with a few native species found in Africa. Several species within this genus produce edible fruits that hold diverse value, particularly in local markets: *Annona cherimola, A. reticulata, A. squamosa, A. muricata, A. macroprophyllata, A. glabra* and *A. purpurea*. The genus Annona was named by Linnaeus (Linnaeus, 1737) using the Central American vernacular name but modifying it to the Latin name Annona, which can be translated as “the harvest of a year”. It is believed to have emerged during the Miocene period, 5–23 Ma ago [Richardson et al., 2004 and Su et al., 2009).

Safford (Safford, 1914) provided an early description of the genus, dividing it into five groups and 15 sections. Later, Fries (Fries et al., 1959), focusing on flower traits, reorganized it into 17 sections. Fries’ classification remains the most widely used for Annona, although some morphological characteristics might have evolved independently in several sections

(Gottsberger, 2012). According to the dichotomous key of Fries, the section Atta, which includes *A. cherimola*, would have its center of origin in Central America and the Caribbean.

This section is characterized by ripe, smooth-skinned fruits with raised areoles delimited by lowered furrows. However, phylogenetic studies indicate that the organization of these and closely related sections may need reconsideration, as they do not exhibit monophyly based on chloroplast genes (Larranaga et al., 2019).

Various studies have been carried out on species of the genus of 17 Annona at both the morphological and/or molecular levels, focusing on identification, diversity or phylogeny, providing valuable insights into the classification and evolutionary relationships within the genus (Larranaga et al., 2019) and (Larranaga et al., 2015).

cherimoya is a semi-deciduous tree belonging to the Atta section of the genus Annona (Fries, et al., 1959) and (Larranaga et al., 2019). At maturity, it can reach a height of 7–8 m. The leaves are simple, entire, alternately arranged and vary from oval to elliptical, with variable sizes, generally 7–18 cm long and 4 to 10 cm wide, with short petioles (Rosell et al.,1997). The flowers are hermaphroditic, pendulous, inconspicuous and fragrant, usually originating in at least 1-year-old wood, either as solitary or in clusters of up to eight or nine flowers. The floral components are arranged in a helical pyramidal manner on the receptacle. Each flower has three large fleshy green tepals (2.5 to 4 cm) and three rudimentary scale-shaped inner tepals. The stamens are numerous (150–200). The pyramid of pistils has approximately 150 independent units, each with a single ovule, which must be fertilized for the ovaries to grow and develop, producing the aggregate fruit. As with other members of the *Annonaceae*, the flowers of *A. cherimola* exhibit dichogamous protogyny, which refers to the temporal separation of female and male functions. This phenomenon hinders self-pollination within the same flower, as well as between flowers of the same tree and between trees of the same variety, due to the synchronization of sexual stages. The flower cycle usually completes in two days; on the first day, the flower opens at the female stage, and on the second day, it transitions from the female to the male stage, coinciding with the dehiscence of the anthers. Pollination is mostly cantharophylous depending on the presence and visits of small Coleoptera, mainly from the family Nitidulidae (Wester, 1910) and (Cautin et al., 2005).

Hand pollination is common in Spain and other countries outside the Americas with a scarcity of pollination insects. The fruit is compound, conical or heart-shaped. The skin, thin or thick, may be smooth with fingerprint-like markings or covered with conical or rounded protuberances. The white flesh is sweet and juicy, with each segment surrounding a single hard black seed. Cherimoya grows best in subtropical climates with average annual rainfall ranging from approximately 600 to 1700 mm, accompanied by low seasonal and interannual temperature fluctuations. Ideal mean temperatures range from 15 to 25 ◦C, with a preferred relative humidity level of 60–70%. Cherimoya thrives in well-drained sandy soils [García et al., 2010).

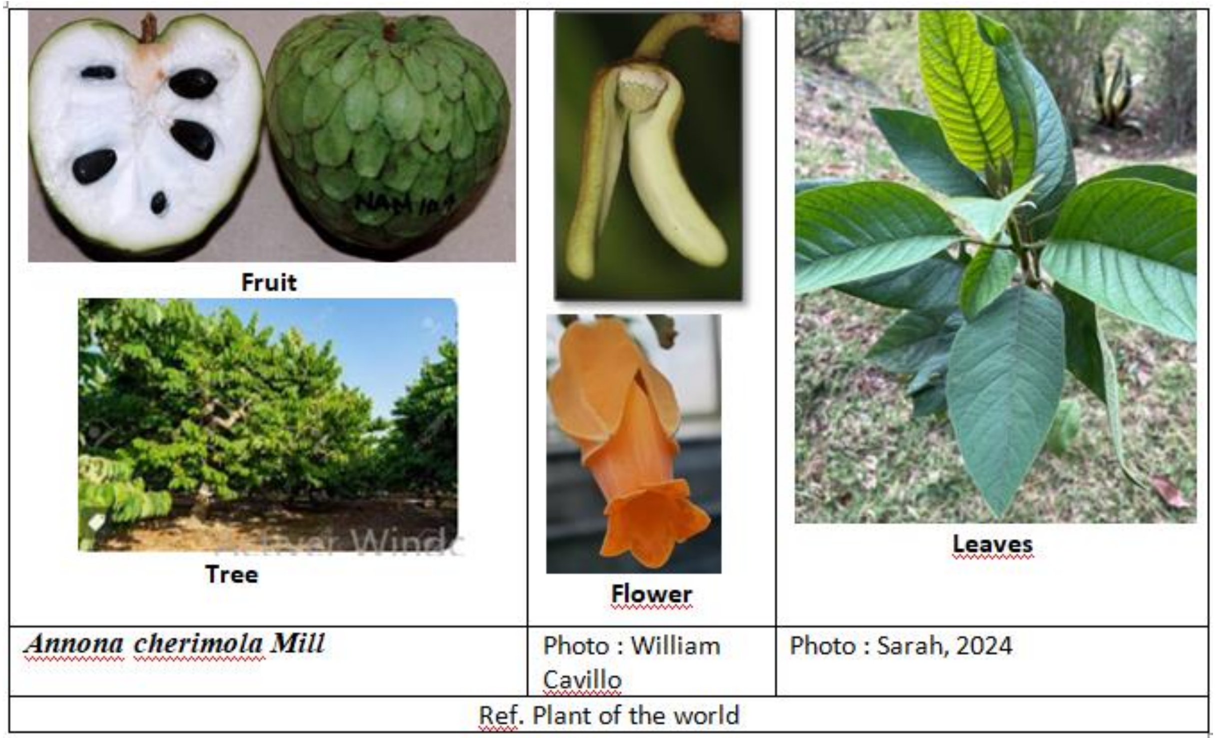

Figure1. *A. cherimola* (Plant of world, 2024)

I.3. Historical and Cultural Significance

The term cherimoya seems to derive from the Quechua words “chiri”, meaning cold, and “muya”, meaning seed. However, recent DNA-based studies have demonstrated a Mesoamerican origin of this species (Larranaga et al., 2017) and (Larranaga et al., 2021), where its closer relatives, included in the *Atta* section and with which *A. cherimola* presents monophyly, are naturally distributed. Since neutral microsatellites have a constant mutation frequency of 10^{-3}–$^{10-4}$ mutations/locus/generation, higher diversity values, which do not necessarily indicate the centers of origin of species, can provide an idea of the populations that have been settled for longer times (Fries et al., 1959); (Larranaga et al., 2019); (Ellegren, 2004 and. Guichoux et al., 2011).

The initial dispersal of cherimoya throughout Central and North America may have been mediated by the native megafauna that inhabited this continent for 20 million years and became extinct about 13,000 years ago (Barlow et al., 2000). Species with fruits exhibiting typical characteristics that would be explained by interaction with extinct animals are considered anachronic and include cherimoya and other species with large fruits that originated in the Americas, such as avocado or cacao. After the extinction of the American megafauna, the subsequent dispersal of these species would depend mainly on humans (Janzen et al., 1982), (Van Zonneveld et al., 2018).

Several civilizations, including the Mayas, Olmecs, Izapa, Toltecs, Mexica—Tenocha or Mixtecas, among others, may have contributed to the dispersal of the cherimoya throughout Mesoamerica in PreColumbian times (Rovira-Morgado et al, 2007). Thus, *A. cherimola* may have been collected and cultivated by Mesoamerican peoples and dispersed, at some point, using ancient sea trading routes, to South America, where cultivation and diversification would have continued mediated by human activity of the different Andean civilizations (Larranaga et al., 2021).

The existence of routes and exchanges between Ecuador, Peru and Mexico is documented in the bibliography based on shared textiles, metallurgical artifacts or mollusk shells (Hosler et al., 1990; Marcos et al., 1994), among others.

This mode of dispersion could also be responsible for the extension of other plant genetic resources along the American continent in pre-Columbian times. The observed cherimoya phenotypic variation (still not studied in detail) in Central America seems to be lower than that observed in northern Peru and southern Ecuador (Scheldeman, personal communication), while the opposite occurs with the analyzed genetic diversity (Larranaga et al., 2014; Larranaga et al., 2021). Thus, the cherimoya would fit the description of a semi-domesticated species (Clement et al., 1999).

All this points to a bottleneck before the establishment of the populations in South America, as has already been reported for other species of Mesoamerican origin such as *Phaseolus vulgaris* (Bitocchi et al., 2012; Bitocchi et al., 2013).

After the colonization of America, the cherimoya was introduced to southern Spain, very likely from the Mexican gene pool (Larranaga et al., in preparation), in the 18th century, from where it was probably spread to Italy, Madeira (Portugal), the Canary Islands, Algeria, Egypt and, possibly, to Libya, Eritrea and Somalia via Italy. Also, in the late 18th century, cherimoya was introduced to Hawaii, Jamaica and Haiti. Seeds were introduced to California from Mexico and, in the early 1900s, the United States Department of Agriculture imported seeds from Madeira (Morton, 1987).

I.4. Introduction of Cherimola in Algeria

Since the 16th century it was introduced into Spain in the region of Valencia and Murcia. but it does not seem to have spread much there. It exists in a few gardens in Algeria, but it only succeeds well near the littoral. Despite the efforts of Dr. L. Trabut Director, Service Botanique, Algiers, Algeria instituto, 1918; who sought to spread cultivation in North Africa. It is at hardly if it exists on the Mediterranean coast of the Alpes-Maritimes and yet we know that he succeeds in a perfect manner in the well sheltered gardens (Chevalier Auguste, 1925).

Dr. Robertson-Proschowsky cultivates it in his garden Tropics near Nice (France), but the specimen which fructified there had not produced, a few years ago, that fruits so full of seeds fertile that there was almost no flesh. It is that this species, like most tropical fruit trees, not having been selected gives by sowing descendants which sometimes behave like wildlings. However, this variation is exceptional, and it is almost always seedlings are used to propagate the plant (Gonzales et al., 2013).

In Algeria, according to Dr. L. Trabut (Fruit arboriculture of Africa from N, I, p. 242), the Cherimoli tree is hardy and bears abundantly in November and December The plants coming from seedlings sometimes give fruit, similar to the mother plant, but it is yet preferable to graft (cleft graft) a good variety second year. It can be obtained from the Jardin du Hamma in Algiers. In greenhouses, Anones can be taken from cuttings, but this operation is quite difficult and can only be succeeded by expert hands: « *There are few exotic fruits, writes Trabut, that please so quickly as the Anone Cherimoia; the first fruit tasted generally appears delicious and if consumption is so limited, it is because the Production is, quite wrongly, limited by the fear of poor sales. On the contrary, it seems obvious that the time has come to give a certain extension to the cultivation of Cherimoli, cultivation which is no more difficult* *than that of the Orange Tree and which, for the moment, would be just as profitable.* » Chevalier Auguste, 1925).

Let us add that there is a second species at Annona whose culture can also undoubtedly be done in This is *Annona Forskahlii* DC = A. *glabra Forsk*. (Non-L.) Cultivated in Egypt where S. Forskaul had reported it in 1775. It was seen again later in the gardens of Damiette and Rosette by Delile, during of Bonaparte’s expedition; It is known to the Arabs under the name of Keshta or Qechtah. According to P. de Candolle. Algeria and Morocco and perhaps even in the south of France, and which produces edible fruits (Chevalier Auguste, 1925); (Gonzales, 2013).

Although this inventory chronicles the arrival of only 370 new plant immigrants, it describes some that are of unusual interest and deserving of special mention:

41488. ANNONA PURPUREA MOC. and Sesse. Annonacese. Soncoya. "This fruit has only two defects—the seeds are too large and are * cling.' It is recommended for crossing with *Annona squamosa* and *Annona cherimola*." (William and Taylor, 1918).

41493. ANNONA CHERIMOLA Miller. Annonacese. Cherimoya. Seeds from Brisbane, Australia. Presented by Mr. Leslie Gordon Corrie. Received November 22, 1915 (William and Taylor, 1918).

I.5. Cultivation and Agronomy

Annona cherimola, a diploid species, is considered to have 2n = 14 chromosomes (Walker ,1972); (Martin, 2019), although some studies have reported a higher number of chromosomes (2n = 16) [54]. This discrepancy could be due to the confusion between distant satellites (or whole arms) and separate chromosomes (Sauer et al., 1984). Interestingly, an unexpectedly high proportion of triploid genotypes was found in the progeny of an interspecific cross involving the diploid species, *A. cherimola* and *A. squamosa* (Martin, 2019).

Cherimoya has been the subject of studies on diversity, inheritance or genetic linkage with morphological markers (Perez-Oteyza et al., 1999; Andres-Agustin et al., 2006) isozymes (Ellstrand et al., 1987; Perfectti, 2005), RAPDs (Ronning et al., 1995) AFLPs (Rahman et al., 1997) or microsatellites (Escribano et al., 2004; Larranaga et al., 2021). Most of these studies included cherimoya accessions collected at the regional level, leading to valuable conclusions about the extent of local diversity and conservation. However, some of them (Perfectti et al., 2005; Escribano et al., 2004; Escribano et al., 2007; van Zonneveld et al., 2012; Larranaga et al; 2021) have analyzed samples on a larger geographical scale and, consequently, have helped to advance the understanding of the genetic diversity and dispersion of the species across the Americas. It has also been the object of the construction of different genetic maps based on microsatellite markers.

The discovery of a natural mutant of *A. squamosa* without seeds has allowed for the identification of a gene (INO; INNER NO OUTER) which is essential for seed formation. (Lora et al., 2011). Both the chloroplast (Blazier et al, 2016) and nuclear (Talavera et al., 2023) genomes of cherimoya have been sequenced. Other biotechnological advances in the species include the development of a micropropagation protocol from nodal explants of juvenile *A. cherimola* 'Fino de Jete', achieving a 100% acclimatization rate (Encina et al., 1994). Micropropagation is also being adapted to other selected cherimoya cultivars and rootstocks.

The Fino De Jete Cherimoya Tree is the main cultivar in Spain. With requiring minimal care and easy to grow it is a great beginner tree for those who are just starting to get into gardening. Grows at a moderate pace with good branching. Fino de Jete is a specific cultivar of cherimoya (*Annona cherimola*) known for its exceptional flavor and quality. It owes its name to the village of Jete, in the province of Granada, Spain, where it originates and where it is mainly cultivated.

I.6. Cherimoya production

Spain is the world's leading commercial producer. Other cherimoya-producing countries are Portugal, Italy and Palestine in the Mediterranean region, and Australia, New Zealand and South Africa elsewhere in the world (Scheldeman, 2002). The following sections will cover key germplasm conservation and crop management information in the main cherimoya-producing countries in Latin America (Bolivia, Chile, Costa Rica, Ecuador, Mexico, Honduras and Peru) and Europe (Portugal and Spain) (Table 1).

Table 1: Yield in tons per year, number of hectares, main cultivars and number of accessions conserved in ex situ collections across the main cherimoya-producing countries. In brackets,

the source of information is indicated either with numbers (references) or personal information (PI). ND: no data avalable.

	Yield (t)/Year	No. Hectares	Main Cultivars (Cultivated and/or Developed)	No. Accessions Conserved
Mexico [102,103], [PI]	178.7	22.3 + 500?	Cortes II 31	106 + 33 + 2000
Honduras [PI]	ND	ND	None	0
Costa Rica [PI]	88.15	ND	None	8
Ecuador [104–111]	1200	700	MAG-Tumbaco, San José de Minas, Lojana, Fabulosa	126
Peru [112,113]	20,000	ND	Chiuna 1, Chiuna 2, Chiuna 3, Cumbe	356
Chile [114,115], [PI]	ND	300	Local Serena, Clavo, Juliana, Juniana	ND
Bolivia [116], [PI]	7000	1000 (expanded to 5000)	ND	150
Portugal [117–122]	627	120	Madeira, Mateus I, Funchal, Perry Vidal	500
Spain [123,124]	44,081	3000	Fino de Jete, Campas, Alboran	350

According to data published by the Ministry of Agriculture "*Mapa: Ministerio de Agricutura Pesca y Alimentación de España. 2021*", Spain recorded a total cherimoya production of 44081 tons during 2020, with nearly all the production (99.6%) concentrated in the Andalusia region (mainly in the province of Granada, but also in Malaga and Cadiz) (Mapa, 2021).

The total irrigated area dedicated to cherimoya cultivation is about 3000 hectares. Cherimoya trees are also found scattered in the Canary Islands. In Spain, the cherimoya flowering season takes place mainly in May, resulting in fruit production from September to December. Management techniques such as pruning in May, resulting in a delayed flowering (July to September), allow for extending the harvesting season up to May (Mapa, 2021).

In Spain, as in most countries outside the Americas where the cultivation of species of the genus *Annona* has been introduced, manual pollination is often performed, since the native pollinating insects are not present. The growers collect pollen and manually apply it to the flowers; this also results in larger fruits of a more regular shape. However, some nitidulid beetles (Coleoptera) present in Spain can also be somewhat effective in pollination under suitable shading and humidity conditions (De la Pena, 2018).

The majority of cherimoya production in Spain is primarily consumed domestically, with exports to other European countries accounting for approximately 10% to 20% of the total production. The main importing country is Portugal, followed by France and Germany. A Protected Designation of Origin (PDO), labeled "Chirimoya de la Costa Tropical de Granada-Málaga", was established in 2010.

I.7. Germplasm bank

Cherimoya germplasm banks have been established in various countries, such as Mexico, Peru, Ecuador and Spain, with the latter being the largest collection worldwide. Usually, the different cherimoya genotypes are classified based on exocarp type (Schroeder et al., 1945) into the following five different types: laevis (smooth), impressa (slight depressions), umbonata (small protrusions), tuberculate (medium protrusions) and mamillata (large protrusions).

The Institute of Subtropical and Mediterranean Hortofruticulture La Mayora (IHSM La Mayora-CSIC-UMA) maintains the Cherimoya and other fruit crops of the *Annonaceae* germplasm bank, located in the province of Málaga, in the municipality of Algarrobo, at the coordinates -4.0431◦ longitude and 36.7561◦ latitude. This region experiences a Mediterranean climate with subtropical temperatures.

Established in the 1980s, the germplasm bank aimed at collecting accessions that would address the deficiencies of the local cultivar ’Fino de Jete’, thereby facilitating genetic improvement projects. Currently, the bank has over 350 accessions of cherimoya and other fruit tree species of the *Annonaceae*. Most of them have a South American origin following the previous hypothesis of the center of origin, so it would be of interest to complete the bank’s accessions with genetic material from Central America to increase its diversity.

Cherimoya cultivation in Spain is 95%, dependent on the local cultivar ‘Fino de Jete’ and, to a lesser extent, on ‘Campas’. Both belong to the impressa type, exhibiting excellent organoleptic qualities, and are very well adapted to the environmental conditions of the production area. However, ‘Fino de Jete’ has some disadvantages, such as a high seed content, susceptibility to Mediterranean fly (*Ceratitis capitata*), the concentration of the production of the best quality fruits being a period of only three months (October– December) and a limited postharvest shelf-life.

Recently, a new cultivar, ‘Alboran’, has been released from the IHSM La Mayora breeding program. ‘Alboran’ has a lower seed index than ‘Fino de Jete’ and excellent organoleptic qualities in the winter months, with a much longer postharvest shelf-life. Selections from a cross between ‘Fino de Jete’ and a spontaneous mutant from *Annona squamosa*, Thai seedless (Ts), which produces normal fruits without seeds, are being evaluated to produce seedless cherimoyas. The absence of seeds in the seedless mutant has been attributed to the deletion of the INNER NO OUTER locus (INO) that is involved in the development of the outer integument of the ovule (Lora et al, 2011).

I.8. Growing Conditions and Soil Requirements

According to *Cherimoya*. University of California Agricultural and Natural Resources Extension: If you have geographic luck, patience, knowledge, and some paintbrushes for hand pollinating, caring for your tree shouldn't be too much trouble. Here are some key things to remember:

- Have patience, as this tree can will not bear fruit until 3 to 5 years after maturity.
- Keep the soil moist but not overly saturated. Maintaining the right balance of moist to dry soil is important.
- Plant in an area with full morning sun and preferably afternoon shade.
- Feed the tree often during the growing season with a balanced fertilizer.
- Hand pollinates the tree. The beetle known to pollinate the cherimoya is not native to the United States so this won't happen on its own.
  a) **Light:** The Cherimoya tree requires full sun but is prone to having its leaves burn. To prevent this, think about placing your tree in a spot where it gets a good amount of bright morning sunlight followed by afternoon shade.
  b) **Soil:** Testing your soil before planting your tree is a good idea. The cherimoya likes rich loamy soil with good drainage that falls into a pH range of 6.5-7.6. If you use an easy test on your soil and the results show that the soil you have does not match up with these requirements, then you know you can amend it. Adding in some good compost or manure can help increase the soil's richness, and amending it with perlite can increase the its ability to drain water.
  c) **Water**: While the tree is in its growing season, you will want to keep the Cherimoya tree's soil moist but not wet. Cherimoyas are susceptible to root rot in soil that stays soaked, so overwatering needs to be avoided, and soil consistency is key.
  d) **Temperature and Humidity**: The cherimoya is a tropical tree that needs cool summers and winter chills to produce fruit. It requires 50 to 100 hours of temperatures ranging between 25 to 43 degrees Fahrenheit to fruit, but temperatures below 25 degrees Fahrenheit can damage the tree.

e) **Fertilizer:** During the growing season, it is a good idea to fertilize your plant often. Every three months is about right, with a general-purpose 10-10-10 fertilizer at the drip line.

f) **Pollination:** The only reason people will look to growing the cherimoya is for its delicious fruit. Unfortunately, it takes some effort to get the tree to actually produce the fruit since the tree isn't pollinated by insects that are native locally. That is where you become the pollinator! You will be collecting and dispersing the pollen with a regular old artist's paintbrush. Cherimoya trees are monoecious, meaning it has both male and female flowers. The first step is to collect the pollen from the anthers of the male flowers and disperse it onto the open female flowers. If male and female flowers of a tree don't open at the same time, you can collect and store the pollen in an airtight container. Use the pollen in storage to pollinate the female flowers when they bloom, and repeat the process regularly while the tree is in bloom. Enjoy the fruits of your labor in no time!

I.9. Chemical Composition and Nutritional Value

The cherimoya is characterized by its high sugar and low acid levels. It is primarily consumed fresh, although it can also be processed into products such as ice creams, smoothies, sorbets, yogurts and even wine. Cherimoya is a valuable source of vitamins B1, B2 and B3, sugars and essential minerals such as iron, calcium or phosphorus, with concentrations of 0.5, 32 and 37 mg per 100 g of pulp, respectively (Scheldeman, 2002).

Beyond the nutritional benefits of the fruit, the leaves, stems, bark and seeds of cherimoya show the presence of interesting secondary metabolites such as isoquinoline or acetogenins, with various pharmacological properties, such as antitumor or insecticide effects (Alaly et al., 1999; Cortes et al, 2014). Traditionally, crushed cherimoya seeds have been considered to have insecticide properties, serving as a natural remedy to combat lice and treat skin diseases in different American countries (Scheldeman, 2002).

I.10. Medicinal Properties and Health Benefits

It can help combat: cholesterol, hypertension, cardiovascular problems, anemia, osteoporosis, celiac disease and stress. It helps regulate blood sugar levels, lower defenses and improve intestinal transit. The Annonaceous acetogenins are promising new antitumor and pesticidal agents that are found only in the plant family *Annonaceae*. Chemically, they are derivatives of long-chain fatty acids. Biologically, they exhibit their potent bioactivities through depletion of ATP levels via inhibiting complex I of mitochondria and inhibiting the NADH oxidase of plasma membranes of tumor cells. Thus, they thwart ATP-driven resistance mechanisms (Alaly et al., 1999).

The consume of soursop Anonacea fruit has increased in the last years because in the pulphas been identified some bioactive compounds aspolyphenols and acetogenins which are associated with prevention of diverse pathologies, such as neurodegeneration, cancer, diabetes, cardiovascular, and anti-inflammatory diseases (Andfasolo et al., 2014).

Annonaceous acetogenins (ACGs) isolated from *Annonaceae* plants exhibited a broad range of biological bioactivities such as cytotoxic, antitumoral, antiparasitic, pesticidal and immunosuppresive activities (Yang et al., 2010).

I.11. Pesticidal Activities

Annonaceous plants have potential use as pesticides, and McLaughlin et al. were the first group to report this application. They determined the pesticidal potencies of extracts from the paw paw tree (*Asimina triloba*) by the brine shrimp lethality test (*Artemia salina L*. larvae). Also, similar pesticidal activities were found against the striped cucumber beetle (*Acalymma vittatum F*.), the Mexican bean beetle (*Epilachna varivestis Mulsant*), mosquito larvae (*Aedes aegypti L*.), blowfly larvae (*Calliphora vicina Meigen*), the melon aphid (*Aphis gossyphii Glover*), the twospotted-spider mite (*Tetranychus urticae Koch*) and the free-living nematode (*Caenorhabditis elegans Maupas*). During preliminary screening work, asimicin was isolated and its pesticidal action was evaluated (Rupprecht et al.,1986).

Utilizing a bioactivity-guided isolation and fractionation method, bullatacin was purified and its pesticidal effects were observed at a fairly low concentration (1 ppm), whereas bullatacinone lacked any discernible pesticidal activity at the concentrations tested (Hui YH et al., 1989). McLaughlin et al. conducted a controlled study to investigate the pesticidal potencies of extracts from various parts of plant of the paw paw tree (Asimina triloba) using the brine shrimp test (Ratnayake, 1992). McLaughlin et al. further evaluated the pesticidal properties of 44 AGEs using a yellow fever mosquito larvae (YFM) assay (He et al., 1997). The results clearly demonstrated that many AGEs possess pesticidal properties.

In addition, the results focused on adjacent bis-THF AGEs with three hydroxy groups. For example, bullatacin and trilobin were the most potent AGEs in this aspect. They further used AGEs of the mono-THF, adjacent bis-THF, and nonadjacent bis-THF types as insecticidal baits for testing the potent toxicity of these compounds against insecticide susceptible and -resistant German cockroaches.

The resultant pesticidal activities were compared with conventional synthetic insecticides (Alali et al, 1998) Ohsawa et al. evaluated the insecticidal activities of AGEs from the seeds of the pond apple, A. glabra with a micro-sprayer on the cabbage leaf or with a filter paper (Ohsawa et al., 1991). Guadano et al. also found that annonaci showed antifeedant effects on L. decemlineata, whereas squamocin was toxic to L. decemlineata and M. persicae. They also proved that both AGEs were not mutagenic but indeed toxic to the insects in the absence of a metabolic energy-activating system (Guadano et al., 2000; Liaw et al, 2015).

Section II

Materials and Methods

Section II

Materials and methods

II.1. Presentation of the study region:

The Laghouat (Arabic: الأغواط, romanized: *al-Aghwāt*) region is located in Algeria coordinates 33°48′10″N 2°52′30″E in an arid to semi-arid area inside the steppe regions of Algeria (Fig. 2). The total area within the administrative boundary is 25,052 km2. Of its 24 communes, 9 are considered urban. and is part of the groupe of 12 pastoral wilayat's in the country as well as the southern wilayat, due to its geographical position and its climatic characteristics.

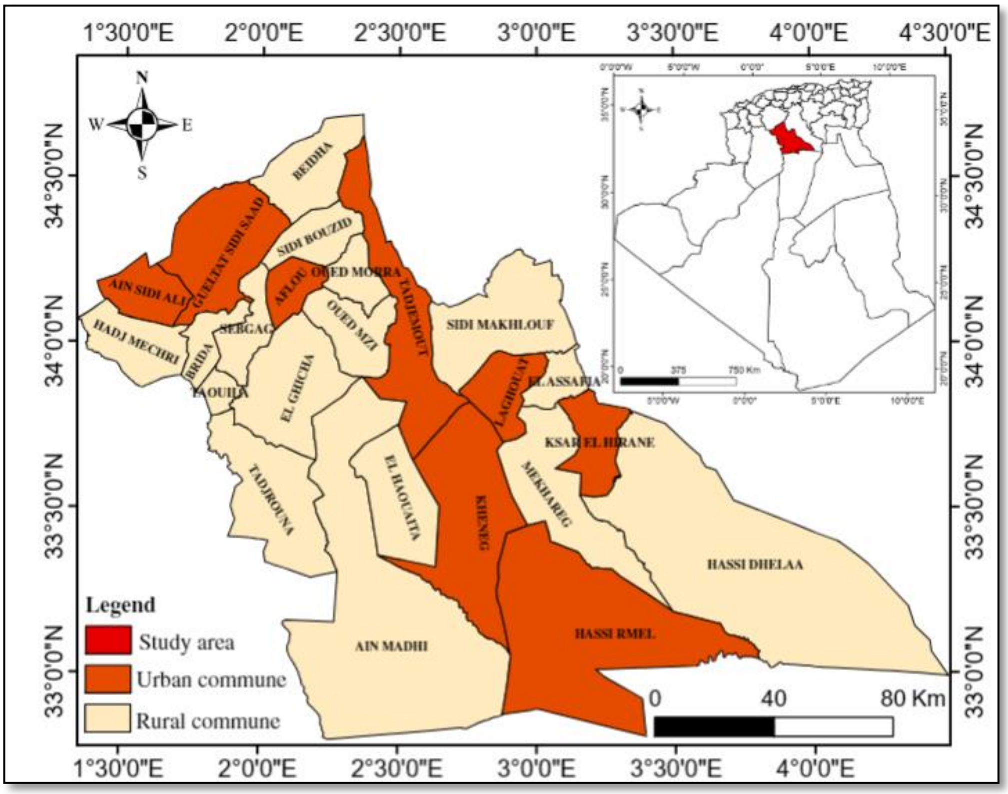

Figure2: Location of Laghouat region (Taibi, 1997)

The territory of the wilaya extends over two different geological domains: The Saharan Atlas in the north, formed by the Amours mountains and the Ouled Nail mountains; The

Saharan platform in the South, formed by a set of diversified subtabular plateaus according to their structures, their positions and the nature of the rock which constitutes them. These plateaus are commonly referred to by Arabic names (Hmada and Reg) (Hannachi, 1981).

II.1.1. Geomorphological framework:

wilaya of Laghouat present a topography typical of the regions dry, the synthetic expression of the interaction between climatic and geological factors characterized by more or less steep reliefs, especially of the Saharan Atlas which oppose the vast subhorizontal surfaces whose morphological values are not the same (Pouget, 1980; Djebaili, 1984; Aidoud, 1984). Geofoam's can be summarized as:

1. Reliefs: The mountains: made up of the mountains of Jebel Amour whose altitudes vary between 800 and 1720 m; The foothills: elongated from West to East, has a reduced width and corresponds in the lower foothills of the Saharan Atlas and the valleys of the Djedi wadis, Atar wadi and Oued-M'zi; Subhorizontal surfaces: commonly called "Dayas Zone" formed practically of a more or less undulated plateau in the regions of El Houita, Hassi Delaa and Hassi R'mel.

2. High surfaces: The Saharan Atlas finds itself raised in a dorsal position in relation to the compartment: Saharan and high plains wedged between the two Atlases. They are presented in the form of gently sloping erosion surface, developed in semi-arid regions at the foot of reliefs. They form all the glacis, terraces, alluvial wadi channels and spreading and overflow zones (Pouget, 1980).

3. Depressions: These are closed type depressions with slightly inclined edges, shaped roughly circular, sometimes elliptical but always globose and rounded in diameter very variable which can exceed a few hundred meters (Tricart, 1969). Populated by "Pistacia atlantica" south of Laghouat. In this region they cover approximately 2% of the surface of the course grounds (Monjauze, 1968).

II.1.2. Pedology

According to Pouget (1980), Laghouat is considered among the richest wilayat in terms of pedological, in fact practically all the soils of southern Algeria cited by this author are met. In the part which covers the wilaya of Laghouat, the map shows a mosaic in which five classes of soils are dispersed (raw mineral soils, soils with little evolved, calcimagnesic soils, isohumic soils, and dayas soils). The soil of the study area is characterized by a sandy texture.

II.1.3. Saharan and sub-Saharan vegetation

The Saharan or sub-Saharan species which dominate in the Laghouat region are those which are adapted to drought as well as high temperatures: *Calligonum spp.*, *Genista saharae*, *Cornulaca spp.*, *Moltkiopsis spp.*, *Salsola spp.*, *Hammada spp.*, *Anabasis spp.*, *Artemisia spp.*, *Stipagrostis pungens*, *Retama raetam*, *Ziziphu slotus*, *Acacia raddiana*, *Pistacia atlantica* (Houyou, 2015).

II.1.4. study site

We carried out this study in the Wilaya Laghouat, Algeria under the abiotic conditions of the Kheneg site. These geographical data are summarized in the following table.

Table 2: Data GPS Kheneg:

Alternative Names:	Kheneg es Sifer
Type:	Gorge(s) - a short, narrow, steep-sided section of a stream valley
Mindat.org Region:	El Bayadh Province, Algeria
Region:	Wilaya de Laghouat, Algeria
Latitude:	33° 45' 45" N
Longitude:	1° 48' 59" E
Lat/Long (dec):	33.76259,1.81655
Köppen climate type:	BSk : Cold semi-arid (steppe) climate
Mindat Feature ID:	2479617
Long-form Identifier:	mindat:2:6:2479617:6
GUID:	ef5c2934-b11f-4948-a26f-d38e436fd7b5

II.1.5. Climate data

Located at an elevation of 765.52 meters (2511.55 feet) above sea level, Laghouat has a Mid-latitude desert climate (Classification: BWk). The city’s yearly temperature is 20.36ºC (68.65ºF) and it is 0.36% higher than Algeria’s averages. Laghouat typically receives about 10.04 millimeters (0.4 inches) of precipitation and has 30.82 rainy days (8.44% of the time) annually.

II.1.5.1. Ombrothermal diagram of BAGNOULS and GAUSSEN

Rainfall data between 1996 and 2016 from the wilaya of Laghouat shows that the rainiest month is September (25.63 mm) and the driest month is January (5.46 mm) and they give an annual average of 151.21 mm per year. The recorded humidity is 46.21%. The study of monthly average temperatures in the region reveals that the hottest month is July with a temperature of 36.08°C, while January is the coldest (1.96°C). The annual variations in wind speed in the study area are between 2.2 m/s and 5.6 m/s; the Laghouat region is classified in the Saharan bioclimatic stage with cool winter, where a single dry period spreads over the entire the year (Mallem et al.,2017), (Figure3).

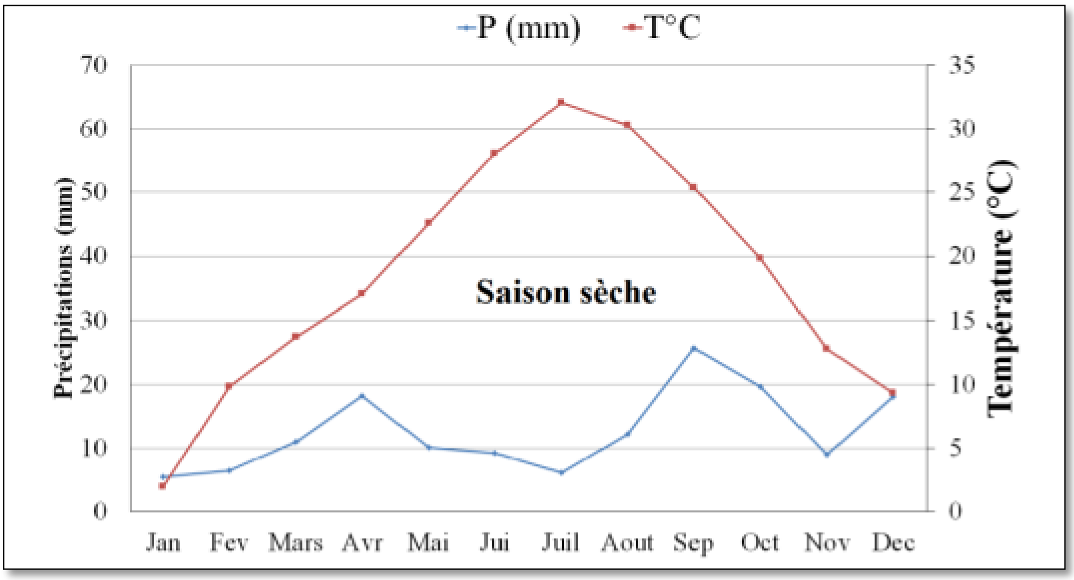

Figure 3: Ombrothermal diagram (1996-2016) from Laghouat region. (Mallem et al.,2017).

Ombrothermal diagram of BAGNOULS and GAUSSEN relating to the year of study between 2023 and 2024 from Larghouat region shows that the rainiest month is May (6 mm) and the driest month is October and November (0 mm). The study of monthly average temperatures in the region reveals that the hottest month is July with a temperature of 35°C, while April is the coldest (18°C) (Figure4).

II.2. Study Material

The experiment was carried out at the University Amar Telidji (Laghouat) faculty of sciences, Agronomy department. It was established in two parts. The first in the laboratory, in Petri dishes, and the second by sowing direct in soil and compost (in seed trays), placed in an aerated room under ambient conditions located in the Khenege site. In carrying out these tests, we used water from natural sources and taps.

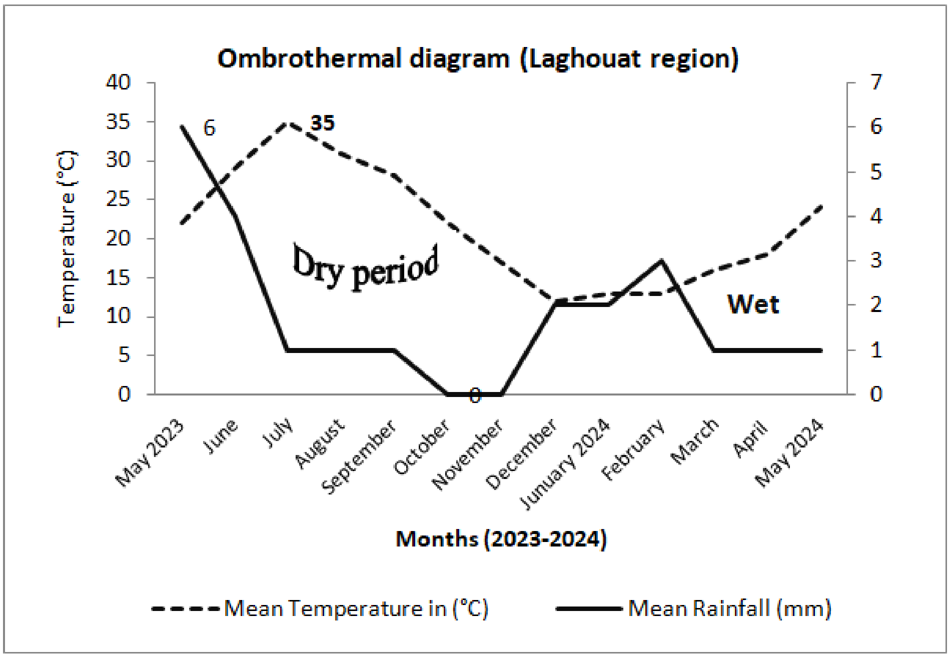

Figure4. Ombrothermal diagram of BAGNOULS and GAUSSEN (2023-2024) (Original, 2024).

II.2.1. Field data

We conducted one field in Laghouat region, collected one soil sample from 0 to 5cm depth and locate by GPS in the field. Sample collected according to the accessibility.

II.2.2. Equipment

We used the following material to carry out this study:

- Petri dishes. distilled water. polythene paper. Aluminum foil sheet. Thermometer fridges. Sprinkler. Plant support, pots
- High Top Humidity Domes. Open bottom Propagation Tray (50 cells).
- paper towel: Cellulose paper sheet size (220x225), 100/100 Virgin pulp
- Botanic Pallet Rack Trays. Accessories (Labels, plastic straws flexible)
- Amber glass (250 ml) wide mouth bottles. Wide mouth glass clear (250ml)

- Premium compost organic 10L bag produced in Laghouat
- Soil collected in a natural environment (Laghouat).

II.2.3. Seed characteristics and sampling

The plant material used to carry out our work consists of fruits and seeds imported of the *A. cherimola Mill* species, in the Laghouat region, within the Amar Telidji University Laboratory. based on data from the work of Kheloufi et al. (2020). This study focused on Cherimoya of varieties (cultivars) grown from *A. cherimola* Mill.

II.2.3.1. Definition of produce

UNECE Standard FFV-47 concerning the marketing and commercial quality control of Annonas : This standard applies to the fruits Cherimoya of varieties (cultivars) grown from *A. cherimola* Mill, classified as "Annonas", to be supplied fresh to the consumer, annonas for industrial processing being excluded by Frutas GARSAN (Source, 2024); (Source, 2019), (Figure5).

Frutas GARSAN is a family business that has been dedicated to the production and marketing of best products for more than 60 years. Garsan cherimoya can be consumed without any problem from September to May. During the first months of the campaign until November, the fruit has a partially ripe texture, however, from December to February it reaches a completely ripe texture due to the increase in hours of sun exposure. The consumption of a Garsan custard apple guarantees a quality production process. complying with the EEC-UN Standard FFV-47 (Annonas) (Source, 2024); (Source, 2019).

Maturity requirements: The development and state of maturity of the Annona must be such as to enable them to continue their ripening process and to reach a satisfactory degree of ripeness. To ensure a suitable degree of commercial maturity, the Annona must present the following characteristics: Cherimoya: the skin should have begun to turn to a pale green color. (Source, 2024).

Packaging: Annona must be packed in such a way as to protect the produce properly. The materials used inside the package must be clean and of a quality such as to avoid causing any external or internal damage to the produce. The use of materials, particularly of paper or stamps bearing trade specifications, is allowed, provided the printing or labelling has been done with non-toxic ink or glue. Stickers individually affixed to the produce shall be such that, when removed, they neither leave visible traces of glue nor lead to skin defects. Information lasered on single fruit should not lead to flesh or skin defects. Package must Be free of all foreign matter (Source, 2024).

Fruit

Fruit and seeds

Figure5: Custrad apple A. *cherimola Mill*. (Original, 2024)

Table3. Characteristics of cherimoya seeds:

	Stored Seeds (2019)		**Fresh Seeds (2024)**	
Weight (g) of fruit	N°1	N°2	N°1	N°2
	344g	270 g	324.4	360
Number of seeds	81		66	43
Weight of seeds	31.64g		42.89g	
Net Kilos	509g		568g	

II.3. Study of lifting the primary dormancy of seeds:

The development of germination techniques for seeds is of crucial importance. Many seeds require some form of pretreatment in order to germinate. This might be moisture enhancement, scarification of the seed coats, or temperature fluctuations which mimic the seasonal conditions for the natural cycle. As removal of the seed coat may damage the embryo, external preconditioning is usually performed by applying osmotic-regulation treatment, physical or chemical scarification, and/or temperature regimes to overcome seed dormancy or improve emergence rates. However, a technique for uniform cherimoya seed germination is still not standardized.

II.3.1. Treatment applied to seeds

Presently, a variety of approaches are being used to overcome abiotic stresses in plants. Recently, seed soaking with various priming agents has emerged as a promising strategy to induce tolerance in plants against abiotic stresses (Table 4).

Table 4. Treatment applied to cherimoya seeds:

Traitement	**Processing method**	**seeds**
Physical treatment	Cold starification	Stored seeds
	Soaking (Water)	Stored seeds Fresh seeds
Technical treatment	Cut or scrape	Stored seeds fresh seeds

II.3.1.1. The effect of seed storage duration on germination

Stored seeds: Two fruits of approximately 500 g weight were collected from mature commercial orchards in Granada (Spain), on November 2019. The seeds were extracted by opening the fruits and removing the pulp. Seeds were then cleaned and air dried for 10 days. Were then stored in Amber glass (250 ml) wide mouth bottles with labels (Figure 6).

Figure6. Stored seeds (*A. cherimola Mill*) (Original, 2024).

II.3.1.2. The effect of cold stratification on stored seeds

Cold treatment of seeds consists of placing the seeds in Petri dishes lined with paper towel, and soaked with 04 ml of distilled water. The petri dishes are covered with aluminum foil. They are then placed in the refrigerator at +2°C to +4°C for 3 days (Figure7). At the end of the treatment period: after treating the seeds for 72 hours in the cold, soak them in water for two days, then seedlings as follows:

- Plant the stored seeds (10 seeds X three replicates) about 1 inch below the soil in a germination tray with 50 cells.
- Plant the stored seeds (10 seeds X three replicates) about 1 inch below the mixture of (two volumes of compost with one volume of soil) in a germination tray with 50 cells.
- Sprinkling water, place the germination tray in the laboratory
- we cover the germination trays with polythene paper (Figure8).

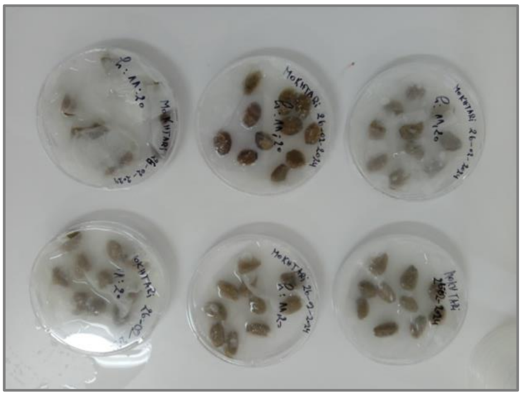

Figure7. seeds in Petri dishes (Original, 2023)

Figure 8: Germination tray of stored seeds in Laboratory (Original, 2024).

II.3.1.3. The effect of Soaking (Water) on fresh seeds

Fresh seeds: we imported cherimoya fruit. The fruits were collected from mature commercial orchards in Granada (Spain), on November 2023 (Figure9). Last reported price USD4.47/Kg; DA 4500 /Kg Cherimoya (Source, *Andalucia, 2023*). The seed sample for our experiment was obtained by mixing the seeds to minimize inter-genetic variation (Kheloufi et al., 2020). Seeds of length: 15 ± 1.77 mm, width: 10 ± 1.48 mm, weight: 0.41 ± 0.042 g, n=40) (Table 1. Annex).

The germination test in the tray was carried out at room temperature, varying , The experiment was performed in May-Jun, 2024. To determine the effect of temperature during germination we applied the following steps:

- Seeds: The seeds were extracted by opening the fruits and removing the pulp. Seeds were then cleaned.,
- Optional: Cut the tip of the pointed side of the seeds with a cutler or Nail cutter disinfected by Alcohol 120 Per cent to expose the inside to speed up germination.,
- Soak the seeds in water in wide mouth glass clear., wrap the boxes with aluminum foil for four days. We don’t throw any floating seeds.

we tested the seeds germination in three different seedlings:

1) Clear plastic box seedlings:

- Take a paper towel and place seed on it,
- Sprinkle some water and fold the paper towel
- Seal in a clear plastic box or polythene sheets or Ziploc bag
- Place at a warm place in shade, check every week germination (Figure 9)

2) Compost seedlings:

- Plant the seeds about 1 inch below the soil in a germination tray
- Place the germination try in shad at worm place
- Keep the compost moist
- cover the seedling tray with High-top Humidity Domes
- Sprinkle some water every 48 or 72 hours (Figure 9).

3) Soil seedlings:

- Plant the seeds about 1 inch below the soil in a germination tray
- Place the germination try in shad at worm place
- Keep the soil moist. cover the seedling tray with High-top Humidity Domes
- Sprinkle some water every 24 or 48 hours (figure 9).

Figure 9. Test germination on abiotic conditions (Original, 2024).

II.4. Parameters evaluated:

Seeds were incubated simultaneously for 15 days, in natural climatic conditions as lights, under room temperature. Germination counts were performed daily, to determine germination kinetics. Seeds were considered germinating only when 2 mm radicles emerged. The parameters evaluated were as follows:

II.4.1. Final germination percentage FGP(%):

$FGP(\%) = (\Sigma ni/N) \times 100$ where :

FGP is the Final Germination Percentage,

ni is the number of seeds germinated on the last day of testing,

N is the total number of seeds incubated per test.

However, FGP only reflects the final percentage of germination attained and provides no picture of the speed or uniformity of germination (Côme, 1970).

II.4.2. Mean germination time MGT (days)

$MGT(days) = \Sigma(ti.ni)/\Sigma ni$. where:

MGT is the mean germination time,

ti is the number of days since the start of the test,

ni is the number of germinated seeds recorded at time ti,

Σni is the total number of germinated seeds (Orchard, 1977).

II.4.3. coefficient of velocity of germination

$CVG(\%) = \Sigma Ni/ \Sigma(Ni.Ti)/ \times 100$, where :

CVG is the coefficient of velocity of germination,

Ni is the number of seeds germinated each day,

Ti is the number of days from sowing corresponding to N (Jones and Sanders, 1987).

The coefficient of velocity of germination gives an indication of the rapidity of germination. It increases when the number of germinated seeds increases and the time required for germination decreases. Theoretically, the highest CVG possible is 100, which is the case if all seeds germinated on the first day (Jones and Sanders, 1987).

II.4.4. The time up to 50% germination

$$T50\ (days) = t1 + \left(\frac{(0.5 - n1)}{(n2 - n1)}\right) \times (t2 - t1)$$

Where:

- T50 (days) is the time up to 50% germination,
- n1 is the cumulative percentage of germinated seeds, which value is closest to 50% by a lower value,
- n2 is the cumulative percentage of germinated seeds, which value is the closer to 50% by higher value,
- t1 is the time necessary for the germination of n1 of seeds,
- t2 is the time necessary for the germination of n2 of seeds. The lengths of eight randomly selected seedlings (SL) per thermal condition were also recorded at the end of the experimental period using a digital caliper (Côme, 1970).

II.4.5. Temperature effect

Temperature is one of the most important factors that determine plant growth, development, and yield. Accurate summarization of plant temperature response is thus a prerequisite to successful crop systems modelling and application of such models to management. This paper reports on a general equation that can be used to simulate the temperature response of plants (Yan et Hunt, 1999).

The equation reads as $$r = R_{max}\left(\frac{T_{max} - T}{T_{max} - T_{opt}}\right)\left(\frac{T}{T_{opt}}\right)^{\frac{T_{opt}}{T_{max} - T_{opt}}}$$

Where:

- *r* is the daily rate of growth (or development) at any temperature, *T*opt is the optimum temperature,

- Tmax is the maximum temperature,
- *R* max is the maximum rate of growth or development at *T*opt.

It has the smallest number of parameters possible to simulate the plant response to the full range of temperatures relevant to plant growth and development. The equation was shown to successfully simulate the growth and development of maize, bean, wheat, barley, sorghum, and lambsquarters. The equation could find application in crop germplasm classification, crop modelling and environmental control of artificial crop production systems (1999 Annals of Botany Company in Yan et Hunt, 1999).

III.5. Statistical analysis

An ANOVA was carried out to determine the effect of the different physical treatments applied for breaking dormancy and on the germination of seeds of the *A. cherimoya* species depending on the variation of the abiotic factors studied.

Section III

Results and Discussion

Section III

Results and Discussion

III.1. The effect of cold stratification on stored seeds

III.1.1. Test of cherimoya seed soaking in water

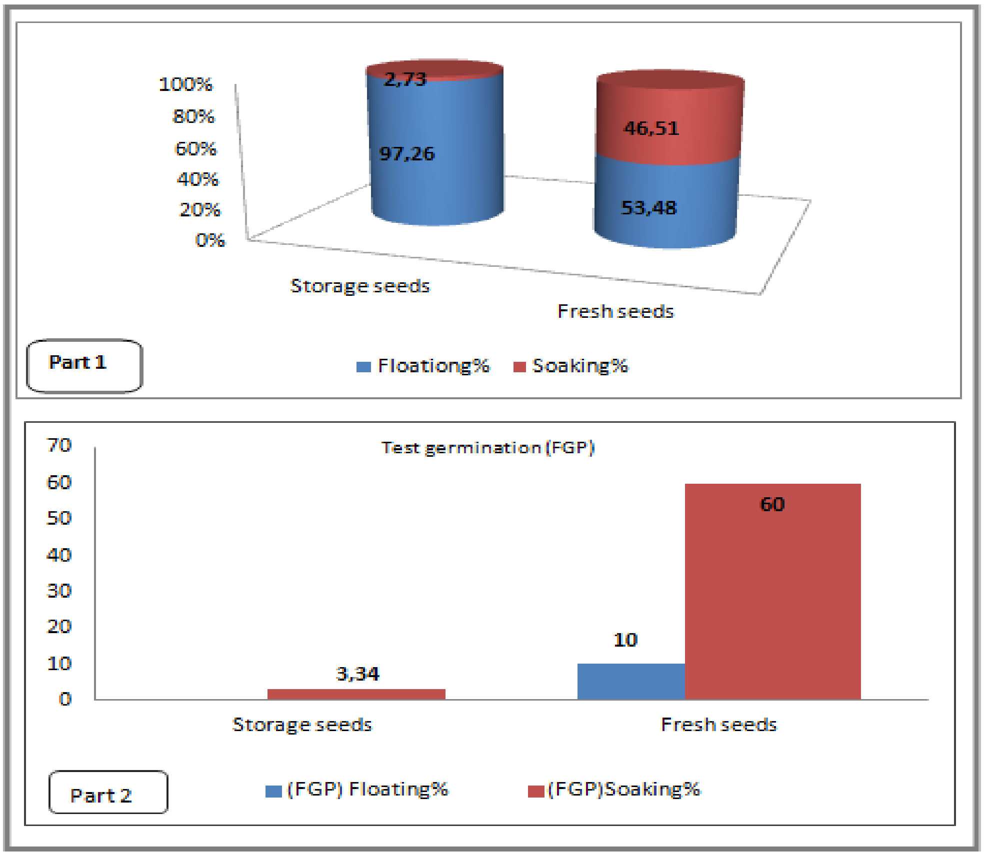

Figure 10. Test of seed Cherimoya soaking in water

The first part in Figure 10, presents the results of soaking the Storage seeds releasing 97.26% of the seeds floated and 2.73% soaked. For the fresh seeds, we have 46.51% of the seeds soaked and 53.48% of the seeds floated.

The second part shows the final germination percentage (FGP): for Storage seeds (FGP Floationg= 0% and FGP= 3.34% Soaking), for Fresh seeds (FGP Floationg = 10% and FGP Soaking= 60%).

III.1.2. Effect of storage duration on Seeds-Storage Germination of Cherimoya

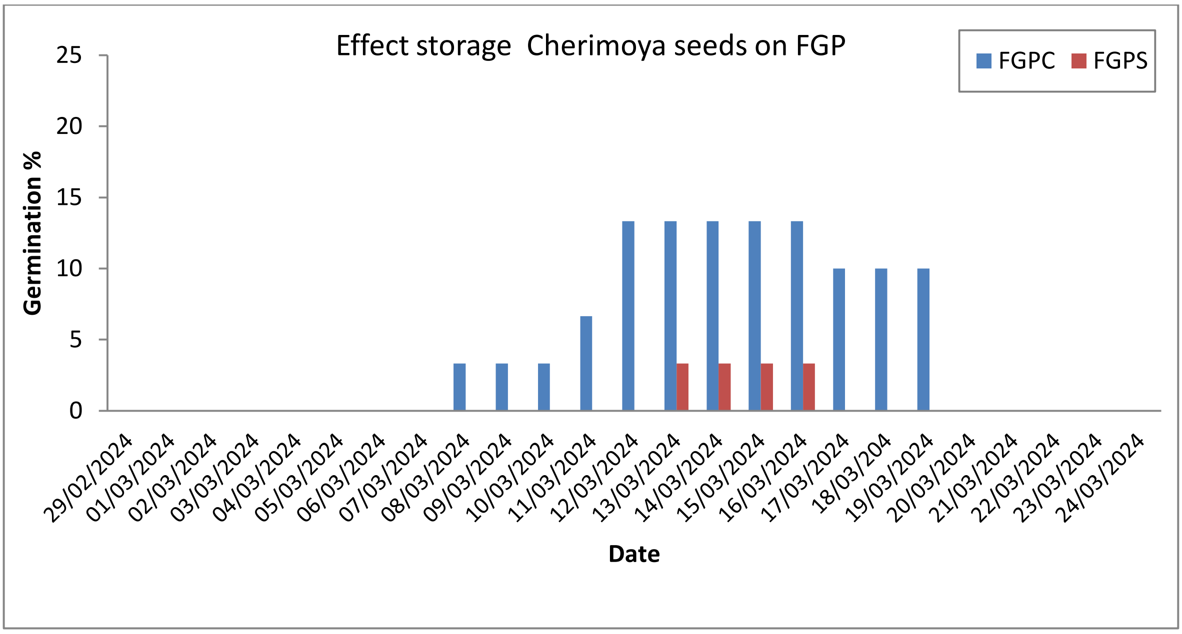

Figure 11. Effect of cold stratification on stored seeds germination of cherimoya in different trays for 25 days.

FGPC: the final germination percentage in Compost trays. FGPS: The final germination percentage in (mixed soil and compost).

The effect of cold stratification on stored seeds germination kinetic of cherimoya seeds is illustrated in Figure 11, in which three stages are indicated: a first period of latency due to the imbibition (8days), a second exponential period where germination is accelerated (9days) and a short and limited stationary phase (3days) in compost trays.

In mixed soil and compost trays, Figure 2 represents two stages the period of latencs (13 days) and period exponential (4 days). we kept the trays until June but we noticed a blockage of germination in the trays.

III.1.3. Tests germination of *A. cherimoya* Storage seeds on different tray seedlings

According to Table6, Final germination percentage (FGP=0%), mean germination time (MGT= 0.66 days), coefficient of velocity of germination (CVG= 8.33), time to 50% germination (T50=0) (n=4) of *A.cherimola* on different tray seedling, these parameters were measured over an incubation period of 25 days And Sowing of stored seeds lasts until mid-June 2024, the equivalent of 14 weeks but we observed no germination. These results showed duration storage effect, which played a very important role in germination activity induction.

Table 6: Tests germination of *Aannona cherimoya* Storage seeds on different tray seedlings

	Treatment	FGP %	MGT (days)	CVG %	T50 (days)
Storage seeds	Compost	0	0,66	8,33	0
Storage seeds	Soil+compost	0	0,2	20	0

Final germination percentage (FGP), mean germination time (MGT), coefficient of velocity of germination (CVG), time to 50% germination (T50=0) (n=4) of Annona cherimola on different tray seedling.

III.1.4. Discussion:

The treatments that promoted the best seedling vigor expression were those that involved cold-temperature storage. Our results indicated that seed storage in combination with GA_3 treatment overcame dormancy (Vidal, 1980).

Soaking the seeds before sowing is an age-old practice of ancient civilizations without the knowledge of plant physiology and biochemistry. As a result, we do not exactly know when and by whom this practice was started, evolved, and promoted to the farming community. Different communities of horticultural crops are soaked differently, and pulse crops vary in time durations of soaking. Seed can germinate in three weeks under these conditions. At lower temperatures (15-20°C), germination is delayed by 3-4 months and the germination percentage decreases (George and Nissen, 1986).

The seed soaking method and duration of seed soaking vary from crop to crop, but commonly used labor-intensive low-technology and high-technology methods are manual or machine shaking in the weather timings. However, the requirement of these technologies depended upon the seed size, age, and seed soaking time duration requirement for the specific crop.

The most likely explanation of the negative result about the Effect of cold stratification on stored seeds germination of cherimoya is the longue storage duration. The results of the Effect of storage of cherimoya seeds on germination show that the storage duration of *A. cherimola* seeds does not exceed 4 years.

III. 2. The effect of Soaking (Water) on fresh seeds

III.2.1. Test soaking seeds and floating seeds germination on different tray seedlings

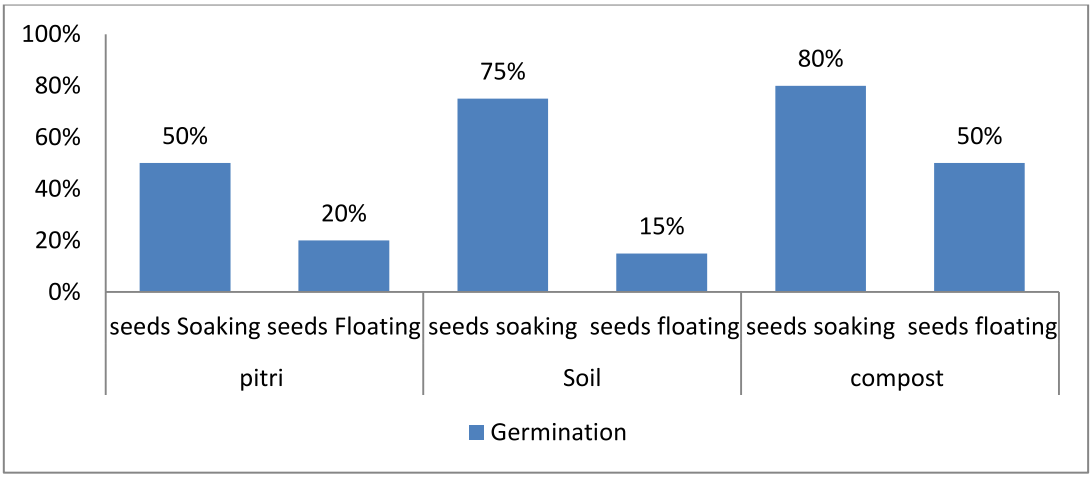

Figure12. Test soaking seeds and floating seeds germination on different tray seedlings

We have introduced a new approach to Test soaking fresh seeds and floating fresh seeds germination on different tray seedlings, The Figure illustrates the results: germination of 50 % seeds soaking and 20% seeds floating in box trays. Germination 75% of seeds soaking and 15% seeds floating in soil trays. Germination of 80% seeds soaking and 50% seeds floating in compost trays.

III.2.2. Effect seedling trays on fresh seed germination of cherimoya

Figure 13 shows the results thus obtained of the differences in germination speed due to tray seedlings under abiotic conditions are:

- The first seeds germinated in compost tray seedlings as rapidly after 10 days (6 May to 16 May 2024),

- The first seeds germinated in soil tray seedlings as rapidly after 18 days (6 May to 24 May 2024).
- The first seeds germinated in box tray seedlings as rapidly after 15days (6May to 21 May 2024).

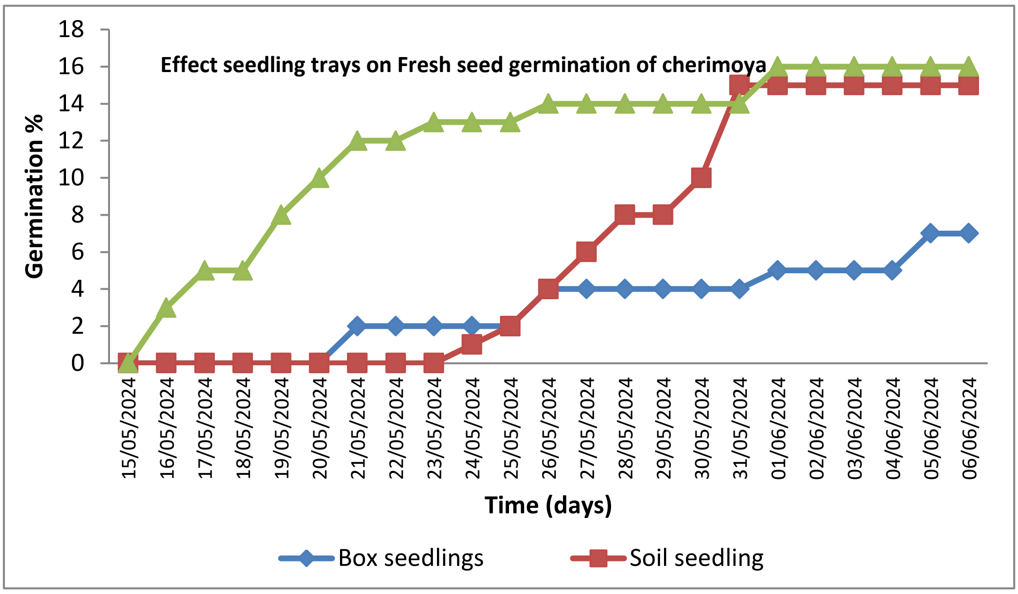

Figure13. Results of effect different tray seedlings on fresh seed germination of *A. cherimola.*

III.2.3. Results of Tests germination of *A.cherimoya*. Fresh seeds on different tray seedlings

Table7.Tests germination of *A. cherimoya* Fresh seeds on different tray seedlings

	Tray seedlings	**FGP%**	**MGT (Days)**	**CVG%**	**T50 (Days)**
Fresh seeds	box	50	16.45	5.88	17.43
Fresh seeds	soil	75	4.58	7.14	6.25
Fresh seeds	compost	80	8.00	4.54	7.78

Final germination percentage (FGP), mean germination time (MGT), coefficient of velocity of germination (CVG), time to 50% germination (T50=0) of A.cherimoya Mill. on different tray seedlings.

The parameters were measured over an incubation period of 25 days during the experimental period (1 May to 15 Jun 2024 equivalent to 6 weeks), According to Table7:

Final germination percentage (FGP=50%), mean germination time (MGT= 16.45 days), coefficient of velocity of germination (CVG= 5.88%), time to 50% germination (T50=17.73 days) of *A. cherimola* on box tray seedlings.

Final germination percentage (FGP=75%), mean germination time (MGT= 4.58 days), coefficient of velocity of germination (CVG= 7.14%), time to 50% germination (T50=6.25 days) of *A. cherimola* on soil tray seedlings.

Final germination percentage (FGP=80%), mean germination time (MGT= 8 days), coefficient of velocity of germination (CVG= 4.54%), time to 50% germination (T50=7.78 days) of *A. cherimola* on compost tray seedlings.

III.2.4. Effect of thermal parameters on cherimoya germination (2024)

Weather report for May 2024 in Laghouat was ideal. On average, at the start of the morning it was 18°C and the sun was shining. The weather generally remained similar at midday with temperatures strengthening to 28°C. In the early evening, temperatures increased to 29°C at 7 p.m. In May 2024 in Laghouat, the maximum temperature was on average 31°C (record 36°C) and the minimum temperature was 18°C. There was little precipitation this month, with a total of 3mm over the month.

Consider Fig.14: Tmax°C: maximum temperatures. Tmin°C minimum temperatures (WorldWeather Online). (FSP) : germination of fresh seeds on box seedlings. (FSS): germination on soil tray seedlings. (FSC): germination compost tray seedlings.

Germination in box: A first period of latency (Tmin=10 to13°C. Tmax=25.4°C), a second exponential period where germination is accelerated (Tmin=10 to18°C. Tmax°C=33.8°C) and a stationary phase (Tmin=10 to 22°C. Tmax= 35°C).

Germination in soil tray seedlings: A first period of latency (Tmin=10 to 20°C. Tmax= 30.1°C), a second exponential period where germination is accelerated (Tmin=22°C. Tmax=31°C) and a stationary phase (Tmin=21°C. Tmax= 32.2°C).

Germination in compost tray seedlings: A first period of latency (Tmin= 10 to 19°C Tmax=33°C), a second exponential period where germination is accelerated (Tmin=12.8°C. Tmax=22.5°C) and a short and limited stationary phase (Tmin=23°C. Tmax= 33°C).

We use the temperature table data (Annex) for the application of the mathematical formula of YAN and HUNT (1999). The results of the non-linear regression of temperatures applied to the number of germinations in the different cherimoya germination trays of the period (May 1 to June 6, 2024) are shown in the table 8.

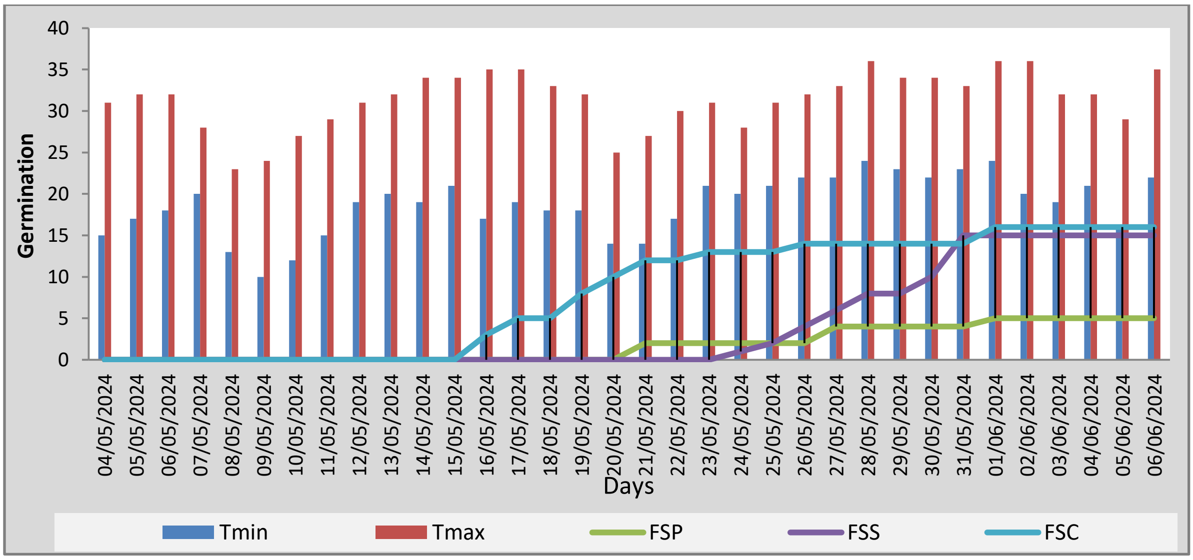

Figure14: Effect of thermal parameters on cherimoya germination (2024).

Table8. Estimation of temperature with formula YAN and HUNT (1999).

YAN-HUNT (1999)					
	R max	TL (°C)	Dmax (Tinf)	TDMAX (°C)	r
FSP	5	10	0	38	0.73
FSS	15	10	0	38	0.9
FSC	16	10	0	38	0.9

FSP: Fresh Seeds on Pitri or box. FSS: Fresh Seeds on Soil. FSC: Fresh Seeds on Compost, r is the daily rate of growth (or development) at any temperature. (Topt) is the optimum temperature. TDMAX (°C) is the maximum temperature of growth or development at (Tmax).

R max is the maximum rate of growth or development at (Topt). TL (°C)=Tmin. Dmax (Tinf) is the maximum rate of growth or development at (Tinf).

Table shows the lowest temperature is 10°C which corresponds to the minimum germination number. the highest temperature is 38°C for the high number of germinated seeds.

Table9: Effect of thermal parameters on cherimoya germination (2024).

	Probability P (Test ANOVA one-way)	
	Tmin	Tmax
FSPbox	0,0001497	0,0001497
FSSsoil	0,0001497	0,0001209
FSCompost	0,0001497	0,0001209

$p \leq 0.001$: very highly *significant*

According to this table cherimoya, fresh seeds exhibit variable behaviors (P<0.0001) at minimum temperature and (p<0.0001) at maximum temperature at room temperature.

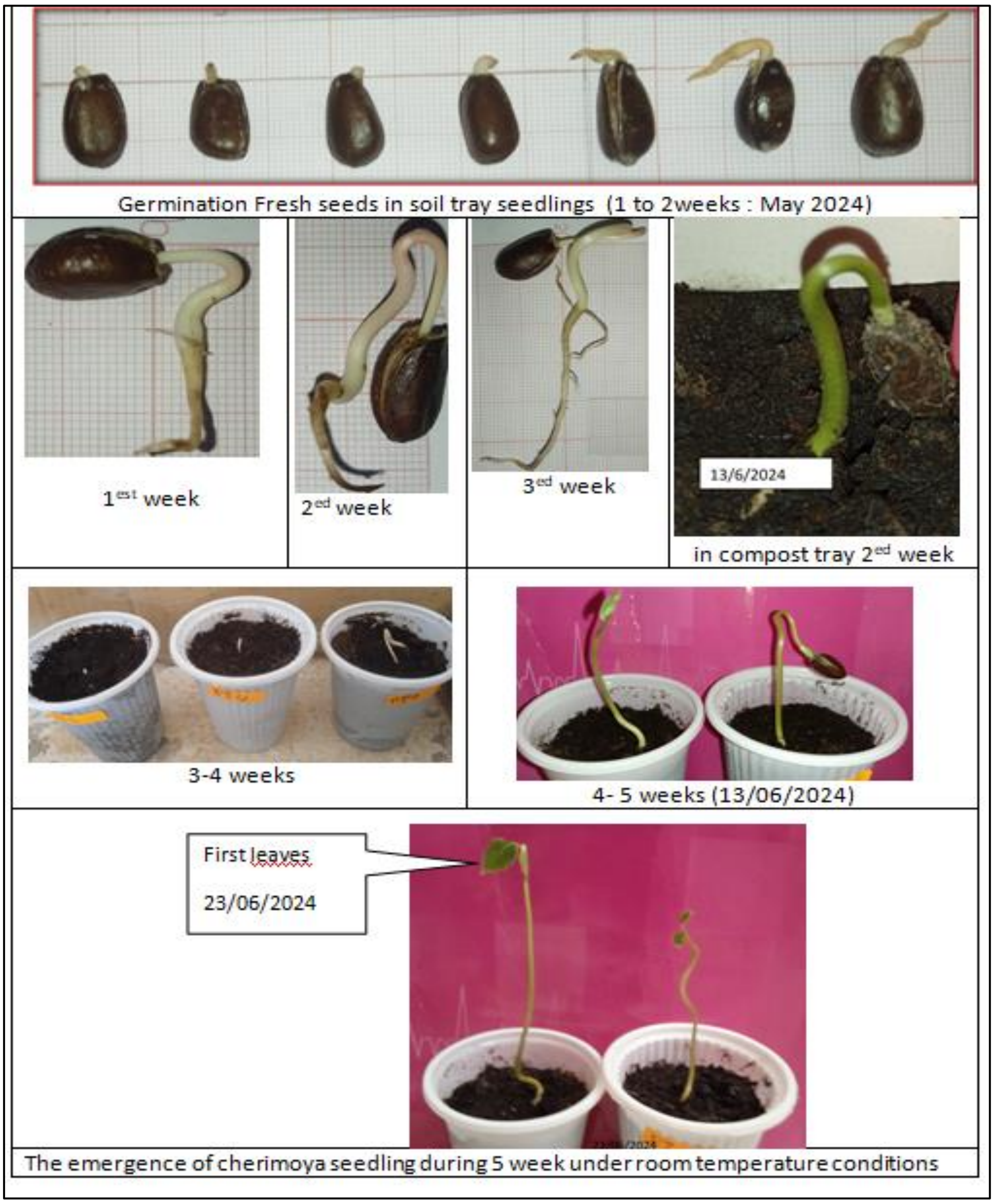

Figure14.Germination of *A. cherimola* Under room temperature condition, Laghouat region

III.2.5. Discussion

Water soaking can directly affect the structural components of the seed coat, potentially enhancing water uptake. Many seeds owe their impermeable seed coat to the deposition of suberin and tight structural associations between the different layers in the mature seed coat. Exogenous treatments, which are referred to as after-ripening treatments, can overcome such dormancy and may include leaching by rinsing seeds in flowing water (often by deposition). the best soaking methods of seeds were standardized. Already then, a few recognized and patented the soaking of the seeds and the production of the seedlings immediately after soaking (https://aithor.com/fr-fr/support).

Temperature preconditioning during seed development and maturation affected the degree of dormancy present in freshly harvested seed. The duration of exposure to different temperatures and the stage of development at which the seeds were exposed to high or low temperature also influenced the degree of dormancy. Exposure to 1 week of low temperature during ripening increased seed dormancy, but at anthesis reduced dormancy. Extended periods of low temperature during seed development increased seed weight. Seed weight was reduced when seeds were exposed to high temperatures during the 2nd week of seed development (Loren, 1972).

The best treatments that promoted germination were room temperature storage with 400 ppm GA3 (83.68%) and room temperature storage with 500 ppm GA3 (83.46%). These treatments had more than 50% germination 10 days after sowing (vidal, 1980).

Among the *Annonaceae*, only a limited number of species, belonging to two genera, Annona and Asimina, produce edible fruits. The genus Asimina, the only member of the family that has successfully adapted to temperate climes, comprises a total of 12 species (Maas et al., 2019).

Conclusion

In this study we have discussed seeds are treated with natural compounds before germination to initiate specific physiological states in plants at abiotic conditions Germination test in germination try was carried out at the Laboratory of the Department of Agronomy, The experiment was performed at room temperature, varying. To determine the effect of temperature during germination.

The main objective of this work was to study the germination and emergence of *A. cherimola* Mill in Laghouat region. It was interested in the study of primary dormancy in the first time, but also on seed germination behavior to cope with some abiotic factors, in emergence, as well as in the conservation of their viability.

Technical and physical (water) treatments were applied on the seeds for breaking of dormancy. Secondly, a simulation on the effect of abiotic factors (Soil, Temperature, humidity, lumière) and depth on the germination of the study *A. cherimola* were applied with temperature levels, water, soil, Compost.

The final germination percentage (FGP): for Storage seeds (FGP Floating= 0% and FGP= 3.34% Soaking), for Fresh seeds (FGP Floating = 10% and FGP Soaking= 60%). The results of the Effect of storage of cherimoya seeds on germination show that the storage duration of *A. cherimola* seeds does not exceed 4 years.

the results of germination fresh: germination of 50 % seeds soaking and 20% seeds floating in box trays. Germination 75% of seeds soaking and 15% seeds floating in soil trays. Germination of 80% seeds soaking and 50% seeds floating in compost trays.

The results thus obtained of the differences in germination speed due to tray seedlings under abiotic conditions are: The first seeds germinated in compost tray seedlings as rapidly after 10 days, The first seeds germinated in soil tray seedlings as rapidly after 18 days. The first seeds germinated in box tray seedlings as rapidly after 15 days.

The results of the parameters germination test were measured over an incubation period of 25 days during the experimental period are Final germination percentage (FGP=50%), mean germination time (MGT= 16.45 days), coefficient of velocity of germination (CVG= 5.88%), time to 50% germination (T50=17.73 days) of *A. cherimola* on box tray seedlings.

Final germination percentage (FGP=75%), mean germination time (MGT= 4.58 days), coefficient of velocity of germination (CVG= 7.14%), time to 50% germination (T50=6.25 days) of *A. cherimola* on soil tray seedlings.

Final germination percentage (FGP=80%), mean germination time (MGT= 8 days), coefficient of velocity of germination (CVG= 4.54%), time to 50% germination (T50=7.78 days) of *A. cherimola* on compost tray seedlings.

Germination in box: A first period of latency (Tmin=10 to13°C. Tmax=25.4°C), a second exponential period where germination is accelerated (Tmin=10 to18°C. Tmax°C=33.8°C) and a stationary phase (Tmin=10 to 22°C. Tmax= 35°C).

Germination in soil tray seedlings: A first period of latency (Tmin=10 to 20°C. Tmax= 30.1°C), a second exponential period where germination is accelerated (Tmin=22°C. Tmax=31°C) and a stationary phase (Tmin=21°C. Tmax= 32.2°C).

Germination in compost tray seedlings:A first period of latency (Tmin= 10 to 19°C Tmax=33°C), a second exponential period where germination is accelerated (Tmin=12.8°C. Tmax=22.5°C) and a short and limited stationary phase (Tmin=23°C. Tmax= 33°C).

We use the mathematical formula of YAN and HUNT (1999). The results of the non-linear regression of temperatures applied to the number of germinations in the different cherimoya germination trays of the period (May 1 to June 6, 2024) are Tmin=10°C a Tmax=38°C. Fresh seeds exhibit variable behaviors ($P<0.0001$) at minimum temperature and ($p<0.0001$) at maximum temperature at room temperature.

Perspective :

- In the light of these results we propose the continuation of this experiment to know the development of this species.
- Try This Protocol in different climatic stages in Algeria.
- We Hope to use the seeds of *Annona cherimoya* in the future in the extraction of oïl as part of the biological fight against plant diseases.

List of references

Acosta, J. *Historia Natural y Moral de las Indias*; Casa Juan de Leon: Sevilla, Spain, 1590.

Alaly, F.Q.; Liu, X.X.; McLaughlin, J.L. Annonaceous acetogenins: Recent progress. *J. Nat. Prod.* **1999**, *62*, 504–540. [CrossRef][PubMed]

Alali FQ, Kaakeh W, Bennett GW, McLaughlin JL (1998) Annonaceous acetogenins as natural pesticides: potent toxicity against insecticide-susceptible and -resistant German cockroaches (Dictyoptera: Blattellidae). J Econ Entomol 91 :641.

Almeida, M.M. El viaje a México de Hilarión de Bérgamo, un testimonio de su vegetación y paisaje. In *Arte, Historia y Cultura:Nuevas Aproximaciones al Conocimiento del Paisaje*; Universidad Autónoma Metropolitana: Mexico City, Mexico, 2017; pp. 71–89.

Andres-Agustin, J.; Gonzalez, F.; Nieto, R.; Barrientos, A.F. Morphometry of the organs of cherimoya (*Annona cherimola* Mill.) and analysis of fruit parameters for the characterization of cultivars, and Mexican germplasm selections. *Sci. Hortic.* **2006**, *107,* 337–346. [CrossRef]

Aidoud A. (1983). Contribution à l'étude des écosystèmes steppiques du Sud-Oranais : phytomasse, productivité primaire et applications pastorales. Thèse Doctorat 3ème Cycle, USTHB, Alger, 256 p.

Ashraf M.A., Akbar A.**,** Sajjad Hassan Askari S.H.**,** Iqbal Hussain I. (2018)**.** Recent Advances in Abiotic Stress Tolerance of Plants Through Chemical Priming: An Overview**.** June 2018**.** DOI: 10.1007/978-981-13-0032-5_4**.** In book: Advances in Seed Priming

Azucena Durán-Ruiz C., González-Esquinca A.R., Iván de-la-Cruz-Chacón. Annonaceous acetogenins: A comparative analysis of insecticidal activity. Acetogeninas de Anonáceas: uma análise comparativa de sua atividade inseticida. Laboratorio de Fisiología y Química Vegetal, Instituto de Ciencias Biológicas, Universidad de Ciencias y Artes de Chiapas (UNICACH), Tuxtla Gutiérrez, Chiapas, México.*Corresponding author: aesquinca@unicach.mx. Rev. Bras. Frutic. 2024; 46: e-508. 19p.

Barlow, C. *The Ghosts of Evolution: Nonsensical Fruit, Missing Partners, and Other Ecological Anachronisms*; Basic Books: New York, NY, USA, 2000.

Blazier, J.C.; Ruhlman, T.A.; Weng, M.L.; Rehman, S.K.; Sabir, J.S.M.; Jansen, R.K. Divergence of RNA polymerase α subunits in angiosperm plastid genomes is mediated by genomic rearrangement. *Sci. Rep.* **2016**, *6*, 24595. [CrossRef] [PubMed]

Bitocchi, E.; Nanni, L.; Bellucci, E.; Rossi, M.; Giardini, A.; Zeuli, P.S.; Logozzo, G.; Stougaard, J.; McClean, P.; Attene, G.; et al. Mesoamerican origin of the common bean (*Phaseolus vulgaris* L.) is revealed by sequence data. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 788–796. [CrossRef] [PubMed]

Bitocchi, E.; Bellucci, E.; Giardini, A.; Rau, D.; Rodriguez, M.; Biagetti, E.; Santilocchi, R.; Spagnoletti, Z.P.; Gioia, T.; Logozzo, G.; et al. Molecular analysis of the parallel domestication of the common bean (*Phaseolus vulgaris*) in Mesoamerica and the Andes. *New Phytol.* **2013**, *197*, 300–313. [CrossRef] [PubMed]

Cortes, D.; Moreno, L.; Parraga, J.; Galan, A.; Cabedo, N. Nuevos fármacos inspirados en Annonáceas. *Rev. Bras. Frutic.* **2014**, *36*,22–31. [CrossRef]

Côme, D. (1970). Obstacles to germination. Masson et Cie., Paris, 162 p.

Couvreur, T.L.; van der Ham, R.W.; Mbele, Y.M.; Mbago, F.M.; Johnson, D.M. Molecular and morphological characterization of a new monotypic genus of *Annonaceae*, *Mwasumbia*, from Tanzania. *Syst. Bot.* **2009**, *34*, 266–276. [CrossRef]

Chatrou, L.W.; Pirie, M.D.; Erkens, R.H.J.; Couvreur, T.L.P.; Neubig, K.M.; Abbott, J.R.; Mols, J.B.; Maas, J.W.; Saunders, R.M.K.; Chase, M.W. A new subfamilial and tribal classification of the pantropical flowering plant family *Annonaceae* informed by molecular phylogenetics. *Bot. J. Linn. Soc.* **2012**, *169*, 5–40. [CrossRef]

Cautin, R.; Agusti, M. Phenological growth stages of the cherimoya tree (Annona cherimola Mill.). *Sci Hortic.* **2005**, *105*, 491–497. [CrossRef]

Chevalier Auguste (1925). La Culture du Chérimolier en France. In: Revue de botanique appliquée et d'agriculture coloniale, 5e année, bulletin n°44, 30 avril 1925. pp. 288-290; doi : https://doi.org/10.3406/jatba.1925.4280https://www.persee.fr/doc/jatba_03703681_1925_num_5_44_4280, Fichier pdf généré le 29/03/2019.

Clement, C.R. 1492 and the loss of Amazonian crop genetic resources. The relation between domestication and human population decline. *Econ. Bot.* **1999**, *53*, 188–202. [CrossRef]

Doyle, J.A.; Le Thomas, A. Phylogeny and geographic history of *Annonaceae*. *Geogr. Phys. Quat.* **1997**, *51*, 353–361. [CrossRef]

Doyle, J.A.; Le Thomas, A. Cladistic analysis and pollen evolution in *Annonaceae*. *Acta Bot. Gall.* **1994**, *141*, 149–170. [CrossRef].

Darwin, C.R. Beagle Diary (1831–1836). Available online: http://http://darwin-online.org.uk (accessed on 20 March 2024).

Djebaili S. (1984). Recherches phytosociologiques et phytoécologiques sur la végétation des Hautes plaines steppique et de l'Atlas saharien. O.P.U Alger, 177p. + Ann.

De la Pena, E. ; Perez, V. ; Alcaraz, L.; Lora, J.; Larranaga, N.; Hormaza, J.I. Polinizadores y polinización en frutales subtropicales:Implicaciones en manejo, conservación y seguridad alimentaria. *Ecosistemas* **2018**, *27*, 91–101.

Doneen L. D. and john H. macgillivray germination (emergence) of vegetable seed as affected by different soil moisture conditions. divisions of irrigation and truck crops university of california,https://www.ncbi.nlm.nih.gov/pmc/articles/PMC438124/pdf/plntphys00285-0211.pdf

Ellstrand, N.C.; Lee, J.M. Cultivar identification of cherimoya (*Annona cherimola* Mill) using isozyme markers. *Sci. Hortic.* **1987**, *32*, 25–31. [CrossRef]

Ellegren, H. Microsatellites: Simple sequences with complex evolution. *Nat. Rev. Genet.* **2004**, *5*, 435–445. [CrossRef]

Encina, C.L.; Barceló-Muñoz, A.; Herrero-Castaño, A.; Pliego-Alfaro, F. In vitro morphogenesis of juvenile Annona cherimola Mill., bud explants. *J. Hortic. Sci.* **1994**, *69*, 1053–1059. [CrossRef]

Escribano, P.; Viruel, M.A.; Hormaza, J.I. Characterization and cross-species amplification of microsatellite markers in cherimoya (*Annona cherimola* Mill.; Annonaceae). *Mol. Ecol. Notes* **2004**, *4*, 746–748. [CrossRef]

Escribano, P.; Viruel, M.A.; Hormaza, J.I. Molecular analysis of genetic diversity and geographic origin within an *ex situ* germplasm collection of cherimoya by using SSRs. *J. Am. Soc. Hortic. Sci.* **2007**, *132*, 357–367. [CrossRef]

Ferrer, C.; Hormaza, J.I.; Lora, J. Phenological growth stages of pawpaw [*Asimina triloba* (L.) Dunal, *Annonaceae*] according to the BBCH scale. *Sci. Hortic.* **2022**, *295*, 110853. [CrossRef]

Fries, R.E. *Annonaceae. Die Natürlichen Pflanzenfamilien*, 2nd ed.; Engler, A., Prantl, K., Eds.; Duncker & Humblot: Berlin, Germany, 1959.

Gottsberger, G. How diverse are *Annonaceae* with regard to pollination? *Bot. J. Linn. Soc.* **2012**, *169*, 245–261. [CrossRef]

Guo, X.; Tang, C.C.; Thomas, D.C.; Couvreur, T.L.P.; Saunders, R.M.K. A mega-phylogeny of the *Annonaceae*: Taxonomic placement of five enigmatic genera and recognition of a new tribe, Phoenicantheae. *Sci. Rep.* **2017**, *7*, 7323. [CrossRef] [PubMed]

Guichoux, E. ; Lagache, L.; Wagner, S.; Chaumeil, P.; Leger, P.; Lepais, O.; Lepoittevin, C.; Malausa, T.; Revardel, E.; Salin, F.; et al. Current trends in microsatellite genotyping. *Mol. Ecol. Resour.* **2011**, *11*, 591–611. [CrossRef]

Gonzales, M. Chirimoya (*Annona cherimola* Miller), frutal tropical y sub-tropical de valores promisorios. *Cultrop* **2013**, *34*, 3.

George, A.P. & Nissen, R.J. (1986).**Custard Apple.** Biennial Report Maroochy Horticulture Research Station**, 4: 46-68.**

García-Carmona M., Márquez-San Emeterio L., Reyes-Martín M.P., Ortiz-Bernad I., Sierra L., Fernández-Ondoño E. (2020). Changes in nutrient contents in peel, pulp, and seed of cherimoya (*Annona cherimola* Mill.) in relation to organic mulching on the Andalusian tropical coast (Spain). Departamento de Agroquímica y Medio Ambiente, Universidad Miguel Hernández. Avenida de la Universidad s/n, 03202-Elche, Spain. Instituto de Recursos Naturales y Agrobiología de Sevilla (IRNAS-CSIC), Avenida Reina Mercedes 10, 41012-Sevilla, Spain._© 2019 Elsevier B.V. All rights reserved.

García, W.; Guzmán, B.; Lino, V.; Rojas, J.; Hermoso, J.M.; Guirado, E.; González, J.; Scheldeman, X.; Hormaza, J.I. *Manual de Manejo Integrado del Cultivo de Chirimoyo*; Fundación para la promoción e Investigación de Productos Andinos (PROINPA): Cochabamba, Bolivia, 2010.

Guadano A, Gutierrez C, de La Pena E, Cortes D, Gonzalez-Coloma A (2000) Insecticidal and mutagenic evaluation of two annonaceous acetogenins. J Nat Prod 63:773.

Hannachi A. (1981). Relation entre aquifères superficiels et profonds : Hydrogéologie de la vallée d'oued M'zi à l'Est de Laghouat. Thèse de Doctorat, Université de Grenoble, 121p.

He K, Zeng L, Ye Q, Shi G, Oberlies NH, Zhao GX, Njoku CJ, McLaughlin JL (1997) Comparative structure-activity relationship evaluations of annonaceous acetogenins for pesticidal activity. Pestic Sci 49:372.

Hui YH, Rupprecht JK, Liu YM, Anderson JE, Smith DL, Chang CJ, McLaughlin JL (1989) Bullatacin and bullatacinone: two highly potent bioactive acetogenins from Annona bullata. J Nat Prod 52:463.

Houyou Z. (2015). Impact de la mise en culture en pluvial sur la dégradation du sol par érosion éolienne dans la steppe centrale (cas de la région de Laghouat). Thèse Doctorat, USTHB, Alger. 168p.

Hosler, D.; Lechtman, H.; Holm, O. *Axe-Monies and Their Relatives*; Studies in Pre-Columbian Art and Archaeology; Dumbarton Oaks, Trustees for Harvard University: Cambridge, MA, USA, 1990; Volume 30, pp. 1–103.

Huang, H.W.; Layne, D.R.; Peterson, R.N. Using isozyme polymorphisms for identifying andassessing genetic variation in cultivated pawpaw (*Asimina triloba* (L) Dunal). *J. Am. Soc. Hortic. Sci.* **1997**, *122*, 504–511. [CrossRef]

Janzen, D.H.; Martin, P.S. Neotropical anachronisms: The fruits the gomphotheres ate. *Science* **1982**, *215*, 19–27. [CrossRef]

Jones, K.W. & Sanders, D.C. (1987). The influence of soaking pepper seed in water or potassium salt solutions on germination at three temperatures. Journal of Seed Technology, 11(1): 97-102, AGR: ADL87055683

Kheloufi A., Mansouri L.M., Khettache H. (2020). seed germination and seedling establishment of cherimoya (ANNONA CHERIMOLA MILL.) at different temperatures. DOI: 10.46909/cerce-2020-016 Original Article Available online: www.uaiasi.ro/CERCET_AGROMOLD/ Print ISSN 0379-5837; Electronic ISSN 2067-

1865Cercetări Agronomice în Moldova Vol. LIII , No. 2 (182) / 2020: 185-194. 10p. E-mail: abdenour.kheloufi@yahoo.fr

Larranaga, N.; Hormaza, J.I. DNA barcoding of perennial fruit tree species of agronomic interest in the genus *Annona* (*Annonaceae*). *Front. Plant Sci.* **2015**, *6*, 589. [CrossRef] [PubMed]

Larranaga, N.; Albertazzi, F.J.; Fontecha, G.; Palmeri, M.; Rainer, H.; van Zonneveld, M.; Hormaza, J.I. A Mesoamerican origin of cherimoya (*Annona cherimola* Mill.). Implications for the conservation of plant genetic resources. *Mol. Ecol.* **2017**, *26*, 4116–4130. [CrossRef]
Larranaga, N.; Albertazzi, F.J.; Hormaza, J.I. Phylogenetics of *Annona cherimola* (*Annonaceae*) and some of its closest relatives. *J. Syst. Evol.* **2019**, *57*, 211–221. [CrossRef]

Larranaga, N.; van Zonneveld, M.; Hormaza, J.I. Holocene Land and Sea-Trade Routes Explain Complex Patterns of PreColumbian Crop Dispersion. *New Phytol.* **2021**, *229*, 1768–1781. [CrossRef] [PubMed]

Linn J. (2016). APG IV. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Bot. J. Linn. Soc.* **2016**, *181*, 1–20.

Liaw C.C., Liou J.R. Tung-Ying Wu, Wu Y.CH. Acetogenins from Annonaceae. 2015. DOI: 10.1007/978-3-319-22692-7_2 © Springer International Publishing Switzerland 2016A.D. Kinghorn, H. Falk, S. Gibbons, J. Kobayashi (eds.), Progress in the Chemistryof Organic Natural Products, Vol. 101, DOI 10.1007/978-3-319-22692-7_2 *(10) (PDF) Acetogenins from Annonaceae*. Available from: https://www.researchgate.net/publication/286992572_Acetogenins_from_Annonaceae#fullTextFileContent [accessed Jun 19 2024].

Liaw C.C, Jing-Ru Liou, Tung-Ying Wu, Fang-Rong Chang, and Yang-Chang Wu (2015) Acetogenins from *Annonaceae*, © Springer International Publishing Switzerland 2016 A.D. Kinghorn, H. Falk, S. Gibbons, J. Kobayashi (eds.), Progress in the Chemistry of Organic Natural Products, Vol. 101, DOI 10.1007/978-3-319-22692-7_2

Loren E. Wiesner, Don F. Grabe. (1972). Effect of Temperatures Preconditioning and Cultivar on Ryegrass (*Lolium* sp.) Seed Dormancy. First published: 01 November 1972 Contribution from the Department of Agronomic Crop Science, Oregon State University, Corvallis, Ore. 97331. Published with the approval of the Director of the Oregon Agricultural

Experiment Station as Technical Paper No. 3297. https://doi.org/10.2135/cropsci1972.0011183X001200060013x

Lora, J.; Hormaza, J.I.; Herrero, M.; Gasser, C.S. Seedless fruits and the disruption of a conserved genetic pathway in angiosperm ovule development. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 5461–5465. [CrossRef]

Losada, J.M.; Hormaza, J.I.; Lora, J. Pollen-pistil interaction in pawpaw (*Asimina triloba*), the northernmost species of the mainly tropical family *Annonaceae*. *Am. J. Bot.* **2017**, *104*, 1891–1903. [CrossRef]

Martin, C.; Viruel, M.A.; Lora, J.; Hormaza, J.I. Polyploidy in Fruit Tree Crops of the Genus *Annona* (*Annonaceae*). *Front. Plant Sci.* **2019**, *11*, 99. [CrossRef] [PubMed]

Maas, P.J.M.; Westra, L.Y.T. Studies in *Annonaceae* II: A monograph of the genus Anaxagorea. Part 1. *Meded. Het Bot. Mus. Herb. Rijksuniv.* **1985**, *543*, 73–134.

Maas, P.J.M.; Westra, L.Y.T.; Rainer, H.; Lobão, A.Q.; Erkens, R.H.J. An updated index to genera, species, and infraspecific taxa of Neotropical *Annonaceae*. *Nord. J. Bot.* **2011**, *29*, 257–356. [CrossRef]

Marcos, J.G. *Los Pueblos Navegantes del Ecuador Prehispanico*; Quito: Abya-Yala, Ecuador, 1994.

Morton, J.F. *Fruits of Warm Climates*; Creative Resources Systems: Winterville, NC, USA, 1987.

Mapa (2021). Ministerio de Agricutura Pesca y Alimentación de España. 2021. Available online:https://www.mapa.gob.es/es/estadistica/temas/estadisticasagrarias/agricultura/superficies-producciones-anuales-cultivos/ (accessed on 20 March 2024).

Mallem H., Benrima A., Houyou Z. (2017). Etude floristique des parcours stéppiques des régions arides : effet de surpaturage, de l'ensablement et des labours (cas de la zone de mokrane wilaya de laghouat). Revue Agrobiologiawww.agrobiologia.net ISSN (Print): 2170-1652e-ISSN (Online): 2507-7627. 12p

Nerea Larranaga et al., (2024). Larranaga, N.; Agustín, J.A.; Albertazzi, F.; Fontecha, G.; Vásquez-Castillo, W.; Cautín, R.; Quiroz, E.; Ragonezi, C.; Hormaza, J.I. Underutilized Fruit Crops at a Crossroads: The Case of *Annona cherimola*—From Pre-Columbian to Present

Times. *Horticulturae* **2024**, *10*, 531. https://doi.org/10.3390/ horticulturae10060531. Academic Editor: Esmaeil Fallahi © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY). (https://creativecommons.org/licenses/by/ 4/). 17P.

Ohsawa K, Atsuzawa S, Mitsui T, Yamamoto I (1991) Isolation and insecticidal activity of three acetogenins from seeds of pond apple, Annona glabra L. Nippon Noyaku Gakkaishi 16:93.

Orchard, T. (1977). Estimating the parameters of plant seedling emergence. Seed Sci.Technol., 5(1): 61-69.

Perez-Oteyza, M.A.; Farre-Massip, J.M.; Hermoso-González, J.M.; Ruiz-Nieto, A. El banco español de germoplasma de chirimoyo. *Parámetros Estud. Var. Actas Hortic.* **1999**, *25*, 7–12.

Perfectti, F.; Pascual, L. Genetic diversity in a worldwide collection of cherimoya cultivars. *Genet. Resour. Crop Evol.* **2005**, *52*, 959–966. [CrossRef]

Popenoe, H.; King, S.; Leon, J.; Sumar, L.; Vietmeyer, N.L. *Lost Crops of the Incas. Little-Known Plant of the Andes with Promise for Worldwide Cultivation*; National Academy Press: Washington, DC, USA, 1989.

Richardson, J.E.; Chatrou, L.W.; Mols, J.B.; Erkens, R.H.J.; Pirie, M.D. Historical biogeography of two cosmopolitan families of flowering plants: *Annonaceae* and Rhamnaceae. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **2004**, *359*, 1495–1508. [CrossRef]

Ronning, C.M.; Schell, J.R.; Gazit, S. Using randomly amplified polymorphic DNA (RAPD) markers to identify *Annona* cultivars. *J. Am. Soc. Hortic. Sci.* **1995**, *120*, 726–729. [CrossRef]

Rahman, M.; Yamada, M.; Yoshida, M. Relationship of *Annona* species as revealed by PCR-RFLP analysis. *Breed. Sci.* **1997**, *47*, 335–339.

Rosell, P.; Galán-Saúco, V.; Hernández, P.M. Cultivo del Chirimoyo en Canarias. Cuadernos de Divulgación. Departamento de Fruticultura Tropical Instituto Canario de Investigaciones Agrarias. ICIA. Gobierno de Canarias, Consejería de Agricultura, Ganadería, Pesca y Alimentación, Spain. 1997. Available online:

https://www.gobiernodecanarias.org/agricultura/docs/otros/ publicaciones/cuadernos/chiri.pdf (accessed on 20 March 2024).

Rupprecht JK, Chang CJ, Cassady JM, McLaughlin JL, Mikolajczak KL, Weisleder D (1986) Asimicin, a new cytotoxic and pesticidal acetogenin from the paw paw, Asimina triloba (Annonaceae). Heterocycles 24:1197.

Ratnayake S, Rupprecht JK, Potter WM, McLaughlin JL (1992) Evaluation of various parts of the paw paw tree, Asimina triloba (Annonaceae), as commercial sources of the pesticidal annonaceous acetogenins. J Econ Entomol 85:2353.

Sauer, W.; Ehrendorfer, F. Notes on the karyosystematics of Annonaceae. *Plant Syst. Evol.* **1984**, *146*, 47–55. [CrossRef]

Soltis, D.E.; Soltis, P.S.; Endress, P.K.; Chase, M.W. *Angiosperm Phylogeny and Evolution*; Sinauer Associates: Sunderland, UK, 2005.

Schroeder, A. *Cherimoya culture in California, Nº 15*; University of California: Los Angeles, CA, USA, 1945.

Source (2019). United nation NewYork and Geneva, 2019. Agricultural Standards Unit. Economic Cooperation and Trade Division United Nations. Economic Commission for Europe Palais des Nations. CH-1211 Geneva 10, Switzerland E-mail: agristandards@unece.org EEC-UN Standard FFV-47 (Annonas), 7p

Source Andalucía (2024). Price Index Changes**,** CHIRIMOYA Andalusia (Andalucía). May 26, 2024. https://www.tridge.com/intelligences/cherimoya/price

Scheldeman, X. *Distribution and Potential of Cherimoya (Annona cherimola Mill.) and Highlands Papayas (Vasconcellea spp.) in Ecuador*; Faculteit Landbouwkundige en Toegepaste Biologische Wetenschappen, Ghent University: Ghent, The Netherlands, 2002.

Su, Y.C.F.; Saunders, R.M.K. Evolutionary divergence times in the *Annonaceae*: Evidence of a late Miocene origin of *Pseuduvaria* in Sundaland with subsequent diversification in New Guinea. *BMC Evol. Biol.* **2009**, *9*, 153. [CrossRef]

Safford, W.E. *Classification of the Genus Annona, with Descriptions of New and Imperfectly Known Species*; Contributions from the United States National Herbarium; Government Printing Office: Washington, DC, USA, 1914; Volume 18, pp. 1–68.

Source (2024). Frut Garsan, © 2024; privacy policy, Ctra. Suspiro del moro. 21, 18698 Otivar (Granada).

Saadoud D., Guettouche M.S., Hassani M., Peinado F.J.M. (2017). Laboratory of Geomorphology & Geohazards (G&G) FTSGAT-USTHB. Arabian Journal of Geosciences. *PDF. 19P. Modelling wind-erosion risk in the Laghouat region (Algeria) using geomatics approach*. Available from: https://www.researchgate.net/publication/319158713_Modelling_wind-erosion_risk_in_the_Laghouat_region_Algeria_using_geomatics_approach [accessed Jun 19 2024].

Taibi AN. (1997). Le piémont sud du djebel Amour (Atlas saharien, Algérie), apport de la télédétection satellitaire à l'étude d'un milieu en dégradation. Ph.D. thesis, Université Denis Diderot, Paris VII, 310 p.

Talavera, A.; Fernandez-Pozo, N.; Matas, A.J.; Hormaza, J.I.; Bombarely, A. Genomics in neglected and underutilized fruit crops: A chromosome-scale genome sequence of cherimoya (*Annona cherimola*). *Plants People Planet* **2023**, *5*, 408–423. [CrossRef]

POUGET MARCEL, (1980). Les relations sol-végétation dans les steppes Sud-Algéroise, Ouvrage, Paris : ORSTOM, 1980, 8-556 p. (Travaux et Documents de l'ORSTOM ; 116). ISBN 2-7099-0564-7.Th. Sc. Nat. : Aix-Marseille 3 : 1979/07/12

Tricart J. et CAILLEUX A. (1969). Le modelé des régions sèches. Traité de géomorphologie, tome IV. Paris : SEDES, 472 p.

Van Zonneveld, M.; Larranaga, N.; Blonder, B.; Coradin, L.; Hormaza, J.I.; Hunter, D. Human diets drive range expansion of megafauna-dispersed fruit species. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 3326–3331. [CrossRef] [PubMed]

Van Zonneveld, M.; Scheldeman, X.; Escribano, P.; Viruel, M.A.; Van Damme, P.; Garcia, W.; Tapia, C.; Romero, J.; Siguenas, M.; Hormaza, J.I. Mapping genetic diversity of cherimoya (*Annona cherimola* Mill.): Application of spatial analysis for conservation and use of plant genetic resources. *PLoS ONE* **2012**, *7*, e29845. [CrossRef]

Van Zuilen, C.M. Patterns and Affinities in the Duguetia Alliance (*Annonaceae*): Molecular and Morphological Studies. Ph.D. Dissertation, Utrecht University, Utrecht, The Netherlands, 1996.

Vidal-Lezama E., Ayala-Villegas M.J, Curiel-Rodríguez A.,. Marroquín-Andrade L.M., Martínez-Solís J., (1986). EFFECT OF STORAGE TEMPERATURE AND GIBBERELLIC ACID ON GERMINATION OF SUGAR APPLE (*ANNONA SQUAMOSAL* L.) SEEDS. ISHS Acta Horticulturae 918: XXVIII International Horticultural Congress on Science and Horticulture for People (IHC2010): III International Symposium on Plant Genetic Resources

Wang, Y.; Reighard, G.L.; Layne, D.R.; Abbott, A.G.; Huang, H.W. Inheritance of AFLP markers and their use for genetic diversity analysis in wild and domesticated pawpaw (*Asimina triloba* (L.) Dunal). *J. Am. Soc. Hortic. Sci.* **2005**, *130*, 561–568. [CrossRef]

Walker, J.W. Chromosome numbers, phylogeny, phytogeography of the *Annonaceae* and their bearing on the (original) basic chromosome number of Angiosperms. *Taxon* **1972**, *21*, 57–65. [CrossRef]

YAN Weikai and L. A. HUNT. (1999). An Equation for Modelling the Temperature Response of Plants using only the Cardinal Temperatures Department of Plant Agriculture, Crop Science Division, University of Guelph, Guelph, Ontario, Canada, N1G 2W1 Received: 16 April 1999 Returned for revision: 20 May 1999 Accepted: 9 July 1999Annals of Botany 84: 607–614, 1999 Article No. anbo.1999.0955, available online at http: www.idealibrary.com.

William A., TAYLOR. (1918). u. s. A.department of agriculture. bureau of plant industry, chief of bureau. inventory of seeds and plants imported by the office of foreign seed and plant introduction during the period from october 1 to december 31, 1915. (no. 45; nos. 41315 to 41684.). issued december 24,1918. washington: government printing office. 1918.75p.

Wester, P.J. Pollination experiments with Anonas. *Bull. Torrey Bot. Club.* **1910**, *37*, 529–539. [CrossRef]

Yang H, Zhang N, Zeng Q, Yu Q, Ke S, Li X. HPLC Method for the Simultaneous Determination of Ten Annonaceous Acetogenins after Supercritical Fluid CO2 Extraction. Int J Biomed Sci. 2010 Sep;6(3):202-7. PMID: 23675194; PMCID: PMC3615266.

Zanis, M.J.; Soltis, D.E.; Soltis, P.S.; Mathews, S.; Donoghue, M.J. The root of the angiosperms revisited. *Proc. Natl. Acad. Sci. USA* **2002**, *99*, 6848–6853. [CrossRef] [PubMed]

Appendices

Table 1. Fresh Cherimoya fruit seed measurements.

nb seed	**Length (mm)**	**Width (mm)**	**Weight (g)**
1	11	9	0,48
2	17	9	0,47
3	15	10	0,46
4	14	10	0,4
5	17	12	0,4
6	16	11	0,42
7	17	11	0,33
8	16	12	0,4
9	14	7	0,39
10	15	9	0,42

Table2 : Temperature parameters of Laghouat. (worldweather)

Date	Tmin	Tmax	FSP	FSS	FSC
04/05/2024	15	31	0	0	0
05/05/2024	17	32	0	0	0
06/05/2024	18	32	0	0	0
07/05/2024	20	28	0	0	0
08/05/2024	13	23	0	0	0
09/05/2024	10	24	0	0	0
10/05/2024	12	27	0	0	0
11/05/2024	15	29	0	0	0
12/05/2024	19	31	0	0	0

13/05/2024	20	32	0	0	0
14/05/2024	19	34	0	0	0
15/05/2024	21	34	0	0	0
16/05/2024	17	35	0	0	3
17/05/2024	19	35	0	0	5
18/05/2024	18	33	0	0	5
19/05/2024	18	32	0	0	8
20/05/2024	14	25	0	0	10
21/05/2024	14	27	2	0	12
22/05/2024	17	30	2	0	12
23/05/2024	21	31	2	0	13
24/05/2024	20	28	2	1	13
25/05/2024	21	31	2	2	13
26/05/2024	22	32	2	4	14
27/05/2024	22	33	4	6	14
28/05/2024	24	36	4	8	14
29/05/2024	23	34	4	8	14
30/05/2024	22	34	4	10	14
31/05/2024	23	33	4	15	14
01/06/2024	24	36	5	15	16
02/06/2024	20	36	5	15	16
03/06/2024	19	32	5	15	16

04/06/2024	21	32	5	15	16
05/06/2024	16	29	5	15	16
06/06/2024	22	35	5	15	16