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Abstract

Over the past millennia, Morocco has undergone a great number of socio-economic changes, its lands having been dominated or occupied in turn or at the same time by Berber, Phoenician, Punic, Mauri, Roman, Arab and Portuguese populations. As elsewhere in the Mediterranean, these socio-economic dynamics have been accompanied by agricultural changes of varying degrees, contributing to the introduction and spread of new plants and practices. From a chronologically and geographically unbalanced corpus of 13 archaeological sites, this paper proposes a general overview of the identified taxa, in order to set out our current knowledge of Moroccan agricultural productions from Antiquity to the early Modern period. A total of 47 cultivated/gathered species are attested by seeds and/or fruits, divided into 8 cereals, 7 pulses, 9 vegetables and condiments, 20 fruit trees, 3 oilseed and textile plants and 1 possibly cultivated grass plant. Greater taxonomic diversity is recorded during the medieval period, which is the most extensively researched. To complete this work, an overview of emerging approaches aimed at better characterizing diversity and agricultural practices (manuring, irrigation) is also proposed.

Keywords

Carpology; Summary; Late Iron Age; Antiquity; Middle Ages

Introduction

Over the past millennia, Morocco has undergone a great number of socio-economic changes, its lands having been dominated or occupied in turn or at the same time by Berber, Phoenician, Punic, Mauri¹, Roman, Arab and Portuguese populations. As elsewhere in the

¹ Mauretania was an ancient kingdom in northwest Africa, encompassing regions of modern-day Morocco and Algeria. Ancient Mauretania was named after the Mauri (Moors), a Berber tribe.

Mediterranean, these socio-economic dynamics have been accompanied by agricultural and culinary changes of varying degrees, contributing to the introduction and spread of new plants and practices. In Morocco, ancient and medieval agriculture is usually considered from two positions: textual and, more recently, archaeobotanical, rarely conducted jointly due to the high degree of specialization required by each (e.g. Fariat 2023; Vanz et al. 2024).

The first approach is based on Arabic texts of diverse nature and origin, among which agronomic and geographic treatises dominate (e.g., Al-Idrîsî 1866; Al-Bakri 1911; Ibn Ḥawqal 1938). These texts have provided-and continue to provide-valuable information not only in the field of Arabic philology, in terms of the agricultural terms used, but also in that of agronomic traditions and affiliations, of plants and their cultivation methods, with ramifications in the medical, pharmaceutical and culinary fields. But these sources, although rich and varied, are not available for all periods or in a uniform way across the country, and are biased towards the interest of the particular author, underlining the importance of complementary approaches. Recently, in the Western Mediterranean, more holistic approaches to understanding the developments of Islamic agriculture have included linguistic approaches (Blench 2021), as well as archaeological field work, multi-proxy sampling and dating techniques (e.g. Kirchner et al. 2023,) providing new perspectives and chronological nuance.

At more local levels, the archaeobotanical details can be linked to local fluctuating socio-economic and climatic conditions, as well as the broader influences of the ruling caliphates and technological advances. For this reason, patterns in the crop repertoire are not necessarily global but can be linked to local customs and environmental conditions. Unfortunately, archaeobotanical research on the Mediterranean Islamic world is uneven. In some parts of North Africa, political instability has limited excavation and archaeobotanical studies in recent years, such as in Libya and Algeria, and we are reliant on old data. Elsewhere in the Western Mediterranean, the renewed interest in medieval archaeology and revisiting of the Islamic Green Revolution model (Watson 1983) has prompted sampling for archaeobotanical remains as well as other environmental proxies, at sites in Tunisia (e.g. van Zeist et al. 2001), Portugal and Spain (e.g. Peña-Chocarro et al. 2019; Ros et al. 2019), Italy (Fiorentino et al. 2024), as well as Morocco (e.g. Ruas 2018). In Morocco, for a long time, archaeobotanical studies of historical contexts were carried out on an ad hoc basis, depending on the sensitivity of the archaeological teams to bioarchaeological and palaeoenvironmental issues and methods. In the 1970s and 80s, a few archaeological missions initiated archaeobotanical research on medieval contexts, leading to some pioneer publications (Pollock 1986), although several studies remained unpublished and difficult to access (e.g. at Sijilmasa, see Mahoney unpublished report 1994, 1995, 1996). The years 2000 have seen a new development of this type of analysis, thanks in particular to large operations carried out on certain emblematic

sites of ancient and medieval Morocco, such as Lixus and Volubilis (Grau Almero et al. 2001, 2010; Fuller 2002, 2004; Pérez Jordà 2005; Fuller and Stevens 2009; Fuller and Pelling 2018). Since the 2010s, new sites have been or still are the subject of large-scale archaeobotanical research (carpology, anthracology), the palaeoenvironmental component forming a significant part of the approach. In the absence of Moroccan archaeobotanists, it is especially through Moroccan-French, Moroccan-Spanish, Moroccan-British and Moroccan-Italian collaborations that this research was developed. We will mention, for example, the large-scale excavations carried out at Îgîlîz² (Ruas et al. 2011, 2016a; Ros et al. 2021a), at Thamusida (Allevato et al. 2013, 2016), at Rirha³ (Ruas et al. 2016b; Carrato et al. 2020), at Aghmat⁴ (Ros et al. 2021b, 2024) and new work emerging from the Middle Draa Project⁵ in the Wadi Draa (Fenwick et al. 2021; Mattingly et al 2017).

The collaborations established over the last decade and important institutional support (e.g. INSAP, MNHN, CNRS, MAE, Casa de Velázquez) have allowed the creation of research programs entirely dedicated to the study of ancient and/or medieval Moroccan agriculture and paleoenvironments. For example, the HARGANA project⁶ was an interdisciplinary project that aimed to study the domestic and wild plant and animal resources of a population of the medieval (Almohad) Anti-Atlas, at Îgîlîz, and the methods of management and use of their territory through the argan tree (*Argania spinosa*), an endemic species. Among these institutional supports, we must make special mention of the Casa de Velázquez and of the École des Hautes Études Hispaniques et Ibériques (EHEHI), which, in addition to providing institutional and financial support for several archaeological programs on medieval Morocco, were also the first institutions to finance a postdoctoral position⁷ entirely dedicated to the archaeobotany of medieval Morocco, while co-funding the organization of the first workshop

² Moroccan-French scientific cooperation (since 2009) "*La montagne d'Îgîlîz et le pays des Arghen - Enquête sur l'histoire du peuplement rural dans le Sud marocain au Moyen Âge et à l'époque prémoderne*" / dir. J.-P. Van Staëvel (Univ. Paris Université Lettres, UMR 8164), A. S. Ettahiri (INSAP, Rabat), A. Fili (Univ. El Jadida).

³ Moroccan-French scientific cooperation (since 2007) "*Rirha (Sidi Slimane, Maroc). Une ville antique et médiévale de la plaine du Gharb*" » / dir. E. Rocca (Univ. Montpellier 3, UMR 5140), C. Carrato (post-doc, UMR 5140), M. Kbir Alaoui, (INSAP, Rabat)

⁴ Moroccan-French scientific cooperation (since 2016) "Aghmat (Maroc) : Archéologie, Restauration et Mise en valeur" » / dir. A. Fili (Univ. Chouaïb Doukkali), C. Capel (UMR 7041)

⁵ Moroccan-British interdisciplinary cooperation (since 2015) "Middle Draa Project" / currently dir. D Mattingly (Univ Leicester), Y. Bokbot (INSAP, Rabat), C. Fenwick (UCL, London) funded by Arts and Humanities Research Council grant for the OasCiv project (Grant no: AH/T002409/1) and a European Research Council grant for the EVERYDAYSLAM Project (Grant no: 949367)

⁶ HARGANA "Histoire et Archéologie des Ressources biologiques et stratégie de Gestion vivrière de l'Arganeraie médiévale en montagne Antiatlasique (Maroc)" / dir. J.-P. Van Staëvel (UMR 8167, Université Paris-Sorbonne IV) and M.-P. Ruas (UMR7209, CNRS/MNHN)

⁷ 2017-2018: Casa de Velázquez Postdoctoral Contract (EHEHI Scientific Member), Madrid, allocated to J. Ros (CNRS, UMR5554 ISEM) for the project: "Agriculture and Plant Resources in the Medieval Muslim West".

dedicated to the archaeobotany of medieval Iberian Peninsula⁸. Today, several archaeobotanical studies follow their course while new ones are initiated (Ros and Badri 2020; Fenwick et al. 2021). However, in view of the scarcity of studies, priority is now given to training and dissemination of the results obtained to date. The current projects are therefore aimed at raising the awareness of new generations of Moroccan archaeologists to the themes and methods of bioarchaeology, thanks in particular to the investment of specialists in the field and in academic institutions. It should also be noted that, since 2023, the National Institute of Archaeological Sciences and Heritage (INSAP) of Rabat funded the first doctoral research⁹ dedicated to the study of Moroccan medieval agriculture, based on the study of archaeobotanical samples.

In recent years, the first syntheses of data have made it possible to address the ancient and medieval history of certain plant categories in the Western Maghreb, for example fruit and vegetables (Ruas 2018) or cereals (Ruas 2020), based on the presence/absence of the cultivated taxa and on their ubiquity. This new review complements the existing ones, first by adding 3 new archaeological sites, among which 2 are located in the south of the country, responding to a major shortfall in terms of data spatialization, and secondly by bringing together, for the first time, all the available quantified data from across the country. We aim: 1) to present a critical assessment of the archaeobotanical data available, 2) to explore the general characteristics of medieval agriculture in Morocco, its legacies and novelties, and 3) to outline the current research on past varietal diversification and agricultural techniques.

Material and methods

For northern Morocco, the available archaeobotanical data is concentrated in the northwest of the country (Gharb plain, Jbala mountains) and concerns the sites of Asilah, Qsar es-Seghir, Nakur, Badis, Thamusida, Lixus, al-Basra, Volubilis and Rirha (Table 1; Figure 1). For the south, we will examine the data from: Sijilmasa, in the oasis region of Tafilalt; the jbel of Îgîlîz in the Anti Atlas; Aghmat in the Ourika valley (south of Marrakech); and those from the Coude du Draa, in the Wadi Draa region (Table 1; Figure 1). This corpus covers a chronological range including the Roman (1st-4th centuries), Medieval (8th-15th centuries) and Modern (16th-17th centuries) periods, with reference to the Late Iron Age, Phoenician, Punic and Mauri data when available.

⁸ International Workshop "Archaeobotanical research on medieval agriculture in the Iberian Peninsula: methodology, assessment and perspectives", June the 12th, 2018, Casa de Velazquez, Madrid (Spain), dir. L. Peña-Chocarro (Instituto de Historia, CCHS, CSIC) and J. Ros (CNRS, UMR5554 ISEM).

⁹ Badri F.E.: "Agriculture and exploited forest landscapes in the medieval Haouz: an interdisciplinary approach in Aghmat", INSAP (Rabat, Maroc), dir. J. Ros (CNRS, UMR5554 ISEM), A. Ettahiri (INSAP) and A. Fili (Univ. Chouaïb Doukkali).

Each of these sites offers a variable window of information depending on the duration of occupation, the contexts and the preserved vegetal deposits. The cities of al-Basra, Sijilmasa, Qsar es-Seghir, Aghmat and the rural fortress of Îgîlîz are settlements from the Islamic period. The excavated sectors of Thamusida correspond to the Roman military and civil quarters. Lixus, a city founded by Punic settlers in the 8th century BCE, and Rirha, whose first settlements date from the Mauri period (5th-4th centuries BCE), became important cities in the Roman period, whose ruins were reinvested by settlements from the Islamic period. For Volubilis, the available archaeobotanical data derives only from the Islamic levels, with recent excavations adding data for the earliest Islamic occupation of the site¹⁰. The contexts in which the plant remains have been preserved mostly correspond to levels of domestic or agricultural dumps, emptying of combustion structures (domestic and artisanal ovens, domestic fireplaces), habitation floors, contents of disused containers or silos reused as dumps, or even storage spaces, sometimes destroyed by fire (Table 1).

The comparison between the different sites suffers from several biases inherent to unequal status (urban, rural, commercial, religious), strong geographical disparity (north, south, coast, plain, mountain), variable corpus of samples (diversity of sampled contexts, quantity of studied samples, original volume of sampled sediment), and, finally, to the study protocol that was applied (proper sieving and extracting method, quantification of the remains). For this reason, it is important to keep in mind that the comparison we propose is preliminary.

To decide which species to include in our list of cultivated or exploited/consumed taxa, we based our choice on several criteria: type and abundance of remains of said taxon in the samples, frequency of appearance identified by archaeobotanists (e.g. Ruas 2018), contexts of discovery (domestic hearth, latrines), mention of consumption/cultivation of the taxa in textual and/or ethnographic sources.

Results

From an unbalanced corpus of 13 sites or study areas for the whole country, it seems premature to attempt a statistical treatment of the data. We therefore propose a general overview of the identified cultivated/gathered taxa, in order to present an updated account of our knowledge on agricultural production. The total number of selected plants, attested by seeds or fruits, includes 47 species that were cultivated/gathered (Table 2). They are divided into 8 cereals, 7 pulses, 9 vegetables and condiments, 20 fruit trees, 3 oilseed and textile plants and 1 possibly cultivated grass (Table 3; Figure 2).

¹⁰ Moroccan-British interdisciplinary cooperation (since 2018) “Medieval Volubilis Archaeological Project” (funding: European Research Council grant for EVERYDAYISLAM Project (Grant no: 949367), Barakat Trust, Gerald Averay Wainwright Fund for Near Eastern Archaeology)/ dir C. Fenwick (UCL, London), E. Fentress (UCL) and H Limane (INSAP, Rabat)

Cereals and possibly cultivated grass

In the different sites of the corpus, hulled barley (*Hordeum vulgare*) and naked wheat (*Triticum aestivum/durum*) seem to constitute the staple cereal productions. Of the identified barleys, it would appear that both types (two-row, six-row) are farmed, although it is not clear whether one type is more prevalent than the other within each site and positive separation of the two types is often not possible. Barley grain appears to be slightly more common than naked wheat at some, but not all sites, especially in southern Moroccan sites.

The presence of sufficiently well-preserved rachis demonstrates the presence of both hexaploid (type *aestivum*) and tetraploid (type *durum*) types, as early as the Early Neolithic in the case of *T. durum* (Morales *et al.* 2013), although durum wheat was long considered to be a novelty linked to the Muslim expansion in the Western Mediterranean (Watson 1983). Unlike emmer (*T. dicoccum*), which is regularly documented in Morocco during previous phases (Punic, Mauri, Roman), einkorn (*T. monococcum*) disappears from the archaeological record after the Neolithic period, and reappears during the Middle Ages in northern Morocco (Al Basra, Lixur and Volubilis).

The Panicoideae subfamily is represented in Morocco by 3 species: broomcorn millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), and sorghum (*Sorghum bicolor*). Broomcorn millet is attested from the Punic/Mauri phases onwards, but is generally discreet in the samples. During the medieval period, it is only recorded in the north (Rirha; Al Basra), but appears in the late medieval-modern samples of Aghmat. Foxtail millet (*Setaria italica*) only appears in the Punic/Mauri contexts of Lixus and has not been recorded in Roman or medieval samples so far. Finally, sorghum is only recorded in one archaeological site so far, in the medieval rural fortress of Îgîlîz in the Anti-Atlas. In some contexts of this settlement, sorghum seems to be, with hulled barley, a staple crop, being more frequent and abundant than naked wheat. Oat (*Avena* sp.) is present in several medieval sites, but its status (cultivated, wild) has not been established so far. The cereals tend to be best represented by grain, chaff finds being very rare across the sites with a few exceptions (threshing residues, in situ stock feeding, e.g., at Aghmat, Îgîlîz, Volubilis). Finally, *Phalaris canariensis* (canary grass), found on a number of medieval sites in northern Morocco, sometimes in large numbers (at Volubilis), should also be considered as a potential crop plant. During the 20th century, this "small cereal" was mainly grown with durum wheat as a fodder crop, in the Rharb zone and in the sub-littoral areas of Casablanca, Mazagan and Safi (Perrin de Brichambaut 1952).

Pulses

Summarized data show that before the Roman period, 5 pulses were exploited: peas (*Pisum sativum*, *Lathyrus cicera/sativus*), faba bean (*Vicia faba* var. *minor*), vetch (*Vicia sativa*) and lentil (*Lens culinaris*). It appears that *Pisum*, more frequent in Phoenician contexts (e.g., at Lixus), seems to have been replaced over time by *Vicia faba*, finds of which increase from the 5th-4th centuries BCE onwards (Ruas 2018). This preeminence is also confirmed during the Islamic period, both in the north and in the south. Lentil is the second most common medieval pulse crop after *Vicia faba* in the northern sites, becoming more common than pea. Other pulses (*Vicia sativa*, *Vicia ervilia*) occur sporadically, in Punic-Mauri and Roman contexts, then in medieval deposits, but without ever reaching high quantities or frequencies. A new legume also appears, *Vicia faba* var. *equina* or var. *major*, a large-seeded bean, in the medieval context of Rirha, although it is unclear if it was imported and just consumed, imported then locally grown (introduction) or a local development of a new variety (Ruas 2018). The absence of chickpeas (*Cicer arietinum*) is surprising, the cooked or roasted seeds being as likely to be preserved in archaeological deposits as peas or beans. The distribution of carpological finds of the species seems eastern, since some remains are attested in the Islamic levels of Carthage (Tunisia) (van Zeist et al. 2001).

Vegetables and condiments/aromatics

The identification of vegetables and condiments/aromatics from archaeobotanical deposits is difficult due to preservation biases: seeds are often poorly preserved by charring and leafy or fleshy parts are unlikely to come into contact with fire. The presence in the corpus of contexts favoring preservation by mineral replacement (cesspits, middens) has increased the range of identified plant categories (van Staëvel et al. 2016). In the Punic/Mauri and Roman contexts, several taxa were identified, such as chard (*Beta vulgaris*), coriander (*Coriandrum sativum*), white mustard (*Sinapis alba*), purslane (*Portulaca oleracea*), carrot (*Daucus carota*) and cabbage/mustard (*Brassica/Sinapis*). Of these taxa, some (coriander, white mustard) have certainly been cultivated, while the status (cultivated, wild) of the others will need to be better clarified. All of them are also found in medieval contexts, with the addition of gourd (*Lagenaria siceraria*), caper (*Capparis* cf. *spinosa*), monk's pepper (*Vitex agnus-castus*), all found in the latrines of Îgîlîz. Amaranth, white mustard and, to a lesser extent, cabbage/mustard and chard seeds form the most common vegetable/condiments/aromatics elements in the carpological assemblages of all periods. Seeds of other species appear at very low rates with fewer than ten remains (caper, purslane, monk's pepper). Several other cultivated fruiting and leafy vegetables are not recorded so far in the carpological spectra of Morocco (for example cultivated artichoke, cucumber, spinach, eggplant) although they have been discovered in other parts of the Western Islamic (e.g. eggplant in Islamic Sicily, Fiorentino et al. 2024) or Christian (e.g. spinach in Christian France, Hallavant and Ruas

2014) world. Finally, seeds of celery (*Apium graveolens*) are recorded in late medieval-modern samples at Aghmat, but its status is still under debate.

Fruits

A great diversity of fruit species is recorded in the corpus. Among them, figs (*Ficus carica*), olives (*Olea europaea*), pomegranates (*Punica granatum*) and pine nuts (*Pinus pinea*) are attested from the Phoenician period (8th-7th centuries BCE) onwards. During the Mauri and Roman periods, other cultivated fruits are added, such as grapevine (*Vitis vinifera*), carob (*Ceratonia siliqua*), plum (*Prunus domestica*), almond (*P. dulcis*) and peach (*P. persica*), as well as wild fruits such as those of the dwarf palm (*Chamerops humilis*), the wild jujube (*Ziziphus lotus*) and the hawthorn (*Crataegus monogyna*). The greatest samples of grapevine are encountered during Late Antiquity (3rd-4th centuries CE), with evidence of wine production at Rirha (Carrato et al. 2020) and during the Middle Ages at Aghmat (12th century). Dates (*Phoenix dactylifera*), walnut (*Juglans regia*), cultivated jujube (*Ziziphus jujuba*), argan (*Argania spinosa*), raspberry (*Rubus idaeus*), blackberry (*Rubus fruticosus*) and possibly melon (*Cucumis* cf. *melo*) are only recorded in the Islamic period. Anthracology makes it possible to confirm the presence of certain taxa in the local landscape. In the south of the country, the discovery of olive, fig, pomegranate and grapevine charcoals, for example, are known from the local landscape of Aghmat from as early as the 12th century, and their important role in domestic fuel (Ros et al. 2024). The same is true of Îgîlîz, where the anthracological study reveals the presence of fig, olive, grapevine and date palm charcoal, confirming the existence of irrigated gardens in this semi-arid context during the 12th century (Cartier 2021).

Oilseed, textile plants

A total of 3 taxa have been recorded for this category. The only one recorded before the medieval period is flax (*Linum usitatissimum*), attested in Punic/Mauri contexts. So far, the plant is absent in the Roman period of the north, but appears regularly in medieval contexts, both in the north (Rirha, Volubilis) and the south (Aghmat) of the country. Although it is most commonly found in seed form, it is also recorded in stem/fiber form at al-Basra and as capsule fragment at Rirha (Ruas et al. 2016b). According to al-Bakri, the city of al-Basra was nicknamed "Basrat al-Kattân", because flax (al-Kattân) was used by its first inhabitants in commercial transactions as a form of currency (Ettahiri and Meftah 2015). Other plants in this category are recorded from medieval times onwards, but never in large quantities: cotton (*Gossypium* sp., Volubilis) and safflower (*Carthamus tinctorius/Carthamus* sp., Volubilis, Îgîlîz).

Discussion

Because of the major imbalance that currently exists between data, both geographically and chronologically, the discussion will first focus on the characterization of the agricultural heritage detected and its evolution, and then on emerging approaches that aim to better characterize diversity and ancient practices.

Between heritage and novelties: "new" plants?

As demonstrated, the staple crops encountered in Morocco for the studied period are those common to the entire Roman and medieval Western Mediterranean (for ex. Ruas 2005; Peña-Chocarro et al. 2019; Ros et al. 2023), regardless of the location or status of the sites, particularly cereals (hulled barley, naked wheat), legumes (peas, fava beans, lentils), and some fruit trees (olive, fig, grapevine). In Morocco, these staple crops, as well as several consumed wild plants (wild *Vitis*, *Chamaerops*, wild *Olea*, and *Ziziphus*), have been present since the Neolithic period, or even earlier (e.g. Morales et al. 2013, 2016).

With regard to "secondary" cultivars, it is difficult to determine what is really new, whether or not driven by certain socio-economic dynamics, such as the Muslim expansion, and what is due to the random nature of the sampling. For example, is the medieval increase in vegetable and fruit diversity really a consequence of socio-economic changes, or simply caused by the greater number and diversity of contexts (latrines) studied for this period? In Morocco, some taxa that are considered "classic" in the Roman eastern Mediterranean only appear during the medieval period; this is the case, for example, of einkorn (although it was recorded in the Neolithic samples of KafTaht el Ghar, Ballouche and Marival 2003), melon, blackberry or walnut. Other species appear in the carpological spectrum during the medieval period, without it being possible to determine their status in terms of novelties. This is the case, for example, of the argan tree and sorghum, identified only in the medieval contexts of Îgîlîz, in an area where no sites prior to the medieval period have been studied or even detected. On the other hand, some taxa considered from textual sources as emblematic of Muslim agriculture, appear in the samples from the Islamic period onwards. This is the case, for example, of the date palm (*Phoenix dactylifera*, at Rirha, Aghmat, Îgîlîz, Sijilmassa, Coude de Draa), the jujube tree (*Ziziphus jujuba*, at Rirha, Îgîlîz), gourd (*Lagenaria siceraria*, at Îgîlîz), capers (*Capparis spinosa*, at Îgîlîz), cotton (*Gossypium* sp., at Volubilis) and safflower (*Carthamus tinctorius/Carthamus* sp., at Volubilis, Îgîlîz). But the archaeobotanical evidence of some of these taxa, such as gourd, or capers, are always scarce, a product of taphonomy and preservation; the bottle gourd, of African origin, was known to the Romans, (Janick *et al.* 2007), and occasional seeds were found in 1st-4th century CE deposits at Jarma, the

Garamantian capital of Fazzān, Libya (Pelling 2013), potentially the product of trans-Saharan trade. The history of cotton is better known, with large numbers of seeds and cotton processing artefacts known from Islamic Mali and Senagal (Chavane 1985; Insoll 2000; Murray 2005), from a trans-Saharan trading town of Tadmakka/Essouk, northern Mali (Nixon et al. 2011). Pre-Islamic finds of cotton seed and historical texts attest to its cultivation in Nubia (Yvanez and Wozniak 2019), Dakhla Oasis, Egypt (Bagnall 1997; Thanheiser 1999) and Fazzān, Libya (Pelling 2013) from at least the early centuries CE. The origin and pathway of introduction of a new legume (*Vicia faba* var. *equina/major*) found at Rirha also require research, since its presence is documented earlier in the Western Mediterranean, in Byzantine Sicily (Fiorentino et al. 2024).

Of all the “new” crop species, the date palm is perhaps the most enigmatic. Despite the presence of cultivated date palm in Fazzān, southern Libya, since at least the 1st millennium BCE (Kaczmarek, et al. 2024) and Egypt since at least the 2nd millennium BCE (Tengberg and Newton 2016), the introduction and cultivation of the species in Morocco is as yet unclear. The oldest archaeobotanical remains date from the medieval period, but, in the area where it could have been cultivated, no site prior to the 10th century CE has been sampled systematically until recently. While its consumption is documented in medieval northern Morocco, in the south, where medieval textual sources mention the existence of large palm groves (e.g. Aghmat), archaeobotanical remains are very rare, limited to a few charred seeds, except at Sijilmassa where they have been found in slightly larger numbers in the 7th-12th century CE deposits. At Îgîliz, the taxon is also present in the charcoal samples, but never by more than a few fragments. If this species is really as widespread as the texts suggest, how can we explain its rarity in archaeobotanical assemblages? Recent field survey and excavation in the Coude du Draa as part of the Middle Draa Project is sampling both Iron Age (pre-8th century CE) and medieval sites including extensive irrigated field systems dating from the 8th century onwards, the first project to target this significant transitional period in the region (Fenwick et al. 2021; Mattingly 2017). Carpological evidence for dates has so far only been found from the 10th-13th century contexts and later. However, preservation bias may account for the absence of the stones: very few date stones were preserved by charring, while in the late and post-medieval deposits, the desiccated outer testa of the stones survived in much larger quantities, the seed having degraded. Date stones do not therefore appear to have been routinely used as a fuel source (in contrast, for example, to the Libyan oases where burnt date stones are present in abundance from the 1st millennium BCE (Pelling 2013)), and they are less likely to become mineralized than smaller fruit seeds, while conditions are not sufficiently dry for desiccation. The absence of date in southern Morocco prior to the 10th century, may therefore be the result of preservation. Intriguingly, preliminary examination of

silica phytoliths from the Coude du Draa by Sigrid Osborne (Bournemouth University) has identified likely palm (spheroid echinate types) in a possible Iron Age silo as well as the medieval deposits (radiocarbon dates for the feature are awaited), although further morphometric analysis will be necessary to distinguish the phytoliths of the date palm from *Chamaerops humilis*, a native palm (García-Granero et al. 2020). Further sampling for carpological and charcoal remains as well as phytoliths from sites prior to the 10th century is therefore a priority for understanding the evolution of the extensive medieval palmeries as well as the processing, storage and trade of the fruits.

Emerging approaches to document medieval agricultural production and practices

In our attempt to produce a comprehensive review of current understanding of agricultural production and practices in ancient and medieval Morocco, we consider as essential the inclusion of emerging studies currently underway.

Documenting varietal diversification of several emblematic Mediterranean productions

According to various researches based on medieval textual sources (Watson, 1983, rééd. 2008 ; Aubaile-Sallenave 1984 ; Lagardère 1997 ; Decker 2009 ; Albertini 2013), the Muslim area in the Western Mediterranean would have experienced an enrichment of its agricultural diversity, particularly of fruits, through the application of three processes: (1) the introduction and acclimatization of "new" plants¹¹, thanks to the development of irrigated agriculture (e.g. citrus, pistachio, apricot), which has also benefited other already well-established species such as the olive tree, (2) the improvement or creation of new varieties from indigenous plants, notably through grafting or transplanting (e.g. cherry, pear, almond), and (3) the introduction of new varieties created in the East (e.g. peach, pomegranate). To characterize fruit diversity and varietal diversification, classical biometrics and geometric morphometrics approaches are developed, conducted on the carpological remains of several sites. This type of approach has been successfully used in the Mediterranean, on archaeological remains of *Vitis vinifera* (pips), *Olea europaea* (pits), *Prunus avium* and *P. cerasus* (pits), *Phoenix dactylifera* (seeds), and, more recently, *Hordeum vulgare* (caryopsis), enabling a finer characterization of the processes of varietal diversification and cultivation of these species (Terral et al. 2004, 2010, 2012; Burger et al. 2011; Ros et al. 2014; Jeanty 2023). The first studies carried out on different sites of the Moroccan corpus are encouraging, with large batches of grapevine pips and olive pits having been discovered at Rirha, Aghmat and

¹¹ The knowledge and methods of consumption/exploitation of a plant vary over time and space, depending on various socio-cultural factors (status of consumers, dietary patterns), economic factors (value of the plant, trade flows) and demographic factors (population movements). The status of "new" plant should thus be considered with caution, as it may be rediscovered and perceived as new at the time it is reintroduced into the food circuit at a given time (Ruas 1992).

Sijilmassa, covering a chronology that spans the 3rd to the 17th century CE. These remains, already photographed, are currently undergoing geometric morphometrics analysis, led by J.-F. Terral (Univ. of Montpellier, UMR5554) and L. Bouby (CNRS, UMR5554). These data will be the very first archaeological data on the medieval varieties of grapevine and olives exploited in Morocco (Ater et al. 2016). This approach is all the more interesting, since, for example, Arab geoponicians do not pay particular attention to the olive varieties grown in the Western Mediterranean (Albertini 2013: 173).

Documenting ancient agro-horticultural practices

In the Muslim West (al-Andalus, Maghreb al-Aqsa), our knowledge of medieval land management was for a long time essentially based on textual sources and also, especially where irrigation is concerned, on archaeology (tools, creation of agricultural terraces, irrigation channels and wells) (e.g., Cressier 2006). To avoid soil depletion due to the cultivation of water- and nutrient-demanding species, and to improve production, medieval Muslim agronomists recommended, for example, extensive soil preparation, the use of green manure, animal manure, and irrigation (Albertini 2013). The use of artificial grasslands was also recommended for feeding livestock. Although these practical recommendations are known, their local application in the different areas studied by archaeology, which sometimes escape the textual sources, remain difficult to clarify by material sources. Besides classical carpological studies (taxonomic diversity, types of remains, weed ecology), two cutting-edge methods are currently developed on some Moroccan sites, shedding light on certain precise aspects of medieval agricultural practices.

The first one, quantitative eco-anatomy, involves the measurement of the vascular elements of the wood and their variations, the anatomy of the wood being influenced by virtually every event that takes place during the growth and development of the tree (age, soil conditions, altitude, exposure, cultural practices, silvicultural treatments, pathogens and pollutants). Quantitative eco-anatomy thus makes it possible to reveal the conditions in which the ancient trees grew, and thus to highlight certain agricultural practices. In Morocco, this approach was pioneered on the Argan tree (*Argania spinosa*) (Ros et al. 2021a), as part of the HARGANA project. The emergence of the Argan tree as an agricultural, pastoral, cultural, economic and ecological keystone species in Southern Morocco is considered to be linked to the settlement of agropastoral communities that favored its expansion. Nevertheless, the use and exploitation of Argan trees is documented by few medieval written sources, and by archaeobotanical studies from a single location, Îgîlîz (Toughmart, Morocco). A quantitative eco-anatomical approach aiming to understand variations of wood characters involved in sap conduction and reserve storage, was developed from modern samples collected in the area of Îgîlîz and from archaeological samples. Results show that diameter of branches and environmental factors

(especially irrigation and manure) are the major parameters explaining plasticity of wood anatomical characters. It would also seem that the argan trees exploited in the medieval period have benefited from the input of irrigation and manure, their anatomical signature being very similar to that of modern cultivated argan trees. This approach will soon be carried out on charcoal of olive wood found at Rirha and Aghmat. In these sites, olive has played a central economic role since during the Roman and medieval periods, especially for fruit consumption, oil production oil and as fuel. The eco-anatomical study of different batches of charcoal fragments will allow new understanding of the evolution of cultivation practices (irrigation?) of this central species.

The second method is based on the isotopic analysis of carpological remains, with the objective of highlighting practices related to manuring or irrigation of exploited soils, and the evolution of these practices over time. A CNRS-INEE PEPS project intitled « AGHMAT: AGrosystèmes Historiques du Maroc: Adaptations, Transformations - L'exemple de la région du Haouz » was initiated in 2020, aiming to highlight manuring and irrigation practices of certain species in the medieval site of Aghmat. A chemical approach (stable isotopes: Carbon, Nitrogen, Sulphur) was carried out on archaeological carpological remains (*Hordeum vulgare*, *Triticum aestivum/durum*, *Olea europaea*, *Vitis vinifera*), which allowed qualification of the cultivation conditions developed during the study period (12th-17th century CE) (Ros et al. 2024). Within the framework of a national ANR project¹² started in 2023, the consolidation of the current isotopic reference system is in progress, and the archaeological dataset expanded by including archaeobotanical specimens from various Moroccan sites.

Conclusion

This initial summary has highlighted a great problem with the representativeness of the archaeobotanical data available in Morocco, which currently suffers from a major imbalance, particularly geographically, with a highly developed north, and a south that remains largely unexplored. Under the impetus of some researchers, certain periods, such as the Middle Ages, have been particularly well investigated, while other chronological phases, notably the Punic and Mauri periods, still require a major sampling effort. For future research, if we wish to better address the issue of species introduction, it will be important to study a greater number of sites, and to focus on two aspects: a better diversity of contexts, preferably urban, favoring a different type of conservation (latrines), and perhaps a more in-depth approach to particular agricultural systems that may have favored the introduction/spread of certain plants of oriental or Near Eastern origin, such as oases. The recent excavation of new contexts at

¹² ANR Project “MICA - Modelling Interactions between Climate change and Agriculture in the ancient West”, PI: L. Bouby (ISEM), 2023-2027.

Sijilmassa, as well as sites in the Coude de Draa, will certainly allow for further research on this theme.

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Site	Location	Chronology	Period	Status	Type of contexts	Number of contexts	References
Al Basra	Al Basra	9th-12th c. CE	Islamic - Medieval	Provincial capital city	Potter's kilns, dumps, housing floors	35	Pollock 1986; Mahoney 2004 ; Pelling 2007
Aghmat	Ghmat	10th-15th c. CE	Islamic - Medieval	Ephemeral capital, city, village	Hearths, charcoal/ash levels, traffic levels, dumps, garden soil	22	Ros et al. 2021, 2024
Asilah	Asilah	16th-19th c. CE	Islamic - Modern	Village	Hearths, charcoal/ash levels, traffic levels, dumps	8	
Asilah	Asilah	5th-3rd c. BCE/CE	Mauri	Rural	Housing floors	1	Ros and Badri 2020
Badis	Badis	11th-13th c. CE	Islamic - Medieval	Rural	Housing floors	5	
Badis	Badis	9th-15th c. CE	Islamic - Medieval	Port city	Concentration of ashes in an inhabited space	1	Pollock 1986
Coude du Draa	Wadi Draa	5th-8th c. CE	Late Iron Age	Fortified hilltop site, Trans-Saharan network	Occupation layers	11	Fenwick et al. 2022
Coude du Draa	Wadi Draa	8th-13th c. CE	Islamic - Medieval	Fortified oasis, Trans-Saharan network	Mudbrick fortified buildings, qsar	18	
Coude du Draa	Wadi Draa	15th-18th c. CE	Late Medieval / Early Modern	Rural, Trans-Saharan network	Buildings, Mosque	5	
Igiliz	Tughmari	10th-15th c. CE	Islamic - Medieval	Rural fortress	Habitats, fireplaces, ovens, latrines, garbage dumps	210	Ruas et al. 2011, 2016a
Igiliz	Tughmari	8th-4th c. BCE	Phoenician	Foundation of the first city	Large landfill and landfill levels	28	
Igiliz	Tughmari	5th-2nd B.C.	Punic			10	
Igiliz	Tughmari	2nd-1st c. BCE	Punic-Mauri	Remotely city, sanctuary	Pits, fire levels, waste	42	Grau Almero 2005, Pérez Jordá 2005;
Igiliz	Tughmari	1st-2nd c. CE	Roman	City, Colonia, temple	Dwellings with storage space and activity waste	12	Grau Almero et al. 2001, 2010
Igiliz	Tughmari	5th-6th c. CE	Late Roman	Reoccupation of a city	Landfills, domestic garbage	7	
Igiliz	Tughmari	8th-14th c. CE	Islamic - Medieval			4	
Nakur	Nakur	9th-11th c. CE	Islamic - Medieval	Dynastic capital of the kingdom of Nakkûr, pole	Pit filling	1	Pollock 1986
Qsar es-sghir	Fahs-Anjir	12th-15th c.	Islamic - Medieval and Portuguese	Port city, commercial center, fortress	Oven, mureaux	3	Pollock 1986
Qsar es-sghir	Fahs-Anjir	5th-2nd c. BCE	Mauri	Agglomeration of habitats	Soil, domestic and agricultural waste, households	10	
Qsar es-sghir	Fahs-Anjir	2nd-1st c. BCE	Late Mauri	Agglomeration of habitats	Soil, domestic and agricultural waste, households	35	
Rirha	Sidi Slimane	1st c. B.C./1st c. CE	Roman	Urban City	Burned levels of domus, praesae, basin	29	Ruas et al. 2016b; Carrato et al. 2020
Rirha	Sidi Slimane	9th-14th c. CE	Islamic - Medieval	Occasional reoccupation of a city	Dumps, domestic and artisanal ovens/kilns	28	
Sijilmasa	Rissani	7th-12th c. CE	Islamic - Medieval	Trans-Saharan urban commercial city	Habitat floors, ovens, dumps	52	Mahoney unpublished
Thamusida	Rabat	end of the 1st c. BCE/4th c. CE	Roman	Military quarter	Streets, dumps, bread oven, military barracks	10	Allevato et al. 2013, 2016
Volubilis	Moulay Idriss	8th-11th c. CE	Islamic - Medieval	City	Storage and activities areas	Two sectors	Failler 2002, 2004; Failler, Pelling 2018

Table 1: List of the Moroccan archaeological sites that have been the subject of a carpological study

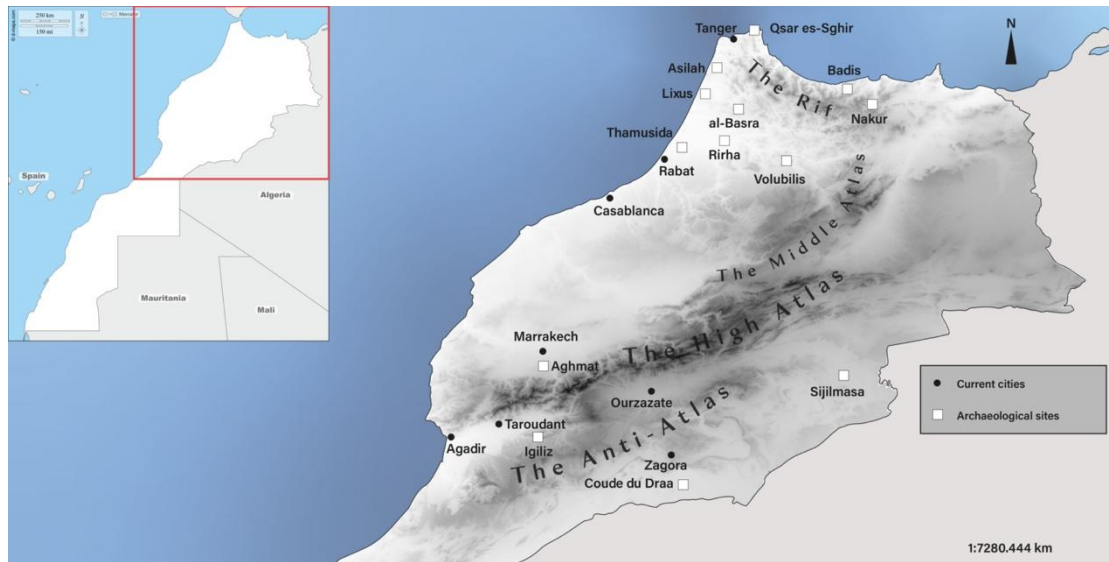


Figure 1: Map of Morocco showing the sites that have been the subject of a carpological study.

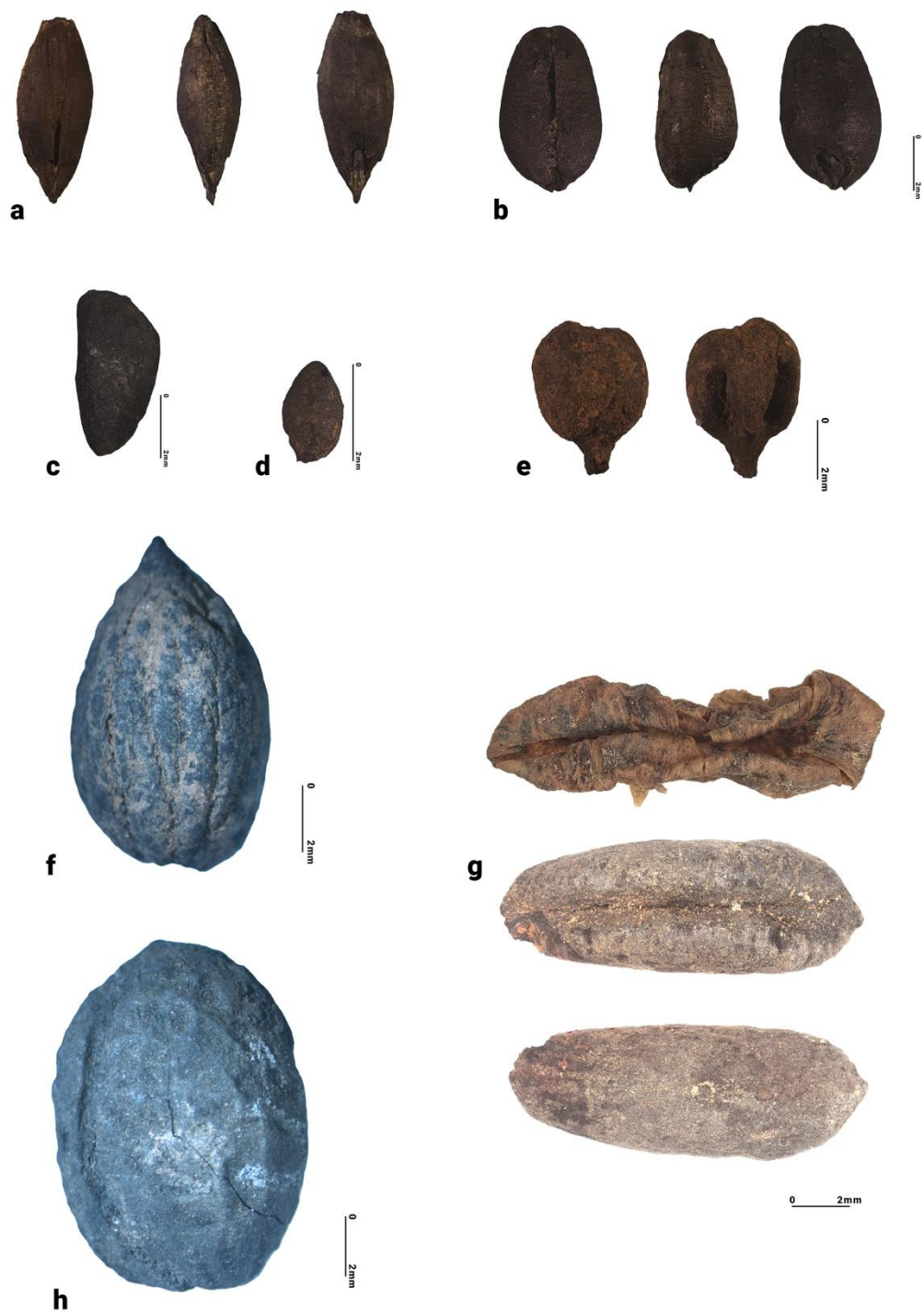


Figure 2: Charred archaeobotanical remains: (a) *Hordeum vulgare* (Aghmat); (b) *Triticum aestivum/turgidum* (Aghmat); (c) *Punica granatum* (Aghmat); (d) *Phalaris canariensis* (Volubilis); (e) *Vitis vinifera* (Aghmat); (f) *Olea europaea* (Aghmat); (g) *Phoenix dactylifera* (Coude du Draa); (h) *Prunus domestica* (Aghmat). Photographed using a Leica MZ75 with Capture V2.3 and AHRC funded Keyence VHX7000 3-D digital microscope at x 20 – 30 magnification (AHRC Award AH/V011758/1).

	Phoenician 8th-4th c. BCE	Punic-Mauri 5th c. BCE - 1st c. CE	Roman 1st-5th c. CE	Islamic - medieval 7th-14th c. CE	Islamic - modern 15th-19th c. CE
CEREALS					
<i>Triticum aestivum/durum</i>					
<i>Hordeum vulgare</i>					
<i>Panicum miliaceum</i>					
<i>Triticum dicoccum</i>					
<i>Setaria italica</i>					
<i>Triticum monococcum</i>					
<i>Sorghum bicolor</i>					
PULSES					
<i>Vicia faba</i> var. <i>minor</i>					
<i>Lathyrus cicera/sativus</i>					
<i>Lens culinaris</i>					
<i>Pisum sativum</i>					
<i>Vicia sativa</i>					
<i>Vicia ervilia</i>					
<i>Vicia faba</i> var. <i>equina/major</i>					
VEGETABLES/CONDIMENTS					
<i>Beta vulgaris</i>					
<i>Amaranthus</i> sp.					
<i>Coriandrum sativum</i>					
<i>Brassica/Sinapis</i>					
<i>Sinapis alba</i>					
<i>Portulaca oleracea</i>					
<i>Lagenaria siceraria</i>					
<i>Capparis spinosa</i>					
<i>Vitex agnus-castus</i>					
<i>Apium graveolens</i>					
FRUITS					
<i>Ficus carica</i>					
<i>Olea europaea</i>					
<i>Punica granatum</i>					
<i>Vitis vinifera</i>					
<i>Pinus pinea</i>					
<i>Ceratonia siliqua</i>					
<i>Prunus domestica</i>					
<i>Prunus dulcis</i>					
<i>Prunus persica</i>					
<i>Phoenix dactylifera</i>					
<i>Rubus fruticosus</i>					
<i>Ziziphus jujuba</i>					
<i>Argania spinosa</i>					
<i>Juglans regia</i>					
Wild fruits					
<i>Pistacia lentiscus</i>					
<i>Ziziphus lotus</i>					
<i>Chamaerops humilis</i>					
<i>Crataegus monogyna</i>					
<i>Quercus</i> sp.					
OILSEED AND TEXTILE PLANTS					
<i>Linum usitatissimum</i>					
<i>Cannabis sativa</i>					
<i>Gossypium</i> sp.					
<i>Carthamus</i> sp.					
Possible cultivated grass					
<i>Phalaris canariensis</i>					

Table 3: Presence/absence of the main cultivated/used plant taxa in Morocco between the 8th century BCE and the 17th century CE.