

Article

The Path of African Millets (*Pennisetum glaucum* and *Sorghum bicolor*) to Iberia

Guillem Pérez-Jordà ^{1,*}, Leonor Peña-Chocarro ², Diego Sabato ¹, Antonio Peralta Gómez ², Agustí Ribera ³, Pablo García Borja ⁴, Joan Negre ⁵ and Jose María Martín Civantos ⁶

¹ Departamento de Prehistoria, Arqueología i H^a Antiga, Universitat de València, Avda. Blasco Ibañez 28, 46010 València, Spain

² Departamento de Arqueología y Procesos Sociales, Instituto de Historia, Spanish National Research Council (CSIC), C/Albasanz, 26–28, 28037 Madrid, Spain; leonor.chocarro@csic.es (L.P.-C.)

³ Museu Arqueològic d'Ontinyent (MAOVA), C/Regall, 2, 46870 Ontinyent, Spain; arqueontinyent12@gmail.com

⁴ Facultad de Geografía e Historia, Universidad Nacional a Distancia, Alzira-València, C/Misericordia 34, 46014 València, Spain; pabgarcia@valencia.uned.es

⁵ Departament de Prehistòria, Universitat Autònoma de Barcelona, Edifici B, Bellaterra, 08193 Cerdanyola del Vallès, Spain; joan.negre@uab.cat

⁶ MEMOLab, Departamento Historia Medieval, Universidad de Granada, Edf. Josefina Castro Vizoso, Avda de Madrid 28, 18075 Granada, Spain; civantos@go.ugr.es

* Correspondence: guillem.perez@uv.es

Abstract: Pearl millet (*Pennisetum glaucum*) is the most widely cultivated millet in Africa and India but has not yet been identified in Europe, while the earliest remains of sorghum (*Sorghum bicolor*) are attested in Italy in the fifth century AD. This paper presents evidence that pearl millet was introduced to Iberia during the 11th–12th centuries AD. This is the first documented evidence for this African crop in Europe. Sorghum, on the other hand, appears as a later introduction (14th century AD) in Iberia. We present archaeobotanical data from eight Andalusí sites in Valencia and Andalucía (southern Iberia) where both crops have been found. We have also examined medieval textual data where references to pearl millet appeared to be absent, and we conclude that the word “dacsá”, currently used to refer to sorghum, should be understood as a reference to pearl millet. From the 16th century onwards, this term was given to maize, when the American cereal replaced the African millets.

Keywords: medieval; archaeobotany; pearl millet; sorghum; agriculture



Citation: Pérez-Jordà, G.; Peña-Chocarro, L.; Sabato, D.; Peralta Gómez, A.; Ribera, A.; García Borja, P.; Negre, J.; Martín Civantos, J.M. The Path of African Millets (*Pennisetum glaucum* and *Sorghum bicolor*) to Iberia. *Agronomy* **2024**, *14*, 2375. <https://doi.org/10.3390/agronomy14102375>

Academic Editor: Carmine Guarino

Received: 6 August 2024

Revised: 11 September 2024

Accepted: 11 October 2024

Published: 14 October 2024



Copyright: © 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) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Iberia is the closest European territory to the African continent and the Strait of Gibraltar has been a barrier and a bridge, facilitating and preventing contact between the two continents. Throughout history, its strategic position has made it a focal point for the movement of ideas, people, animals, and plants, which have moved in both directions [1–4]. In this way, the first groups of neolithic farmers utilized this strait as a passageway between the two continents [5]. This communication route persisted thereafter, facilitating the arrival of other crops of eastern origin during the first millennium BC, such as Asian millets (*Panicum miliaceum* and *Setaria italica*) [6,7] and fruit trees [8].

Most of these crops originated in the Asian continent, while contact with sub-Saharan territories was much more limited. In fact, the Sahara Desert appears as a barrier particularly after its expansion [9], leading to two distinct areas with different social and cultural trajectories and little contact between them.

The Islamic conquest of Iberia started in northern Morocco and, among the forces involved, there were both Berbers and Arabs [10,11]. After 711 AD, almost the entire Iberian Peninsula was brought under Islamic control. In the long term, this enabled entering an

economic world-system that stretched from Asia to the westernmost regions of Europe and from sub-Saharan Africa to the Mediterranean characterized by an intense exchange of ideas, people, goods, food, technology, etc. This melting pot of cultures and traditions was the context in which, according to Watson [12], new crops of Asian origin, such as eggplant, rice, or sugar cane, were introduced.

This work combines an analysis of the archaeobotanical remains of pearl millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) from different sites located in the southern half of Iberia with evidence from written sources where these crops are mentioned.

2. Materials and Methods

This study is based on a series of archaeobotanical analyses conducted at various sites located in the southern half of Iberia, although the data published from other medieval sites in Iberia [13] have also been considered. The sites included in this paper are still under research; therefore, the comprehensive results are not presented in this work but will be published in future studies. This research focuses specifically on analyzing the presence of millets of African origin in Iberia.

Systematic sampling was carried out at all sites, with the samples treated in two different ways depending on the preservation of the plant material. In the case of Benaxuai, where plant remains were desiccated, the samples were dry-sieved to prevent the deterioration of the remains. In other instances, where the plant remains were charred or mineralized, flotation was employed, using a 1 mm mesh within the flotation tank and a 0.25 mm mesh for collecting the flots.

The identification of these remains followed the morphometric criteria defined in various studies [14–16].

At the same time, a review of the information provided by Christian and Islamic written sources was conducted.

3. Results

The archaeobotanical remains originate from seven sites (Figure 1; Table 1) with occupation dating to the medieval and early modern periods, spanning the provinces of Valencia, Alicante, Almería, Granada, and Córdoba. In Valencia, plant remains have been retrieved from the cliff granaries of Benaxuai and the hillfort of Castell de Bairén, while, in Alicante, remains were found in the rural site of Pego, a Muslim community that persisted after Christian occupation. Two rural Islamic sites, Aldeire and Benamaurel, and two cities, Mojácar and Córdoba, were selected for sampling in Andalusia, the latter with remains recovered from a latrine. The earliest pearl millet remains (12th century AD) come from Benaxuai and Córdoba, while, in Mojácar, the finds are dated to the 13th century. The remains from Castell de Bairén, Pego, Aldeire, and Benamaurel (Table 2) are dated from the 14th to the 17th centuries. The remains were preserved by desiccation, charring, and mineralization.

Table 1. Sites in Iberia with pearl millet (PM) and sorghum (S).

| Site | Town | Province | Type | Chronology | Preservation | No. |
|-------------------|--------|----------|------------|------------|------------------------|-------------|
| Benaxuai | Chelva | Valencia | Granary | 12th | Desiccated/ Charred | PM 3150 |
| Castell de Bairén | Gandía | Valencia | Hillfort | 14th | Charred | S/PM xxx |
| Pego | | Alicante | Rural site | 15–17th | Mineralized | PM 1 |
| Córdoba | | Córdoba | Urban site | 12th | Mineralized | PM 1 |
| Mojácar | | Almería | Urban site | 13th | Charred | PM 2 |
| Aldeire | | Granada | Rural site | 15–17th | Charred | PM 8 |
| Benamaurel | | Granada | Rural site | 15–17th | Charred | PM 4 |

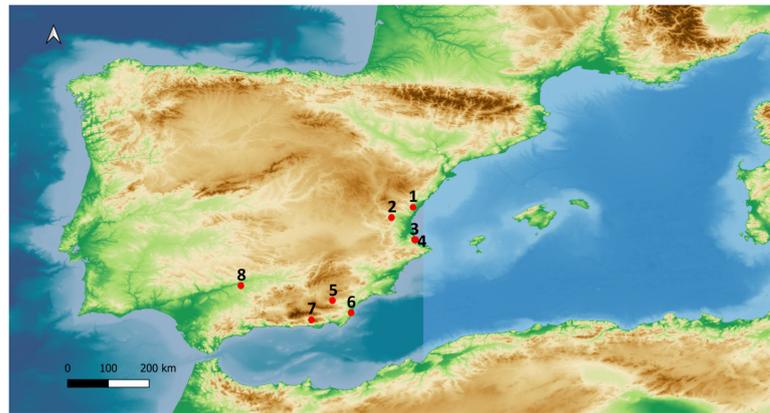


Figure 1. Map of Iberian sites with pearl millet and sorghum remains: 1. Benialí; 2. Benaxuai; 3. Castell de Bairén; 4. Pego; 5. Aldeire; 6. Mojácar; 7. Benamaurel; and 8. Córdoba.

Table 2. Results of the radiocarbon dating of pearl millet and sorghum remains. Dates have been calibrated using the IntCal20 atmospheric calibration curve and CALIB rev. 8 software [17].

| Site | Lab Code | US | Taxon | | BP | Cal AD 1 σ | Cal AD 2 σ | Median |
|-------------------|-------------|------|---------------------------|------|--------------|-------------------|-------------------|--------|
| Benaxuai | Beta 587088 | 1234 | <i>Pennisetum glaucum</i> | seed | 950 \pm 30 | 1038–1153 | 1028–1162 | 1100 |
| Castell de Bairén | Beta 548109 | 25 | <i>Sorghum bicolor</i> | seed | 630 \pm 30 | 1300–1393 | 1294–1397 | 1349 |

The Benaxuai plant material is represented by a collection of pearl millet ears, spikelets, and caryopses preserved inside a series of artificial caves (window caves or cliff granaries) excavated in a cliff over the Chelva river (Figure 2) [18,19]. The caves were used for storing grain and other plant foodstuffs by Islamic groups. The main characteristic of these caves is that the organic material is beautifully preserved in a desiccated state. The remains of pearl millet have been recovered from four (C1, C2, C3, and C12) of the five cavities excavated. Although most of the material is desiccated, there are also some charred remains. Most of the remains consist of spikelets, whose caryopses have only rarely been preserved, probably due to the action of rodents or other animals. Besides the caryopses, the central stalk of two pearl millet ears has also been preserved (Figure 2).

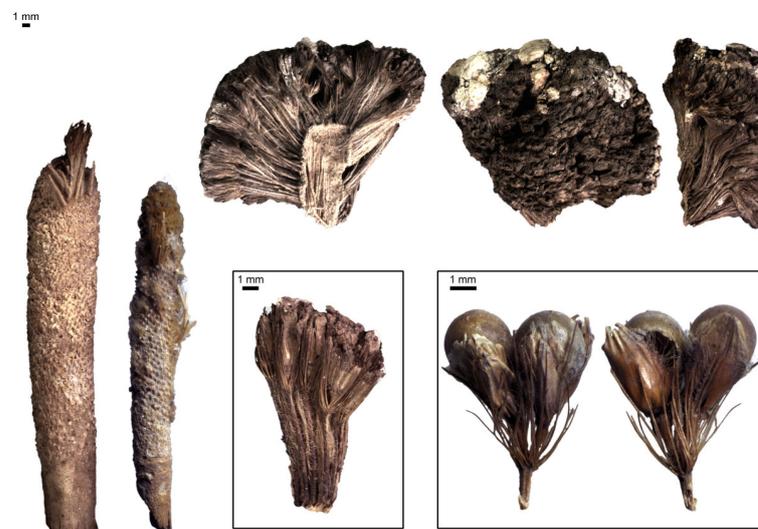


Figure 2. Desiccated ears, spikelets, and caryopses of *Pennisetum glaucum* from Benaxuai.

A large assemblage of charred sorghum and pearl millet has been retrieved from different Christian archaeological contexts at Castell de Bairén, connected to the storage area of the fortress [20]. Additionally, the charred remains of pearl millet were recovered from Mojácar, Aldeire, and Benamaurel (Figure 3).

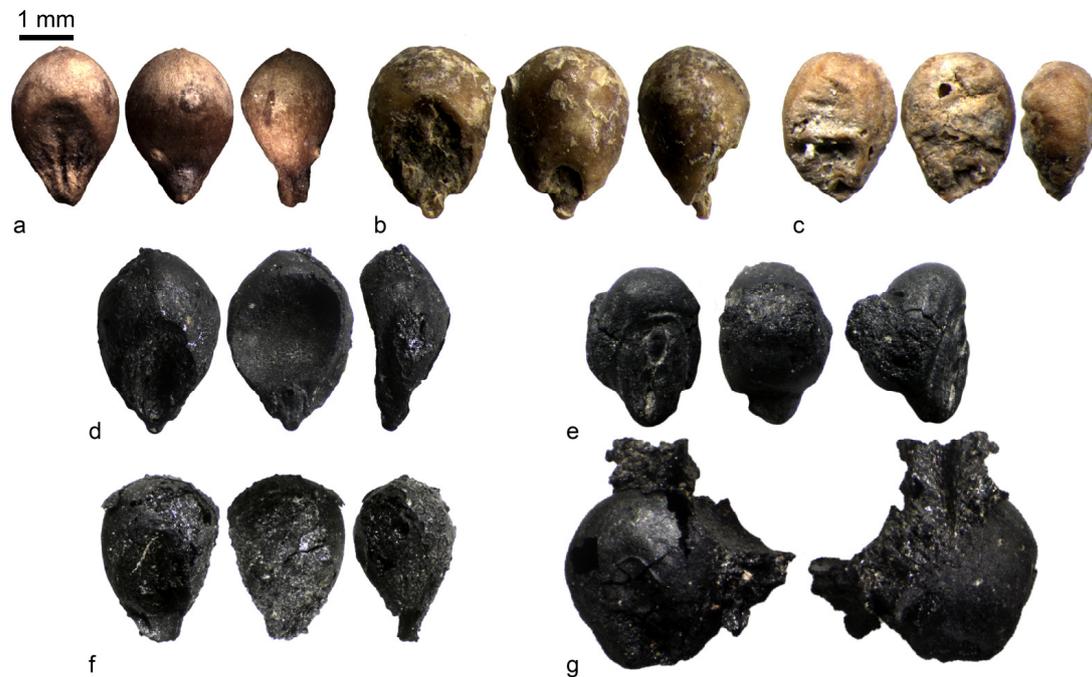


Figure 3. *Pennisetum glaucum* caryopses from (a) Benaxuai *, (b) Córdoba **, (c) Pego **, (d) Mojácar ***, (e) Benamaurel ***, (f) Castell de Bairén ***, and (g) *Sorghum bicolor* caryopsis from Castell de Bairén ***. * desiccated, ** mineralized, and *** charred.

The mineralized pearl millet caryopses come from a latrine in the city of Córdoba (12th century AD) and from a pit in the town of Pego (16th century AD).

The pearl millet caryopses from the Iberian sites studied are oval to round, with a long embryo and a wide scutellum that often protrudes and occupies practically two-thirds of the caryopsis length. The small, basal, and oval hila are often also projecting outside the caryopsis. The morphology of the Benaxuai grains is similar to that of the race “typhoides” [14,15], which is the only one that has been attested outside the African continent. This species was possibly introduced into Iberia during the Islamic period.

The sorghum caryopses from Castell de Bairén are oval or almost spherical, with the greatest width above the middle and with a scutellum that exceeds 60% of the ventral face. The hilum is slightly prominent, which could bring them closer to the “durra” species [21].

4. Discussion

4.1. A History of Sorghum and Pearl Millet in Africa

Millets, including sorghum, are one of the most important groups of economic plant species in Africa. They are the staple food of many developing regions, particularly in dry areas in temperate, subtropical and tropical regions [22]. Millets include several small-seeded crop species that belong to the Paniceae tribe of the Poaceae family. The most important species are pearl millet (*Pennisetum glaucum* (L.) R.Br., a synonym of *Cenchrus americanus* (L.) Morrone); foxtail millet (*Setaria italica* (L.) P.Beauv.); common, proso, or broomcorn millet (*Panicum miliaceum* L.); and finger millet (*Eleusine coracana* (L.) Gaertn.). Of these, common millet and foxtail millet were domesticated in northern China between 6000 and 3000 BC [23], while the wild progenitors of pearl millet (*Pennisetum violaceum* (Lam.) Morrone, a synonym of *Cenchrus violaceus* (Lam.) Morrone) and sorghum (*Sorghum*

arundinaceum (Desv.) Stapf, a synonym of *Sorghum bicolor* subsp. *verticilliflorum* (Steud.) de Wet ex Wiersema and J.Dahlb.) [14,15,21] grow in the Sahel area [24,25].

According to the archaeobotanical data [26], the wild *P. violaceum* was present in Mali by the fifth millennium BC and it is suggested that its domestication took place between the fourth and third millennia BC in the region between Niger and Mauritania. Indeed, recent genetic data [27] point to the central Sahel as the area where domestication occurred. From this area, pearl millet spread eastwards, crossing the southern Sahara and arriving in India around 1700 BC [26,28–32]. In Mediterranean north Africa, pearl millet has been identified in southern Libya at the end of the first millennium BC and later, during the first millennium AD [33,34], and in southern Egypt under Roman rule [35]. Further south, it has been found in medieval Sudan (sixth century AD) [36], and on the Egyptian coast of the Red Sea (eleventh–twelfth centuries AD) [37].

As far as sorghum is concerned, between the eighth and fourth millennia BC, wild sorghum species were in use in the area corresponding to the Sahara Desert in Egypt and in the southwestern part of Libya [38,39]. Furthermore, impressions in pottery corresponding to wild sorghum were discovered in Sudan [40–42]. However, the first evidence of sorghum domestication is found at the beginning of the fourth millennium BC [30,43], but the process of domestication seems to have lasted until the middle of the second millennium BC [21]. Based on the available data, it is assumed that sorghum could have been domesticated between the Blue and the White Nile. From there, it spread across the southern part of the Sahara, reaching the Indian continent at the beginning of the second millennium BC [44,45]. So far, there is no evidence of the spread of sorghum to the Mediterranean area of the African continent until much later when sorghum caryopses were retrieved from Almohad levels (11th–12th centuries AD) in the Atlas mountains, near Igiliz [46].

According to current data, the Sahara, at the height of its expansion from the late fifth millennium BC, is believed to have functioned as an effective natural barrier [9,47,48], which probably impeded the spread of pearl millet and sorghum towards the north of the continent. This situation enabled the development of two distinct agrarian systems, one to the north and one to the south of the desert. In the Mediterranean region, agriculture developed in accordance with oriental models and was based on the cultivation of wheat, barley, and several legumes. In contrast, agriculture in the southern Sahara was anchored in an African substratum, with sorghum and pearl millet representing a prominent role.

4.2. The European History of Pearl Millet and Sorghum

The migration of pearl millet and sorghum to Europe remains an area of research that has yet to be fully explored. The earliest references to pearl millet and sorghum in Europe can be found in central and northern Italy where different assemblages of *Sorghum bicolor* have been identified and dated to the fifth and fifteenth centuries AD, respectively [49–52]. The identification of sorghum at the end of the Roman period in northern Italy, even before its presence in the Mediterranean fringe of the African continent is, nevertheless, controversial. Further research has revealed the presence of sorghum in Poland dating back to the ninth–eleventh centuries AD [53], as well as in southwestern France, specifically in Aquitaine [54], dating to the eleventh century AD and two others from the thirteenth century AD. In the case of Poland, it is hypothesized that the presence of sorghum is more likely the result of commercial activity rather than local cultivation. Conversely, in the French case, the possibility of local cultivation is considered, although it cannot be ruled out that the crop could have been a product of trade with North Africa or with territories under Islamic control in Iberia. In any case, it would be a crop that could be cultivated in soils less suitable for other cereals, with the potential to yield high returns.

In Iberia, the only published identified sorghum caryopsis comes from the site of Benialí (Castellón) [55], a farmhouse dated to the 14th–16th centuries AD located inland in the north of Valencia. However, the report does not include the graphic documentation of the caryopsis that would have enabled confirming or rejecting this initial identification.

A review of the historical sources [12,56,57] indicates that pearl millet and sorghum were introduced to Iberia in the eighth century AD. However, there is currently no archaeobotanical evidence to support this early introduction. The remains of pearl millet found at the Benaxuai caves (1035–1209 cal AD) and those in Andalucía represent the first evidence of this crop in Iberia and in the wider European context. The limited number of archaeobotanical studies from Islamic sites may be a contributing factor to the scarcity of remains [13]. Most recently, a significant quantity of sorghum caryopses were also retrieved from Castell de Bairén (1292–1398 cal AD), representing the first record of this crop in Iberia. The context in which these remains were found corresponds to the period following the Christian conquest.

The absence of sorghum in earlier contexts is surprising. This is particularly noteworthy when one considers the recent studies of stable carbon and nitrogen isotopes on bone collagen from several Islamic communities who settled between the 10th and 12th centuries in the vicinity of Castell de Bairén. These studies indicate that their diets were based on the direct consumption of C3 plants (such as wheat or barley) and C4 plants (such as millets and sorghum) at similar levels [58]. The issue here relates to the difficulty of establishing whether they were consuming common and foxtail millet (present in Iberia since the late Bronze Age), or whether pearl millet and sorghum were involved. Whether the lack of the archaeobotanical remains of sorghum is related to the limited development of archaeobotany in medieval Iberia and northern Africa or to the minor role this cereal may have had still needs to be investigated.

A further point of discussion concerns the presence of sorghum in southwestern France during the 11th–13th centuries AD, which is notably absent throughout the northern half of Iberia, the area controlled by the Christian kingdoms. It is currently challenging to ascertain whether there was closer contact between the French western coast and the territories under Islamic control in Iberia and North Africa, which could have facilitated the introduction of this crop into Aquitaine, or whether the crop arrived via northern Italy. Only future research in Iberia and France will allow us to gain a definitive understanding of the actual process that occurred.

4.3. Pathways of African Millets into Iberia: A Fascinating Chronicle

By the end of the first millennium AD, pearl millet and sorghum had already become established crops in India and the Sahel. In the Arabian Peninsula, sorghum has been found in contexts attributed to the early Islamic period in both the United Arab Emirates (UAE) at the site of Kush and in the Sultanate of Oman by the mid-seventh–eighth centuries AD at the fort of Fulayj [59,60]. Archaeobotanical data is still patchy in Yemen, and, as a result, textual evidence has also been used for reconstructing the existing crop diversity [61,62]. In fact, it has been proposed [63] that sorghum was introduced to Yemen before the Islamic era, but it was during the Islamic period that it became a significant crop that was exported to other regions. The case of pearl millet is much more complex as archaeobotanical data have not provided any evidence of its cultivation during the first millennium AD in the Arabian Peninsula.

In Europe, the earliest evidence of an African crop (sorghum) has been identified in Italy, dating back to the fifth century AD [51]. Conversely, pearl millet has only been recovered from archaeological contexts in Iberia, making it the only European region where this crop has been identified (Figure 4).

Two main questions emerge from this evidence: firstly, how did these crops find their way to Iberia? and secondly, who introduced them? As with many other crops, pearl millet and sorghum could have been introduced to the Iberian Peninsula with the first Berbers and Arabs that arrived at the beginning of the eighth century AD. However, textual data do not seem to support this hypothesis as neither pearl millet nor sorghum are mentioned in the agricultural treatises written by Hispano-Arab agronomists prior to the 11th century AD. The potential mention of sorghum (*šamkhà*, *samkhà*) in Andalusian texts has been evaluated on the basis of its similarity with the term currently used by Berber

communities in northern Morocco [64]. References to sorghum can be found in the works of two Andalusí agronomists, al-Tignarī and Abū l-Khayr, by the end of the 11th century. Later, in the 12th century, sorghum is quoted by Ibn al-'Awwām and by Ibn Luyūn in the 14th century [64]. To the best of our knowledge, this term does not appear in medieval Christian sources.

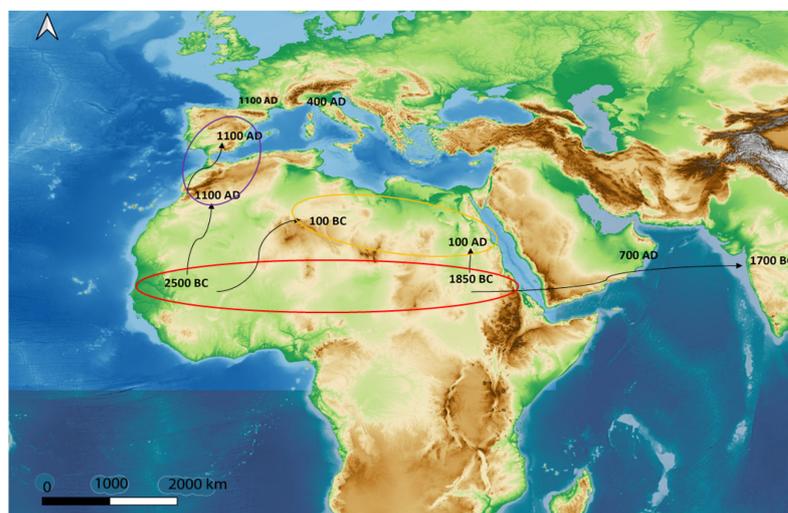


Figure 4. Possible routes of expansion of African millets to Iberia.

Current archaeobotanical data do not provide evidence of sorghum, nor has pearl millet been found north of the Saharan Desert up to the 11th–12th centuries AD. By this time, sorghum was recorded in Morocco, at the site of Igiliz [46], and pearl millet in Iberia. This is the period during which both Morocco and Iberia entered into the Almoravid and subsequently the Almohad Empires [65], together with areas of the African Sahel such as Mauritania where these crops originated. In fact, a working hypothesis is that sub-Saharan communities may have facilitated the introduction of both species to North Africa and Iberia.

Other than archaeobotanical data, there are supplementary ways of approaching this topic, such as, for instance, the linguistic evidence [66,67]. In particular, it is interesting to explore the vernacular names of sorghum and pearl millet at the time, which were both in use in Iberia, specifically during the Islamic period, but also after the Christian conquest of those territories. A first step relates to the identification of both species in the Christian written sources, which is per se a problematic issue as, in many cases, crop names are poorly identified in those sources. Documents from the Iberian territories that were conquered by Christians include references to different millets as being cultivated but it is not always straightforward to establish which botanical species were actually involved. For example, at the end of the 13th century AD, shortly after the Christian conquest of the Valencia region and the Balearic Islands, tax records from the conquerors, as well as various literary works from the 14th and 15th centuries AD, provide insights into the cultivation of different cereals in the region (forment, ordi, espelta, civada, sègol, arrós, mill, panís, and dacsà) [68–72]. Most of them can be readily identified, both because the vernacular name bears resemblance to the Latin name but also because some of these names are still in use today. This is the case of “mill” and “panís”, which can be securely identified with common millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*), respectively. Both species were already present in the area during the first millennium BC [6] and subsequently during Roman times [13]. It is during this latter period that the vernacular names currently in use are believed to have originated. Of particular interest is the fact that, together with “mill” and “panís”, the texts also include a third species, “dacsà”, which has traditionally been translated as sorghum [55]. However, “dacsà” is currently the vernacular name for maize in the Valencian area in the Catalan language.

A similar situation has been observed in southwestern France, where medieval and early modern documentation mentions three types of millets: milium, interpreted as foxtail millet; panicum, identified as common millet; and milhoca, thought to be sorghum [54].

There has been some discussion among philologists around the word “dacsá”. Initially, it was considered an Arabism derived from the word “daqsa” [72,73]. The word was in fact included in the renowned lexicon of Freytag [74], which explained that “daqsa” was a grain similar to millet (milio similia). Freytag’s lexicon was a translation of a 14th century dictionary (Qāmūs al-Muḥīt) written by the Iranian lexicographer al-Fīrūzābādī, which specified that “ad-duqsa” was a grain similar to millet.

Our search of Berber words for pearl millet and sorghum [67] has not revealed similarities between the term “dacsá” and the local names given to both crops. Nevertheless, our research has identified two African millets whose vernacular names may be related to the word “dacsá”. In Ethiopia, finger millet (*Eleusine coracana*) is named “dagusa” in Amharic (an Ethiopian Semitic language), and different Cushitic languages (spoken primarily in the Horn of Africa but also by minorities in parts of Egypt, Sudan, Kenya, and Tanzania) use similar words (“dagus, dāwsa, dāwʃa, dāgusi”) [75]. In the Gulf of Guinea, the Bassari people use the word “dagave” for sorghum [76]. This may indicate a relationship between the term “dacsá” and the sub-Saharan area suggesting the potential involvement of Sahelian communities in the introduction of African millets to Iberia.

The use of similar names for different cereal species is quite common when new crops are introduced into a region and become established in place of existing varieties. In fact, the practice of reborrowing names is a common phenomenon, as evidenced by different examples in Africa [77] and in the Iberian Peninsula with regard to maize. In many parts of Iberia, the local names for maize refer to the name of the cereal that was substituted with the American crop. By way of illustration, in the northwest (Galicia region), maize was known as “millo”, which is the vernacular name for common millet. Similarly, in the Basque Country, “artoa” is the popular name for common millet that was applied to maize when it was adopted in the region.

There is also a further significant point of interest that strongly suggests a link between the word “dacsá” and pearl millet. In the 16th century AD, the Meccan jurist and chronicler Jar Allah Muhammad Ibn Fahd wrote a geographical work describing the valleys around Mecca. This included descriptions of the food available in the area, including fish, fruits, vegetables, cereals, etc. Among the grains Ibn Fahd mentioned, there were wheat (hintā), barley, millet (dukhn), sorghum (dhurra), and daqsa. The latter, he added, “is among the products of Mecca, and Bilad al Sudan, and Hadramawt, and Yemen, and so it is said, India” [78]. For non-specialists, it should be clarified that the term Bilad al Sudan refers to the “Land of Black People”, which embraces the southern part of the Sahara, extending from Senegal and Mali to Sudan and Southern Sudan. This area fully coincides with the area where pearl millet was first domesticated. The identification of daqsa with pearl millet in ibn Fahd’s account seems highly plausible. He clearly distinguished four well-known crops (wheat, barley, millet, and sorghum) and added a fifth one, daqsa. The assimilation of daqsa to pearl millet, one of the most important crops in the Arabian Peninsula today, appears convincing.

The archaeobotanical and textual data suggest that African millets were introduced to Iberia no earlier than the 11th–12th centuries AD. They have only been identified in the southern part of the Iberian Peninsula, specifically in Valencia and Andalucía. In contrast, there is no archaeobotanical evidence of these crops in other regions north of the Ebro Valley, such as Catalonia. The absence of pearl millet and sorghum in Catalonia in both Lérida and Tortosa (the only two locations where archaeobotanical data are available from the Almoravid period) [79,80] remains unresolved and requires further investigation. This silence is also reflected in the texts, which only record the words “mill” (common millet) and “panís” (foxtail millet). The term “dacsá”, in fact, is not quoted until much later, in a document dated to 1497 AD near Lérida [81]. Based on this information, a possible

hypothesis to explain the arrival of pearl millet into Iberia is that it was introduced in the Almoravid period.

Beyond the likely reborrowing of names, it is clear that, both in Iberia and in Arabia, there was a cereal with an identical name (“dacsá” or “daqsa”). Furthermore, the morphological similarity between the ears of pearl millet and maize is considerably more pronounced than that observed between pearl millet and sorghum. Pearl millet and maize exhibit a thick central axis to which the caryopses are directly attached (the cob) in the case of maize and in the form of spikelets in the case of pearl millet (Figure 5).

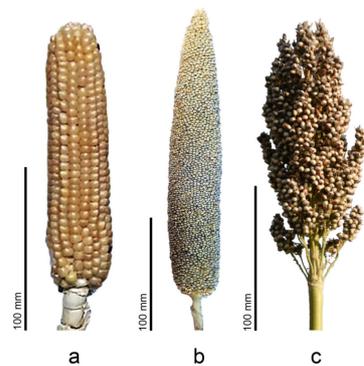


Figure 5. Ears of (a) maize [82] modified, (b) pearl millet, and (c) sorghum (courtesy of Dr. C. Stevens).

The evidence presented here strongly suggests that the term “dacsá”, as recorded in Iberian Christian sources, is likely to refer to pearl millet, rather than sorghum, as previously thought.

4.4. The Role of African Millets in Medieval Iberian Agriculture

The integration of the new African millets into the Iberian agricultural cycle is likely to have introduced not only novel tastes and food resources to the diet but also new agricultural practices. Both crops are summer crops cultivated in irrigated and drained fields, a practice developed during the Islamic period, mostly in urban farming areas [83–85]. Their summer cycle enabled a more intensive exploitation of the land through crop rotations with autumn/winter crops. Likewise, both pearl millet and sorghum could be grown in poor soil, where the most demanding cereals failed to thrive.

The two sites in the Valencian region where these millets have been recovered are associated with areas where first Islamic and then Christian communities developed irrigated agricultural systems [18,86]. Benaxuai is located in the Turia Valley, an area where irrigated spaces “huertas” have been maintained until the present day [87]. On the other hand, the castle of Bairén is situated in close proximity to an uncultivated marshland that was only drained in the 14th century [88]. Documents from the 15th century AD from the Valldigna monastery, close to the castle, confirm that the “huertas” (irrigated spaces) were sown with “dacsas” and “panissos” at the beginning of March. Irrigation was conducted on two or three occasions until the summer. Subsequently, the crops were harvested between October and November. Following the harvest, the land was ploughed and sown with wheat, thus completing the crop rotation system. This system, which combined different millets with the major cereals (wheat and barley), facilitated an expansion of the productive capacities of farmers in these areas [89]. The development of irrigated systems in Andalusí agriculture contributed to the development of a novel farming organization, in which the role of water was of paramount importance. This enduring association between irrigated zones and African millets can be observed in other areas of the Valencia region much later. For example, written sources from the 16th century AD from the village of Novelda, where irrigated land was abundant, indicate that “dacsá” was a significant crop. In contrast, in the neighboring village of Monòver, the role of “dacsá” was comparatively minor, corresponding to the extent of the less irrigated land.

With regard to the second region where pearl millet has been identified at various sites, it is necessary to explore the textual information in greater depth.

The cultivation of sorghum and pearl millet in the Valencia and Andalucía regions is evidently associated with the presence of an Islamic population in these areas. It was not until 1609 that the Moorish communities that continued to live in this territory were expelled, which resulted in a decline in the cultivation of these crops, with a shift towards wheat and vines [90]. This process coincides with the advent of the expansion of American maize, which is referenced in documents as “dacsá grossa” (big dacsá) or “dacsá de les Indies” (dacsá from the Indies). This period witnessed changes in agricultural practices, which were influenced by shifts in the population, their preferences, the fiscal interests of the ruling classes, and the introduction of a new, more productive crop, which ultimately displaced the millets of African origin.

The millets in medieval Iberia were used for making bread, which was blended with other cereals [89]. A more general use was for the preparation of “cocas”, small cakes of unfermented dough that were baked in ovens or directly on hearths. This tradition has been maintained in the Valencia region until the present day, although now millet flour has been superseded by maize.

5. Conclusions

A review of the available data suggests that the introduction of African millets in Iberia likely occurred between the 11th and 12th centuries AD, potentially coinciding with the Almoravid presence. The introduction of these crops occurred concurrently with the settlement of groups of sub-Saharan origin or with influences from these territories in areas of Iberia. The connection between both sorghum and pearl millet and irrigation practices appears evident; they undoubtedly played a pivotal role during a period of significant advancement in irrigated agriculture. In a way, the late arrival of these crops both in North Africa and on the European continent is indicative of the extent to which the Sahara Desert acted as a barrier separating the territories located to the south and north of this desert.

Finally, the data discussed in this paper strongly suggest that the term “dacsá” found in textual sources corresponds to pearl millet and not to sorghum as has been traditionally considered. This term was later transferred to maize.

Author Contributions: Conceptualization, G.P.-J. and L.P.-C.; methodology, G.P.-J. and L.P.-C.; formal analysis, G.P.-J., L.P.-C., A.P.G. and D.S.; writing—original draft preparation G.P.-J. and L.P.-C.; writing—review and editing, G.P.-J., L.P.-C., J.N., D.S., P.G.B., J.M.M.C., A.R. and A.P.G.; and funding acquisition G.P.-J. and L.P.-C. All authors have read and agreed to the published version of the manuscript.

Funding: This research has received support from the following projects: Medieval Appetites: plant foods in multicultural Iberia (500-1100 AD)—MEDAPP, funded by the European Research Council (grant no. ERC-AdG2021, 101054883); and Uso y función de las cuevas-granero peninsulares: una aproximación a partir de la arqueobotánica—CUGRABOT (grant no. PID2021-127936NB-I00), both coordinated by L.P.-C.; A.P.G. worked under a pre-doctoral scholarship from the MEDAPP project (ERC-AdG2021, 101054883).

Data Availability Statement: The original contributions presented in this study are included in this article; further inquiries can be directed to the corresponding author.

Acknowledgments: We are grateful to Joaquín Bustamante (University of Cádiz, retired), who has opened many interesting avenues of research and provided us with references and obscure information; Maribel Fierro (ILC-CSIC) for the guidance; and Ferran Garcia-Oliver (University of Valencia) for reading and commenting on a previous version of this paper. We also thank Dorian Fuller and Chris Stevens for checking the identification of pearl millet.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. González-Fortes, G.; Tassi, F.; Trucchi, E.; Henneberger, K.; Paijmans, J.L.A.; Díez-del-Molino, D.; Schroeder, H.; Susca, R.R.; Barroso-Ruiz, C.; Bermudez, F.J.; et al. A Western Route of Prehistoric Human Migration from Africa into the Iberian Peninsula. *Proc. R. Soc. B* **2019**, *286*, 20182288. [CrossRef] [PubMed]
2. Valdiosera, C.; Günther, T.; Vera-Rodríguez, J.C.; Ureña, I.; Iriarte, E.; Rodríguez-Varela, R.; Simões, L.G.; Martínez-Sánchez, R.M.; Svensson, E.M.; Malmström, H.; et al. Four Millennia of Iberian Biomolecular Prehistory Illustrates the Impact of Prehistoric Migrations at the Far End of Eurasia. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 3428–3433. [CrossRef] [PubMed]
3. Gosden, C. (Ed.) Continental Fusion—Connections across Europe, Asia, and Africa. In *Prehistory: A Very Short Introduction*; Oxford University Press: Oxford, UK, 2018.
4. Broodbank, C. *The Making of the Middle Sea: A History of the Mediterranean from the Beginning to the Emergence of the Classical World*; Thames and Hudson: London, UK, 2013.
5. Morales, J.; Pérez-Jordà, G.; Peña-Chocarro, L.; Bokbot, Y.; Vera, J.C.; Martínez Sánchez, R.M.; Linstädter, J. The Introduction of South-Western Asian Domesticated Plants in North-Western Africa: An Archaeobotanical Contribution from Neolithic Morocco. *Quat. Int.* **2016**, *412*, 96–109. [CrossRef]
6. Alonso, N.; Pérez-Jordà, G. The Origins of Millet Cultivation (*Panicum miliaceum* and *Setaria italica*) Along Iberia's Mediterranean Area from the 13th to the 2nd Century Bc. *Agronomy* **2023**, *13*, 584. [CrossRef]
7. Filipović, D.; Meadows, J.; Corso, M.D.; Kirleis, W.; Alsleben, A.; Akeret, Ö.; Bittmann, F.; Bosi, G.; Ciută, B.; Dreslerová, D.; et al. New Ams 14c Dates Track the Arrival and Spread of Broomcorn Millet Cultivation and Agricultural Change in Prehistoric Europe. *Sci. Rep.* **2020**, *10*, 13698. [CrossRef] [PubMed]
8. Pérez-Jordà, G.; Alonso, N.; Rovira, N.; Figueiral, I.; López-Reyes, D.; Marínval, P.; Montes, E.; Peña-Chocarro, L.; Pinaud-Querrac'h, R.; Ros, J.; et al. The Emergence of Arboriculture in the 1st Millennium Bc Along the Mediterranean's "Far West". *Agronomy* **2021**, *11*, 902. [CrossRef]
9. Broodbank, C.; Lucarini, G. The Dynamics of Mediterranean Africa, Ca. 9600–1000 Bc: An Interpretative Synthesis of Knowns and Unknowns. *J. Mediterr. Archaeol.* **2020**, *32*, 195–267. [CrossRef]
10. Taha, A.D. *The Muslim Conquest and Settlement of North Africa and Spain*; Routledge: London, UK, 1989.
11. Manzano, E. *Conquistadores, Emires y Califas: Los Omeyyas y la Formación de Al-Andalus*; Crítica: Barcelona, Spain, 2006.
12. Watson, A.M. *Agricultural Innovation in the Early Islamic World: The Diffusion of Crops and Farming Techniques, 700–1000*; Cambridge University Press: Cambridge, UK, 1983.
13. Peña-Chocarro, L.; Pérez-Jordà, G.; Alonso, N.; Antolín, F.; Teira-Brión, A.; Tereso, J.P.; Montes Moya, E.; López Reyes, D. Roman and Medieval Crops in the Iberian Peninsula: A First Overview of Seeds and Fruits from Archaeological Sites. *Quat. Int.* **2019**, *499*, 49–66. [CrossRef]
14. Brunken, J.; de Wet, J.; Harlan, J. The Morphology and Domestication of Pearl Millet. *Econ. Bot.* **1977**, *31*, 163–174. [CrossRef]
15. Brunken, J.N. A Systematic Study of *Pennisetum* sect. *pennisetum* (Gramineae). *Am. J. Bot.* **1977**, *64*, 161–176. [CrossRef]
16. Fuller, D. Millet Atlas. Some Identification Guidance (3rd Revision, 2017). 2019. Available online: https://www.researchgate.net/publication/333661449_Millet_Atlas_Some_Identification_Guidance_3rd_revision_2017 (accessed on 10 October 2024).
17. Reimer, P.J.; Austin, W.E.N.; Bard, E.; Bayliss, A.; Blackwell, P.G.; Ramsey, C.B.; Butzin, M.; Cheng, H.; Edwards, R.L.; Friedrich, M.; et al. The Intcal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 Cal Kbp). *Radiocarbon* **2020**, *62*, 725–757. [CrossRef]
18. Ribera Gómez, A. Las Cuevas De Benaxuai. Un grupo de cuevas ventana Andalusíes en el río Chelva (Valencia). *Cuad. Madinat Al-Zahar.* **2010**, *7*, 343–367.
19. Sanchis Serra, A.; Real Margalef, C.; Morales Pérez, J.V.; Pérez Ripoll, M.; Tormo Cuñat, C.; Carrión Marco, Y.; Pérez-Jordà, G.; Ribera Gómez, A.; Bolufer Marqués, J.; Villaverde Bonilla, V. Towards the Identification of a New Taphonomic Agent: An Analysis of Bone Accumulations Obtained from Modern Egyptian Vulture (*Neophron percnopterus*) Nests. *Quat. Int.* **2014**, *330*, 136–149. [CrossRef]
20. Negre, J.; García-Borja, P.; Palmer, J. Programa, diseño y ejecución arquitectónica del Hişn Bayrān (Gandía, València). Análisis del proceso constructivo de una fortaleza protourbana en el Šarq Al-Andalus. *Arqueol. Arqut.* **2023**, *20*, e140. [CrossRef]
21. Fuller, D.Q.; Stevens, C.J. Sorghum Domestication and Diversification: A Current Archaeobotanical Perspective. In *Plants and People in the African Past: Progress in African Archaeobotany*; Mercuri, A.M., D'Andrea, A.C., Fornaciari, R., Höhn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2018; pp. 427–452.
22. Kole, C. (Ed.) *Cereals and Millets*; Genome Mapping and Molecular Breeding in Plants; Springer: Berlin/Heidelberg, Germany; New York, NY, USA, 2006.
23. Stevens, C.J.; Shelach-Lavi, G.; Zhang, H.; Teng, M.; Fuller, D.Q. A Model for the Domestication of *Panicum miliaceum* (Common, Proso or Broomcorn Millet) in China. *Veg. Hist. Archaeobot.* **2021**, *30*, 21–33. [CrossRef]
24. Harlan, J. *Crops and Man*; American Society of Agronomy and Crop Science Society of America: Madison, WI, USA, 1975.
25. Upadhyaya, H.D.; Reddy, K.N.; Ahmed, M.I.; Kumar, V.; Gumma, M.K.; Ramachandran, S. Geographical Distribution of Traits and Diversity in the World Collection of Pearl Millet [*Pennisetum glaucum* (L.) R. Br., Synonym: *Cenchrus americanus* (L.) Morrone] Landraces Conserved at the Icrisat Genebank. *Genet. Resour. Crop Evol.* **2017**, *64*, 1365–1381. [CrossRef]

26. Fuller, D.Q.; Barron, A.; Champion, L.; Dupuy, C.; Commelin, D.; Raimbault, M.; Denham, T. Transition from Wild to Domesticated Pearl Millet (*Pennisetum glaucum*) Revealed in Ceramic Temper at Three Middle Holocene Sites in Northern Mali. *Afr. Archaeol. Rev.* **2021**, *38*, 211–230. [[CrossRef](#)]
27. Burgarella, C.; Cubry, P.; Kane, N.A.; Varshney, R.K.; Mariac, C.; Liu, X.; Shi, C.; Thudi, M.; Couderc, M.; Xu, X.; et al. A Western Sahara Centre of Domestication Inferred from Pearl Millet Genomes. *Nat. Ecol. Evol.* **2018**, *2*, 1377–1380. [[CrossRef](#)]
28. Manning, K.; Pelling, R.; Higham, T.; Schwenniger, J.-L.; Fuller, D.Q. 4500-Year Old Domesticated Pearl Millet (*Pennisetum glaucum*) from the Tilemsi Valley, Mali: New Insights into an Alternative Cereal Domestication Pathway. *J. Archaeol. Sci.* **2011**, *38*, 312–322. [[CrossRef](#)]
29. Zach, B.; Klee, M. Four Thousand Years of Plant Exploitation in the Chad Basin of Ne Nigeria II: Discussion on the Morphology of Caryopses of Domesticated *Pennisetum* and Complete Catalogue of the Fruits and Seeds of Kursakata. *Veg. Hist. Archaeobot.* **2003**, *12*, 187–204. [[CrossRef](#)]
30. Winchell, F.; Brass, M.; Manzo, A.; Beldados, A.; Perna, V.; Murphy, C.; Stevens, C.; Fuller, D.Q. On the Origins and Dissemination of Domesticated Sorghum and Pearl Millet across Africa and into India: A View from the Butana Group of the Far Eastern Sahel. *Afr. Archaeol. Rev.* **2018**, *35*, 483–505. [[CrossRef](#)] [[PubMed](#)]
31. Boivin, N.; Fuller, D.Q. Shell Middens, Ships and Seeds: Exploring Coastal Subsistence, Maritime Trade and the Dispersal of Domesticates in and around the Ancient Arabian Peninsula. *J. World Prehistory* **2009**, *22*, 113–180. [[CrossRef](#)]
32. Pokharia, A.K.; Kharakwal, J.S.; Srivastava, A. Archaeobotanical Evidence of Millets in the Indian Subcontinent with Some Observations on Their Role in the Indus Civilization. *J. Archaeol. Sci.* **2014**, *42*, 442–455. [[CrossRef](#)]
33. Pelling, R. Garamantian Agriculture and its Significance in a Wider North African Context: The Evidence of the Plant Remains from the Fazzan Project. *J. N. Afr. Stud.* **2005**, *10*, 397–412. [[CrossRef](#)]
34. Mercuri, A.M.; Bosi, G.; Olmi, L.; Mori, L.; Gianassi, E.; Assunta, F. Human-Plant Relationships in the Garamantian Culture (Fezzan, Libya, Central Sahara). *Boccone* **2009**, *23*, 379–393.
35. Clapham, A.; Rowley-Conwy, P. New Discoveries at Qasr Ibrim, Lower Nubia. In *Fields of Change: Progress in African Archaeobotany*; Cappers, R., Ed.; Barkhuis & Groningen University Library: Groningen, The Netherlands, 2007; pp. 157–164.
36. Fuller, D.; Edwards, D.N. Medieval Plant Economy in Middle Nubia: Preliminary Archaeobotanical Evidence from Nauri. *Sudan NUBIA* **2001**, *5*, 97–103.
37. Van der Veen, M.; Morales, J. Food Globalisation and the Red Sea: New Evidence from the Ancient Ports at Quseir Al-Qadim, Egypt. In *Human Interaction with the Environment in the Red Sea*; Agius, D.A., Khalis, E., Scerri, E.M.L., Willimas, A., Eds.; Brill: Leiden, The Netherlands; Boston, MA, USA, 2017; pp. 254–289.
38. Wasylkowska, K.; Dahlberg, J. Sorghum in the Economy of the Early Neolithic Nomadic Tribes at Nabta Playa, Southern Egypt. In *The Exploitation of Plant Resources in Ancient Africa*; Van der Veen, M., Ed.; Plenum Press: New York, NY, USA, 1999; pp. 11–32.
39. Barakat, H.; Fahmy el-Din, A.G. Wild Grasses as ‘Neolithic’ Food Resources in the Eastern Sahara: A Review of the Evidence from Egypt. In *The Exploitation of Plant Resources in Ancient Africa*; Van der Veen, M., Ed.; Springer: New York, NY, USA, 1999; pp. 33–46.
40. Magid, A.A. *Plant Domestication in the Middle Nile Basin: An Archaeobotanical Case Study*; Cambridge Monographs in African Archaeology 35; BAR International Series 523; BAR Publishing: Oxford, UK, 1989.
41. Magid, A.A. Exploitation of Food-Plants in the Early and Middle Holocene Blue Nile Area, Sudan and Neighbouring Areas. *Complutum* **2003**, *14*, 345–372.
42. Stemler, A.B. A Scanning Electron Microscopic Analysis of Plant Impressions in Pottery from Sites of Kadero, El Zakiab, Um Direiwa and El Kadada. *Archaeol. Du Nil Moyen* **1990**, *4*, 87–106.
43. Winchell, F.; Stevens, C.J.; Murphy, C.; Champion, L.; Fuller, D.Q. Evidence for Sorghum Domestication in Fourth Millennium Bc Eastern Sudan: Spikelet Morphology from Ceramic Impressions of the Butana Group. *Curr. Anthropol.* **2017**, *58*, 673–683. [[CrossRef](#)]
44. Fuller, D. African Crops in Prehistoric South Asia: A Critical Review. In *Food, Fuel and Fields. Progress in Africa Archaeobotany, Africa Praehistorica 15*; Neumann, K., Butler, A., Kahlheber, S., Eds.; Heinrich-Barth-Institut: Cologne, Germany, 2003; pp. 239–271.
45. Fuller, D.; Boivin, N. Crops, Cattle and Commensals across the Indian Ocean: Current and Potential Archaeobiological Evidence. In *Plantes et Societes, Etudes Ocean Indien 42–43*; Lefevre, G., Ed.; Institut National des Langues et Civilisations Orientales: Paris, France, 2009; pp. 13–46.
46. Ruas, M.-P.; Tengberg, M.; Ettahiri, A.S.; Fili, A.; Staëvel, J.-P. Archaeobotanical Research at the Medieval Fortified Site of Îgiliz (Anti-Atlas, Morocco) with Particular Reference to the Exploitation of the Argan Tree. *Veg. Hist. Archaeobot.* **2011**, *20*, 419–433. [[CrossRef](#)]
47. Kuper, R.; Kröpelin, S. Climate-Controlled Holocene Occupation in the Sahara: Motor of Africa’s Evolution. *Science* **2006**, *313*, 803–807. [[CrossRef](#)]
48. Mercuri, A.M.; Sadori, L.; Ollero, P.U. Mediterranean and North-African Cultural Adaptations to Mid-Holocene Environmental and Climatic Changes. *Holocene* **2011**, *21*, 189–206. [[CrossRef](#)]
49. Buonincontri, M.; Moser, D.; Allevato, E.; Basile, B.; Di Pasquale, G. Farming in a Rural Settlement in Central Italy: Cultural and Environmental Implications of Crop Production through the Transition from Lombard to Frankish Influence (8th–11th Centuries A.D.). *Veg. Hist. Archaeobot.* **2014**, *23*, 775–788. [[CrossRef](#)]

50. Bosi, G.; Mercuri, A.; Guarnieri, C.; Mazzanti, M.B. Luxury Food and Ornamental Plants at the 15th Century A.D. Renaissance Court of the Este Family (Ferrara, Northern Italy). *Veg. Hist. Archaeobot.* **2009**, *18*, 389–402. [[CrossRef](#)]
51. Castiglioni, E.; Rottoli, M. Broomcorn Millet, Foxtail Millet and Sorghum in North Italian Early Medieval Sites. *Eur. J. Postclassical Archaeol.* **2013**, *3*, 131–144.
52. Castiglioni, E.; Rottoli, M. Il Sorgho (*Sorghum bicolor*) nel Medioevo in Italia Settentrionale. *Archeol. Mediev. Cult. Mater. Insediamenti Territ.* **2010**, XXXVII, 485–495.
53. Wasylkowa, K.; Tomczyńska, Z.; Nalepka, D. Szczątki Roślinne Z Warstw Wczesnośredniowiecznych Z Rejonu IX Na Wawelu. *Acta Archaeol. Wawel.* **2006**, *3*, 135–143.
54. Pradat, B.; Ruas, M.P. Plante Importée Ou Acclimatée ? Le Sorgho (*Sorghum bicolor* (L.) Moench) dans le Nord de L'Aquitaine Au Moyen Age. In *Plantes, Produits et Pratiques: Diffusion et Adoption de la Nouveauté dans les Sociétés Préindustrielles*; Buendía, N.R., Bouchette, A., Bouby, L., Ruas, M.P., Eds.; Monographies d'Archéologie Méditerranéenne, H.S. 8.; Association pour le Développement de L'archéologie en Languedoc-Roussillon (ADAL): Lattes, France, 2017; pp. 177–190.
55. Butzer, K.; Butzer, E.; Mateu, J. Medieval Muslim Communities of the Sierra De Espadán, Kingdom of Valencia. *Viator. Mediev. Renaiss. Stud.* **1986**, *17*, 339–420. [[CrossRef](#)]
56. Colmeiro, M. *Enumeración y Revisión de las Plantas de la Península Hispano-Lusitana e Islas Baleares*; Imprenta de la Viuda e Hija de Fuentenebro: Madrid, Spain, 1886.
57. Glick, T.F.; Glick, T. Islamic and Christian Spain in the Early Middle Ages: Second, Revised Edition. In *Agriculture, Settlement, and the Moving Frontier*; Brill: Leiden, The Netherlands, 2005; pp. 42–112.
58. Negre, J.; Alexander, M.; García-Collado, M.I.; García-García, M. La Maqbara De La Alquería De Xaresa. Estudio arqueológico y antropológico de una comunidad campesina en El Šarq Al-Andalus. In *Maqbara. Espacios Rituales y Ceremoniales de Enterramientos Islámicos*; Sarr, B., Ed.; Alhulia: Granada, Spain, forthcoming.
59. Dabrowski, V.; Bouchaud, C.; Desormeau, X.; Herveux, L.; Chambraud, E.; Ryan, S.E.; Tengberg, M. A Tale of New Crops in the Arid Arabian Peninsula Oasis from Antiquity to the Early Islamic Period. *Veg. Hist. Archaeobot.* **2024**. [[CrossRef](#)]
60. Dabrowski, V.; Bouchaud, C.; Tengberg, M.; Zazzo, A.; Priestman, S. Archaeobotanical Analysis of Food and Fuel Procurement from Fulayj Fort (Oman, 5th-8th C. Ce) Including the Earliest Secure Evidence for Sorghum in Eastern Arabia. *J. Arid. Environ.* **2021**, *190*, 104512. [[CrossRef](#)]
61. Varisco, D.M. Agriculture in Al-Hamdānī's Yemen: A Survey from Early Islamic Geographical Texts. *J. Econ. Soc. Hist. Orient* **2009**, *52*, 382–412. [[CrossRef](#)]
62. Varisco, D.M. *Medieval Agriculture and Islamic Science. The Almanac of a Yemeni Sultan*; University of Washington Press: Seattle, WA, USA; London, UK, 1994.
63. Varisco, D.M. Agricultural Crops in South Arabia/Yemen in the First Millennium Ce. *Veg. Hist. Archaeobot.* **2023**. [[CrossRef](#)]
64. Hernández-Bermejo, J.E.; García-Sánchez, E.; Carabaza Bravo, J.M. *Flora Agrícola y Forestal de Al-Andalus. Vol I: Monocotiledóneas, Cereales, Bulbosas y Palmeras*; Ministerio de Agricultura, Alimentación y Medio Ambiente: Madrid, Spain, 2012.
65. Bennison, A.K. *The Almoravid and Almohad Empires*; The Edinburgh History of the Islamic Empires; Edinburgh University Press: Edinburgh, UK, 2016.
66. Ehret, C. Linguistic Evidence and the Origins of Food Production in Africa: Where Are We Now? In *Archaeology of African Plant Use*; Stevens, C., Nixon, S., Murray, M.A., Fuller, D., Eds.; Left Coast Press: Walnut Creek, CA, USA, 2014; pp. 233–242.
67. Blench, R. Relating Linguistic Reconstructions of Plant Names in Berber to the Archaeobotany of North Africa. *J. Archaeol. Sci. Rep.* **2021**, *38*, 103009. [[CrossRef](#)]
68. Alpera, L. *Los nombres Trecentistas de Botánica Valenciana en Francesc Eiximenis*; Institució Alfons el Magnànim, Diputació Provincial de València: Valencia, Spain, 1968.
69. Torró, J. *El Naixement d'una Colònia: Dominació i Resistència a la Frontera Valenciana (1238-1276)*; Universitat de València: València, Spain, 2006.
70. Garcia-Oliver, F. Els cultius. In *Història agrària dels Països Catalans*; Universitat de Barcelona: Barcelona, Spain, 2004; pp. 301–334.
71. Riera i Melis, A. *Els cereals i el pa en els Països de llengua Catalana a La Baixa Edat Mitjana*, 1st ed.; Memòries de la Secció Històrico-Arqueològica; Institut d'Estudis Catalans: Barcelona, Spain, 2017; pp. 76–77.
72. Alcover, A.A. *Diccionari Català-Valencià-Balear: Inventari Lexicogràfic i Etimològic de la Llengua Catalana*; Institut d'Estudis Catalans: Palma de Mallorca, Spain, 1975–1977.
73. De Eguílaz Yanguas, L. *Glosario Etimológico de las Palabras Españolas (Castellanas, Catalanas, Gallegas, Mallorquinas, Portuguesas, Valencianas y Bascongadas) de Origen Oriental (Árabe, Hebreo, Malayo, Persa y turco)*; Impr. de la Lealtad: Granada, Spain, 1886.
74. Freytag, G.W. *Lexicon Arabico-Latinum*; Librairie du Liban: Beirut, Lebanon, 1975.
75. Blench, R. Finger Millet: The Contribution of Vernacular Names Towards Its Prehistory. *Archaeol. Anthropol. Sci.* **2016**, *8*, 79–88. [[CrossRef](#)]
76. Burkill, H.M. *The Useful Plants of West Tropical Africa*; Royal Botanic Gardens: Kew, UK, 1985.
77. Blench, R.M. Vernacular Names for African Millets and Other Minor Cereals and Their Significance for Agricultural History. *Archaeol. Anthropol. Sci.* **2016**, *8*, 1–8. [[CrossRef](#)]
78. Meloy, J. Mecca Entangled. In *The Mamluk Sultanate from the Perspective of Regional and World History*; Conermann, S., Walker, B.J., Eds.; Bonn University Press/V&R unipress: Göttingen, Germany, 2019; pp. 453–478.

79. Alonso, N.; Antolín, F.; Kirchner, H. Novelty and Legacies in Crops of the Islamic Period in the Northeast Iberian Peninsula: The Archaeobotanical Evidence in Madīna Balagī, Madīna Lārida, and Madīna Turṭūša. *Quat. Int.* **2014**, *346*, 149–161. [[CrossRef](#)]
80. Kirchner, H.; Virgili, A.; Antolín, F. Un espacio de cultivo urbano en Al-Andalus: Madīna Turṭūša (Tortosa) antes de 1148. *Hist. Agrar.* **2014**, *62*, 11–45.
81. Morelló i Baget, J. Els impostos sobre la renda a Catalunya: Redelmes, onzens i similars. *Anu. Estud. Mediev.* **1997**, *27*, 903–968. [[CrossRef](#)]
82. Oas, S.E.; Adams, K.R. The Nutritional Content of Five Southwestern Us Indigenous Maize (*Zea mays* L.) Landraces of Varying Endosperm Type. *Am. Antiq.* **2021**, *87*, 284–302. [[CrossRef](#)]
83. Kirchner, H. The Archaeology of Field Systems in Al-Andalus. *Agronomy* **2024**, *14*, 196. [[CrossRef](#)]
84. Martí, R.; Negre, J. Agua y poblamiento en el curso inferior del Ebro: Los espacios agrarios de la ciudad de Tortosa en época antigua y medieval. *Agua Territ.* **2024**, *24*, e7233.
85. Jiménez-Castillo, P. La Expansión agrícola en Šarq Al-Andalus. *Al-Qantara* **2022**, *43*, e24. [[CrossRef](#)]
86. Glick, T.F.; Almor, A.; Ferrer Navarro, R. *Regadío y Sociedad en la Valencia Medieval; Del Cènia al Segura: València, Spain, 1988.*
87. Esquilache, F. *Els Constructors de L'horta de València. Origen, Evolució i Estructura Social d'una Gran Horta Andalusina Entre els Segles VIII i XIII*; Universitat de València: València, Spain, 2018.
88. Torró, J. Tierras ganadas. Aterrazamiento de pendientes y desecación de marjales en la colonización cristiana del territorio valenciano. In *Por una Arqueología Agraria. Perspectivas de Investigación Sobre Espacios de Cultivo en las Sociedades Medievales Hispánicas*; Kirchner, H., Ed.; Archeopress: Oxford, UK, 2010; pp. 157–172.
89. Garcia-Oliver, F. *The Valley of the Six Mosques. Work and Life in Medieval Valldigna*; Brepols: Turnhout, Belgium, 2011.
90. Pérez Medina, T. La melca i la pansa. Els conreus moriscos de les Valls del Vinalopó. In *Cultius, Especialització i Mercats. X Congrés Sobre Sistemes Agraris, Organització Social i Poder Local*; Vicedo, E., Ed.; Institut d'Estudis Ilerdencs: Lerida, Spain, 2019; pp. 219–239.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.