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ORIGINAL ARTICLE

A brief history of plants in north-eastern France: 6,000 years of crop introduction in the Plain of Troyes, Champagne

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Abstract

The amount and strength of archaeobotanical and archaeological data available for the territory of the Plain of Troyes, in Champagne (north-eastern France), make it possible to write a local history of domestic plants. The story begins with the arrival of the early Neolithic farmers (5200 BC), introducing agriculture with the first staple crops, the hulled wheats emmer and einkorn, pea, lentil, and possibly opium poppy. Their descendants left few traces, but from the very beginning of the Late Bronze Age (14th century BC), human expansion quickly resumed, supported by a completely remodelled farming system. Many new plants (spelt, millets, pulses…), introduced from far-off countries were cultivated, securing production, and decreasing gathering. This apparently successful agriculture lasted for one millennium till the middle of the Late Iron Age (2nd century BC). Technical innovations in agricultural tools then triggered new changes in production systems, evidenced by a sharp decline in millets and a more modest rise in naked wheats. This trend continued during the Roman era, a time where many agricultural innovations took place, especially concerning fruticulture and possibly viticulture. The true development of the latter occurred during Early Middle Ages. At that time hulled six-row barley and naked wheats were well established as the main crops, while two more species, cultivated oat and rye, were added to the already large panel of cereals. Our investigations do not go further than the 10th century AD, but despite the large gap till today, some legacies of the past are still perceptible in the contemporary agricultural heritage.

Keywords France · Champagne · Agriculture · Archaeobotany · Crop introduction

Introduction

The Plain of Troyes is situated in the Aube department (Grand-Est region), which forms the southern part of the ancient province of Champagne, in north-eastern France (Fig. 1). This small territory spans approximately 20 km around the city of Troyes and is crossed in its middle by

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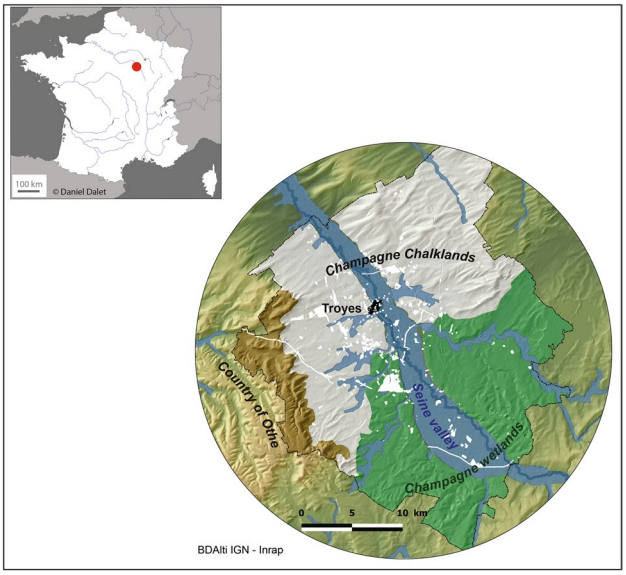

Fig. 1 Location and map of the Plain of Troyes (France)

the river Seine. It includes varied landscapes, and soils with contrasting agricultural potentials. The main entities are the Champagne wetlands, with heavy clayed soils and the Champagne chalklands, with thin and light chalky soils (Fig. 1). The valley of the Seine river, which runs through both wetlands and chalklands, offers fertile silty soils. Climate is mild, with a continental twist. It is a region that provides excellent opportunities for agriculture.

More than seven millennia ago, farmers of the Linearbandkeramik (LBK) culture, arriving from the East, chose to settle there and to cultivate the lands. The diversity of landscapes, the wealth of natural resources, the quality of available soils and the softness of reliefs subsequently encouraged the development of human occupations and agricultural activities on this territory. The presence of the Seine river, a privileged route of circulation and trade, made it a strategic place. It favoured the introduction of innovations coming from the East or South, according to changes in alliances or influence networks. The power and the wealth of the elites who controlled this land are illustrated for the Metal Ages by the tomb of the Celtic Prince of Lavau, recently discovered in the vicinity of Troyes (Dubuis et al. 2015; Dubuis and Riquier 2018).

This history is known thanks to the expansion of preventive archaeology in the Plain of Troyes, over the last two decades. It has led to the investigation of a great number of sites with various functions (settlement, storage, cemetery…). About 50% of the excavated occupations (395 out of a 784) are settlements sites. This makes the archaeological database an extraordinarily strong one for developing analyses on the economy of ancient societies (Riquier et al. 2017a). Due to the more recent development of palaeo-environmental studies, archaeobotanical documentation lags archaeological one. Plant macro-remains have been studied from less than 10% of the excavated settlements. Nevertheless, a steady increase in archaeobotanical research since the first study in 2004 has led to the collection of a strong and coherent archaeobotanical database. It follows similar progress as archaeological data and shares the same hiatus in documentation (cf. below). Environmental studies concerning anthracology and palynology are scarce (Riquier and Dandurand in press) and make it difficult to trace back the evolution of the natural and agricultural landscapes over time. The history of crop husbandry in the Plain of Troyes therefore relies mainly on plant macro-remains analyses, within the limits of this discipline.

All available data have been synthesized and interpreted, within the framework of a Collective Research Project (PCR) led by the Institut national de recherches archéologiques préventives (Inrap, Riquier et al. 2017a). The archaeobotanical synthesis reveals the history of the introduction and cultivation of domestic plants over more than 6,000 years, from the pioneer Neolithic farmers (5200 BC), to the first village network of the Early Middle Ages (EMA, AD 1000) (Toulemonde et al. 2017c).

The purpose of our article is to present the results of this regional synthesis. It traces the arrival of new plant species, their role in local agronomic systems and food habits, their rise, decline or resilience over time, in conjunction where possible with contemporary technical or social changes. It gives a local version of the Western European history of cultivated plants, all imported, consciously or not, from far-off places.

Material and methods

Data were collected from 23 settlement sites, many of them occupied during several distinct time periods (ESM 1). Nearly all of them are open-air rural settlements, except for the Roman urban site of Troyes "Place de la Libération". Their chronology spans from the Neolithic LBK to the end of the Early Medieval Period, that is 5200 BC to 1000 AD.

Settlements are generally modest in surface and their organisation is basic (less than one hectare and a few dozens of structures); they show discontinuous occupation. One exception is the large site of Buchères "Parc Logistique de l'Aube" (PLA), which concentrates more than 3,000 structures on an area of 250 ha and was continuously occupied for nine centuries during the Metal Ages (1350-450 BC; Riquier et al. 2012, 2015).

Sampled features are mainly pits of different kinds (extraction, storage…) reused as waste pits, and building post-holes; they also include hearths, ovens and wells.

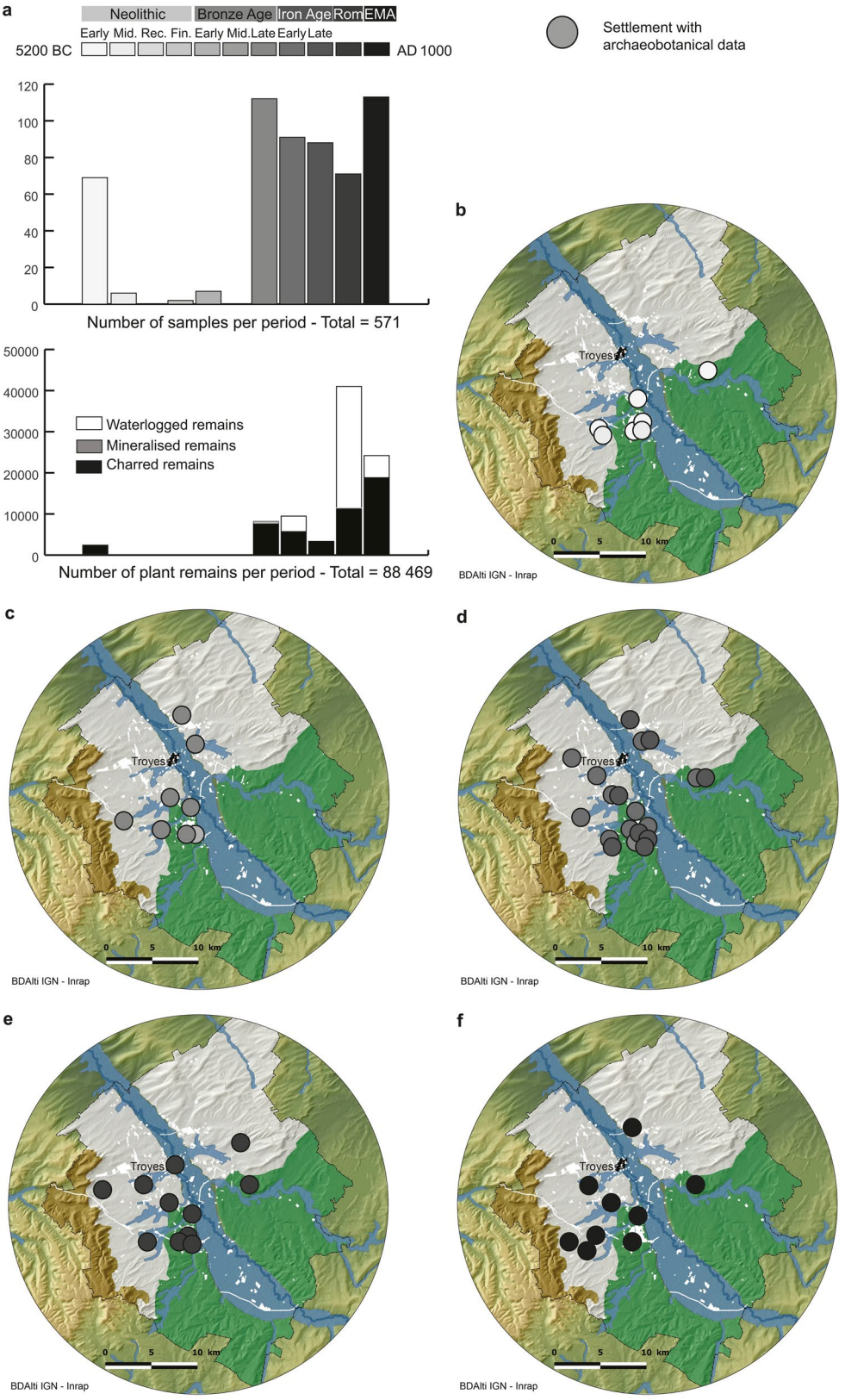

Fig. 2 **a** Graphic display of numbers of samples and plant remains per period and type of preservation **b** Location of Neolithic sites **c** Location of Bronze Age sites **d** Location of Iron Age sites **e** Location of Roman sites **f** Location of Early Middle Ages sites

Table 1 Numbers of settlements, samples and plant remains per period

Period	Settlements (*n*) (max = 24)	Features (*n*)	Samples (*n*)	Volume (*l*)	Total remains (*n*)	Charred remains (*n*)	Mineralized remains (*n*)	Water-logged remains (*n*)
Neolithic	7	56	89	1,367	2,169	2,169	–	–
Bronze Age	7	91	119	1,618	8,264	7,621	643	–
Early Iron Age	9	82	91	1,189	9,476	5,701	–	3,775
Late Iron Age	10	70	88	781	3,358	3,341	17	–
Roman Era	11	63	71	533	41,006	11,228	242	29,536
Early Middle Ages	9	86	113	929	24,196	18,809	3	5,384
Total		448	571	6,417	88,469	48,869	905	38,695

Systematic bulk sampling was done, with a minimum volume of 10 L per sample whenever possible.

Methods used for sample processing are not homogeneous, as archaeobotanical studies have been conducted by five archaeobotanists, in a timespan of fifteen years. Nevertheless, all samples were processed by water-sieving, using a minimal mesh size of 0.315 to 0.5 mm. Results of the studies can therefore be reasonably compared. Archaeobotanical data was collected and analysed using *Arbodat*© 2013 English version.

For data synthesis and analysis, we use the variable ubiquity. Ubiquity for one taxon (or one category of plants, e.g. pulses) and one period is given by the number of samples dated to that period (all sites combined) that contain at least one macro-remain of the so-called taxon (for cereals it can be either grain or chaff) or category of plants, divided by the number of samples dated to that period. This number is given in percentages and is used to show the relative importance of taxa in graphics (Figs. 3, 4, 5, 6a, 8).

Results and discussion

A total of 571 samples taken in 448 features delivered 88,469 macrofossil plant remains. More than half of them (48,869) are charred; 38,695 are waterlogged; the remaining 905 are mineralized. The distribution of the results by chronological period and type of fossilization is given in Table 1 and Fig. 2a.

Some additionally remarks on the results are necessary that may have consequences for the interpretation of archaeobotanical data. First, important quantities of waterlogged macro-remains were recovered for the most recent phases (Roman and Early Medieval periods). Those available for Early Iron Age (EIA) consist only of wild herbaceous species (Table 1). We will analyse the results from charred and waterlogged deposits separately because waterlogging implies a higher taxonomic diversity of cultivated plants.

Important differences can also be observed in densities of plant remains/l, according to chronological phases. They increase sharply as we get closer in time: from 1.6 charred remains/l on average for Neolithic periods to 4 or 5 remains for Metal Ages and more than 20 remains for Roman and Early Medieval periods. Preservation of archaeobotanical remains is greatly affected by erosion processes. Not much can be done against that, except sampling more for the earliest periods, and keeping aware of the bias.

Finally, considering the distribution per chronological period with a higher resolution (Fig. 2a), we observe a huge gap of nearly 3,000 years between the Early Neolithic and the Late Bronze Age (LBA), with scarcity of archaeobotanical data. This situation is not specific to the Plain of Troyes, nor is it specific to archaeobotany. Archaeological finds are scarce for these periods in many places of north-eastern France, especially for the Early and Middle Bronze age (EBA, MBA; Carozza et al. 2017; Lachenal et al. 2017). This is not due to a lack of archaeological research, but probably to a more nomadic way of life and a decline in population density (Riquier et al. 2017c; Riquier 2018b). For the Plain of Troyes, even though archaebotanical data is not available for all excavated sites, it follows a similar curve and show similar gaps to those of archaeological documentation (Riquier et al. 2017a).

First farmers, first crops in the plain of Troyes—neolithic period (5200–2200 BC)

Archaeobotanical data for the Neolithic come mainly from three excavations (Bréviandes, Buchères PLA 2005–2006, and Buchères PLA 2012–2013, Fig. 2b) dated to the Early Neolithic, from LBK culture (5200-4800 BC) to Blicquy-Villeneuve-Saint-Germain cultures (B-VSG, 4800-4400 BC). They delivered 2,115 charred macro-remains, issued from 69 samples. For the following phases of the Neolithic, data are scant and badly preserved: only 21 charred macro-remains were delivered by four more settlements.

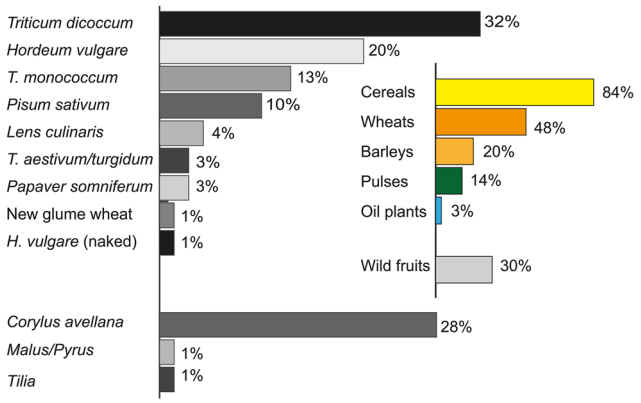

Fig. 3 Ubiquity of plants (by species and by categories) cultivated or gathered during Early Neolithic (5200-4400 BC) calculated from 69 samples

When LBK farmers arrived in the Plain of Troyes, they settled in the Champagne wetlands, on the silty and fertile terraces of the Seine river and of its tributaries, in small villages of three to six long houses (Riquier et al. 2018a). They introduced staple crops, mainly cereals and pulses domesticated in the Near East (Fig. 3). Eight species are attested: five cereals, two pulses plus one oil/medicinal plant. They include emmer (*Triticum dicoccum*), barley (*Hordeum vulgare*), einkorn (*Triticum monococcum*), a naked wheat (*Triticum aestivum* s.l./*durum/turgidum*), the new glume wheat (NGW), lentil (*Lens culinaris*), pea (*Pisum sativum*) and opium poppy (*Papaver somniferum*).

Concerning the new glume wheat remains recovered are two *furcas*, delivered by the oldest settlement in the plain, the LBK site of Bréviandes "ZAC Saint-Martin". In the Seine valley, it is so far the only mention for the Early Neolithic in the Seine valley. The taxonomy of this wheat is still uncertain, but most likely it is *Triticum timopheevi*, a species whose wild ancestor originates from the northern regions of the fertile crescent (Jones et al. 2000). It is attested in Champagne from the Early Neolithic to the end of the Bronze Age, sometimes as a mere contaminant, sometimes as a culture on its own, especially in some parts of the upper Seine valley downstream of Troyes (Toulemonde et al. 2015; unpublished studies).

The opium poppy is the only plant not originating from the Near East. According to the preliminary results of an ongoing project on opium poppy origin and spread, the most ancient finds of the plant come from Early Neolithic settlements in Europe, suggesting a European domestication (Salavert et al. 2018). One seed has been recovered at the LBK site of Bréviandes, but it has not been radiocarbon dated.

For the following phase of the Neolithic, ninety-nine charred seeds of opium poppy were found in a lateral pit at a B-VSG settlement in Buchères (Fig. 10a, b). A radiocarbon dating of the pit has been done using a piece of charcoal (Poznan 60673: 5950 ± 35 BP, 4932-4729 cal BC), and a radiocarbon dating of a poppy seed itself is in progress within the framework of the opium poppy project. For the B-VSG period, a naked variety of barley has also been identified, while less overall fewer cultivated species is attested altogether, the archaeobotanical dataset for this period deriving from a small number of samples (ESM 1).

Weeds and cereal chaff are scarce, making it difficult to reconstruct farming practices. Less than a dozen of weeds has been identified to species level, the most frequent being *Galium aparine*, *Polygonum convolvulus* and *Chenopodium album*.

Besides cultivation, gathering remains important during the Early Neolithic (Fig. 3). It is mostly represented by hazelnuts (*Corylus*), but a wild apple/pear (*Malus/Pyrus* sp.) and a fruit of large-leaved lime (*Tilia platyphyllos*) are also mentioned. The presence of the lime tree fruit suggests the picking of the flowers: as the blooming period is short, fruits and flowers are often seen together in the harvest.

For the Middle Neolithic (Cerny culture, 4400-4200 BC), the very scarce data only testify to the continuity of naked wheat cultivation, while only a few grains of *Cerealia indeterminata* have been recovered for the last phase of the Neolithic.

The farming system established in the Plain of Troyes during the Early Neolithic relies on cereals, mainly on hulled wheats, emmer being the main crop (Fig. 3). Cultivation of pulses however, of peas especially, is quite important, as shown by ubiquity and recovering of small sets of up to 200 seeds in LBK and BVSG settlements. The mention of opium poppy in these two cultures suggests an early introduction of the plant in the local agriculture. These data clearly show that the first farmers in the Plain of Troyes belonged to the north-western community, who settled in an area extending from the left bank of the Rhine river to the Paris basin (Bakels 2009). These farmers cultivated a quite standardised set of domestic plants that included all species here attested. Only flax is missing in the local set, while naked wheat seems to be mentioned quite early comparatively to other references (Bakels 2009; Bouby et al. 2018a).

Towards a more complex polycultural system—Bronze Age (2200-800 BC)

As mentioned above, archaeobotanical evidences are scarce for EBA and MBA (2200-1350 BC). Only two features of settlements at Buchères (PLA 2005 and PLA 2012-13), dated to 2200-1600 BC and 2000-1450 BC provided some information, with a modest amount of 70 charred macro-remains recovered from seven samples. For the LBA (1350-800 BC), data are more abundant. Deriving from seven excavations (Fig. 2c), 112 samples delivered 7,561 charred and 643 mineralized plant remains. The settlements of Buchères provided more than 90% of those data.

Despite the very dynamic archaeological research in the Plain of Troyes, we know little about human societies that lived there at the end of the third millennium and during the first half of the second millennium BC. A few isolated pits are all that remains of their settlements (Riquier et al. 2017a, b, c; Riquier 2018b). Consequently, diet and crop husbandry practices are nearly unknown for these periods. The few identified plant remains reveal the on-going cultivation of barley (a naked variety is still attested), emmer and new glume wheat. Spelt (*Triticum spelta*) is for the first time identified, by four glume bases. There are part of a refusal assemblage recovered from an oven, dated back to 1683-1521 cal. BC, according to a radiocarbon date from a cereal grain (Paresys et al. 2019).

Starting from the beginning of the LBA (14th century BC), human settlements develop in the plain, farmers are colonizing progressively the different landscape units of the territory (Fig. 2c). This flourishing period is characterized by a sharp and steady increase of open settlements, occupying a larger area than before, and being more grounded with features and pits of all kinds, delivering layers of charred refuses (Riquier et al. 2017a, 2018a, b). Family farms became gradually fixed on the territory, possibly leading to the birth of the first "terroirs" (territories with homogenous agricultural and/or cultural characteristics), almost continuously exploited. At the end of the LBA, hamlet-like settlements appear, grouping several farms together and suggesting changes in crop organisation and farming systems.

A larger diversity of soils than during the Neolithic is exploited. Besides the silty valley bottoms, farmers also start to cultivate the thinner chalky soils of the Champagne chalklands also. A complex farming system develops, that includes many new plants, requiring a more sophisticated organisation. Broomcorn millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), bitter vetch (*Vicia ervilia*), Celtic bean (*Vicia faba* var. *minor*) and gold-of-pleasure *(Camelina sativa*) occur for the first time (Figs. 4, and 10c, d, e). A hulled species of barley and a tetraploid naked wheat (*Triticum durum/turgidum*) are identified. The only mentions of flax (*Linum usitatissimum*) and grass pea (*Lathyrus* cf. *cicera/sativus*) for the Plain of Troyes also date back to that period.

According to the identification mentioned above, spelt seems to have been introduced in the Plain before the LBA, but we have no clue for the time of arrival of the other species. Tetraploid naked wheat probably arrived much earlier in the Plain of Troyes but could not be identified due to the lack of rachis remains. Indeed, the cultivation of this wheat is attested in some parts of northern and eastern France, during the Middle and Recent Neolithic (Neveu 2010; Bostyn et al. 2012; Dietsch-Sellami 2014; Martin et al. 2016; Bouby et al. 2018a), and downstream of the Plain of Troyes since the very beginning of LBA (Toulemonde 2013; Toulemonde et al. 2015). Recent archaeobotanical synthesis mention the presence of Celtic bean during MBA in north-western France (Toulemonde et al. 2020); a few previous studies report the erratic presence of broomcorn millet for EBA/MBA in northern France (Toulemonde 2013; Bouby et al. 2017), but this requires to be checked by radiocarbon dating. Nevertheless, most recent documentation points to the beginning of LBA as an important time of diffusion for millets, spelt, bitter vetch and gold-of-pleasure (Bouby et al. 2017; Toulemonde et al. 2020). They probably arrived through Central Europe, as north-eastern France had strong cultural connections with this area at that time (Mordant 2010, 2013).

These Bronze Age newcomers became rapidly important in the crop production, or so it seems in the absence of previous data (Fig. 4). Like in many places in Europe, hulled barley superseded hulled wheats (Stika and Heiss 2013). In the Plain of Troyes, spelt predominated over emmer, the first one often mixed in the deposits with einkorn and other wheats. Broomcorn millet (Fig. 10c) was abundantly cultivated, while foxtail millet (Fig. 10d) was restricted to some places. Pulse production had increased a lot, driven by lentil and bitter vetch. Gold-of-pleasure (Fig. 10e) had become the predominant species among oil plants, while poppy still appeared regularly.

Compared to Neolithic times, agriculture has changed a lot. A very diversified polyculture system is now prevailing, based on a better balance between the different plant categories (cereals, pulses, oil plants) than previously. This system seems better suited to daily food needs, as suggested by the decrease of gathering (Fig. 3). Hazelnuts are still the most exploited wild fruits, prevailing before sloe (*Prunus spinosa*) and other species, but they appear only in one sample out of five, compared to one out of three during the Early Neolithic (Fig. 3).

Stability and changes in crop organisation—Iron Ages (800-30 BC)

Early Iron Age (EIA, 800-460 BC) data come from 9 excavations and 91 samples, which delivered 5,701 charred, and 3,775 waterlogged, macro-remains. As stated before, waterlogged remains are deriving from natural deposits in wells, which did not reveal any cultivated species. Only charred species are used for the analysis. Concerning the Late Iron Age (LIA, 460-30 BC), 10 excavations with a total of 88 samples are considered, which delivered a total of 3,341 charred, and 17 mineralised plant remains (Fig. 2d). As for the Bronze Age, the settlements of Buchères did provide a large part (80–90%) of the archaeobotanical data set.

As well as during LBA, the expansion of population and settlements goes on during EIA, although at a slower pace. This latter period culminates at the end of the 6th century/beginning of the 5th century BC with the emergence of the

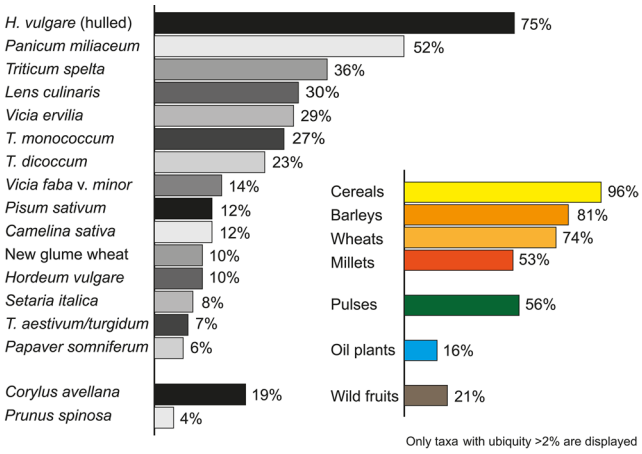

Fig. 4 Ubiquity of plants (by species and by categories) cultivated or gathered during Late Bronze Age calculated from 113 samples

Celtic Princes. That ephemeral phenomenon is illustrated in the Plain of Troyes by the tomb of Lavau, recently discovered in the vicinity of Troyes. After that, expansion stops till the second century BC, for reasons still poorly known or studied.

Regarding crop introduction in the Iron Ages, innovation is scant. During a timespan exceeding half a millennium, the only new species put into cultivation is the common vetch (*Vicia sativa*), its first mention dating to the 5th century BC. Agriculture of the EIA is much alike that of LBA. Even if some minor fluctuations in crop choices are noticeable over time, few changes affect the global distribution of the main categories of crops (Fig. 5a). Crop organisation is quite stable, while cultivation is more and more intensive, according to weed flora analyses (Toulemonde 2013).

Some local preferences, however, developed in agriculture and diet, like the taste for einkorn (Figs. 5a, and 10f). After the LBA, this undemanding cereal superseded spelt in wheat production, not only on poor soils where it can excel, but also on rich soils where other wheats could have better yields. The huge quantities of einkorn remains (grains and glume bases) confirm the importance shown by its ubiquity. Einkorn and spelt are quite often mixed in the deposits, suggesting maslin crops.

During the LIA, this preference for einkorn is accentuated (Fig. 5b). It is an interesting trend to note, as in other parts of northern France, einkorn is less and less cultivated at that time (Zech-Matterne et al. 2017). This originality looks like a marker of food identity in the Plain, a cultural choice more than a mere agricultural one.

Stability in crop production ends during the LIA. Even if no new crop is added, some important changes occur in crop distribution. Millets are less and less cultivated, and wheats are more, especially naked wheats which become gradually almost as important as hulled wheats (Fig. 5c, d). This trend, which is mostly visible after the 2nd century BC, is part of a global dynamic. It has been highlighted at a larger scale for many territories in northern France. This evolution of agriculture during the second half of the LIA, from a diversified polyculture system to a more specialised system (less millets, more wheats, and especially naked wheats, less pulses and oil plants) has been linked to the contemporary development of iron-made tools. They allowed the clearing of larger spaces than before and the evolution towards a more extensive and cereal-based agriculture (Zech-Matterne and Brun 2016; Toulemonde et al. 2017b; Bouby et al. 2018b). In some territories, such as Picardie and Ile-de-France regions, the switch from one system to another—the rise of the naked wheats in particular—was quite fast, homogenous, and spectacular (Zech-Matterne et al. 2014). Meanwhile, in the Plain of Troyes, millets production has also sharply decreased, and naked wheats have become more important, especially on the fertile soils of the Champagne wetlands. But hulled barley remains an important staple crop, and hulled wheats are still widely grown, most notably on the thin soils of the Champagne chalklands (Boulen et al. 2012).

New types of crop: fruit growing, and the beginning of viticulture? Roman Era (30 BC–AD 475)

Ten modest rural settlements and one urban site located in the city of Troyes, "Place de la Libération", delivered data for the Roman period. A total of 11,228 charred plant remains, 29,536 waterlogged remains and 242 mineralised remains were recovered from 71 samples (Fig. 2e). This time, both charred and waterlogged material contain domestic species. Charred material includes a mass find of barley and bitter vetch (9552 remains) recovered from the site of Torvilliers, and 1,676 remains issuing from refuse assemblages.

The Roman era is a period of demographic expansion in the Plain of Troyes, from the conquest to the end of the third century. Many rural settlements develop, and a town appears, the ancient city of *Augustobona/Troyes*, capital *(caput civitatis)* of the Tricasses tribe, probably built on an Iron Age urban settlement of the Senones people (Kasprzyk 2017). The period ends with a sharp decline, in both urban and rural sites.

Regarding agriculture, this period is a time of massive introduction of plants. Unlike previous waves of Neolithic and Bronze Age, innovations do not concern staple crops (cereals and pulses), but new categories of plants, mainly fruits, kitchen herbs and condiments.

In rural settlements, no big changes are noticeable in the production of staple crops (Fig. 6a). No new species is added, hulled barley remains a key cereal crop, while the rise of naked wheats goes on, at the expense of hulled wheats. Einkorn cultivation seems to be abandoned. Oat (*Avena* sp.)

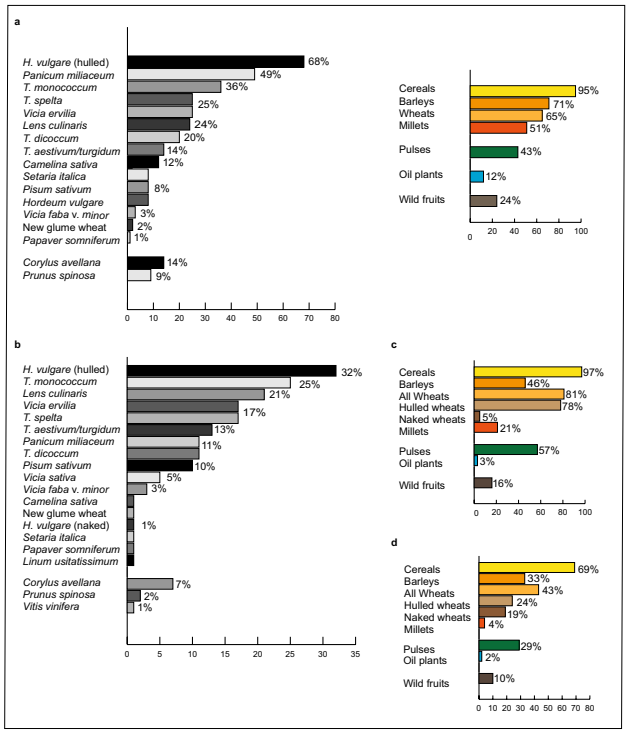

Fig. 5 **a** Ubiquity of plants (by species and by categories) cultivated or gathered during Early Iron Age calculated from 91 samples **b** Ubiquity of plants (by species) cultivated or gathered during Late Iron Age calculated from 101 samples **c** Ubiquity of plants (by categories) cultivated or gathered during the 1st half of LIA (5th to 3rd century BC) calculated from 37 samples **d** Ubiquity of plants (by categories) cultivated or gathered plants during the 2nd half of the LIA, (3rd century BC to 0 AD) calculated from 58 samples

appears regularly in assemblages, but always in small quantities, making its cultivation unlikely, as this is also the case for rye (*Secale cereale*). In the continuity of the second half of the LIA, pulses frequency is low compared to previous periods, despite the discovery of a few large assemblages mixing barley and bitter or common vetch (fodder?). Oil plants seem to have disappeared, at least in charred assemblages, whereas they are still mentioned in urban waterlogged contexts (Fig. 6b). Could this be a consequence of changes in the organisation of cultivated spaces, like a decrease of mix-farming and a clearer separation between cereal fields and garden areas?

Important innovations concentrate on fruit growing and cultivation of aromatic plants and vegetables. The origins of the new species are diverse; they come from all over the Roman Empire through long-distance trade, from the Mediterranean to Indian coasts and Far-East (Mathelart et al. 2014; Toulemonde et al. 2017a) Some of these new plants, like walnut (*Juglans regia*), domestic pear (*Pyrus communis*) and plum (*Prunus domestica* ssp. *insititia*) are quickly put into cultivation in rural settlements, but a larger variety of them is mentioned for the urban site of Troyes. Twenty-four fruits, wild or cultivated, and five aromatic plants are attested in that site, compared to eleven and three in rural places (Fig. 7). They include imported fruits like fig (*Ficus carica*), olive (*Olea europea*), medlar (*Mespilus germanica*) and dogwood (*Cornus mas*), which are rarely mentioned in northern France. Some of them, hard to transport when fresh, like fig and melon (*Cucumis melo*), and acclimatable in northern France, may have eventually been put into cultivation (Zech-Matterne et al. 2017). This was probably also the case of aromatic plants like coriander (*Coriandrum sativum*), dill (*Anethum graveolens*) and savory (*Satureja hortensis*), which are mentioned in both rural and urban settlements.

One major issue of the history of fruit growing in Champagne concerns the beginnings of viticulture. In the neighbouring Ile-de-France region, a few evidences (multiplication of cultivated grape pips discoveries, pollen markers, local amphoras production, presence of a wine press, vine plantation pits…) point to the starting of this activity from the 1st century AD (Toupet and Lemaître 2003; Zech-Matterne et al. 2011). In Champagne, pollen evidences are missing (but pollen analyses are few); plantations pits are frequent but, when studied, interpreted as orchard pits because of their square shape; no material evidence like wine presses have yet been discovered. However, two waterlogged vine shoots have been recently recovered from a roman well, in Dienville (Aube department), located 40 km east of Troyes (Sartou et al. 2015). The well is part of the possible *pars rustica* of a *villa*. The vine shoots were radiocarbon dated to the Early Roman period (end of 1st century/beginning of 3rd century AD). Besides the shoots, six mineralised grape pips were discovered in a cesspit also dated to the Early Roman (second half of the 1st century to first half of the 2nd century AD). In another roman rural settlement, located outside the Plain of Troyes, in Plichancourt (Marne), two more pips, this time waterlogged, were recovered from a well dated to the 2nd century AD. Other finds come from urban sites: 14 mineralized pips dated to the 2rd/4th century in Reims, and hundreds of waterlogged pips, issuing from different features in Troyes. Dating of the features spans from the very beginning of the 1st century AD to the 3rd century. One of this feature is a well, dated to the 2nd century, which delivered marc-like grape residues, associated to pips (Fig. 10g) These discoveries correlated to the existing production of local amphoras, may suggest the beginning of vinification in urban contexts, from local grapes (Zech-Matterne et al. 2011; Bonnaire and Zech-Matterne 2013). Looking at the evidences, viticulture may well have begun during Roman times in Champagne. Findings are still scarce, but all the rural sites excavated so far in the Plain of Troyes are modest farms. The excavation of roman *villae*, some of which already been detected by aerial archaeology, may reveal some interesting discoveries in the future.

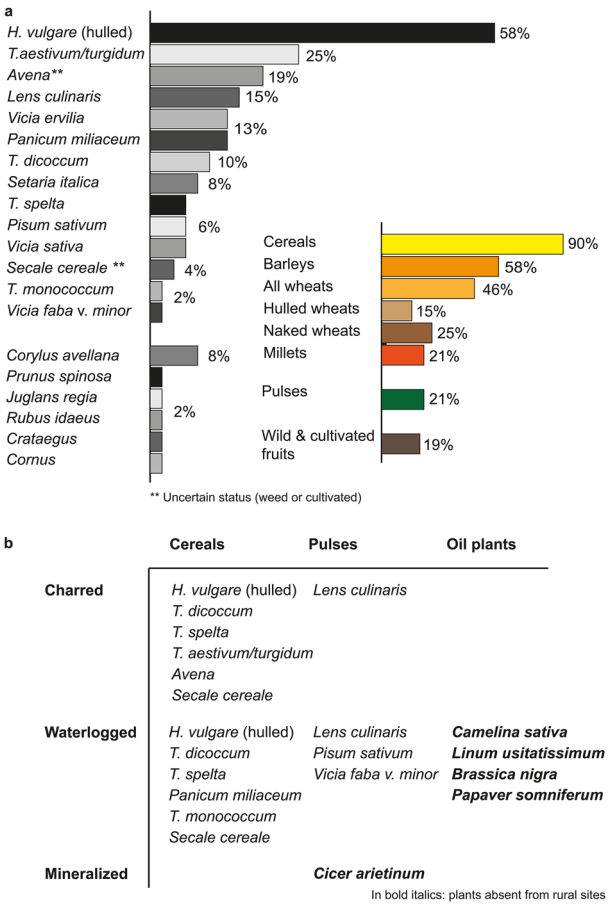

Fig. 6 **a** Ubiquity of plants (by species and by categories) cultivated or gathered in Roman rural settlements (charred material) calculated from 48 samples **b** Staple crops attested in the Roman urban site of Troyes per type of preservation calculated from 15 samples

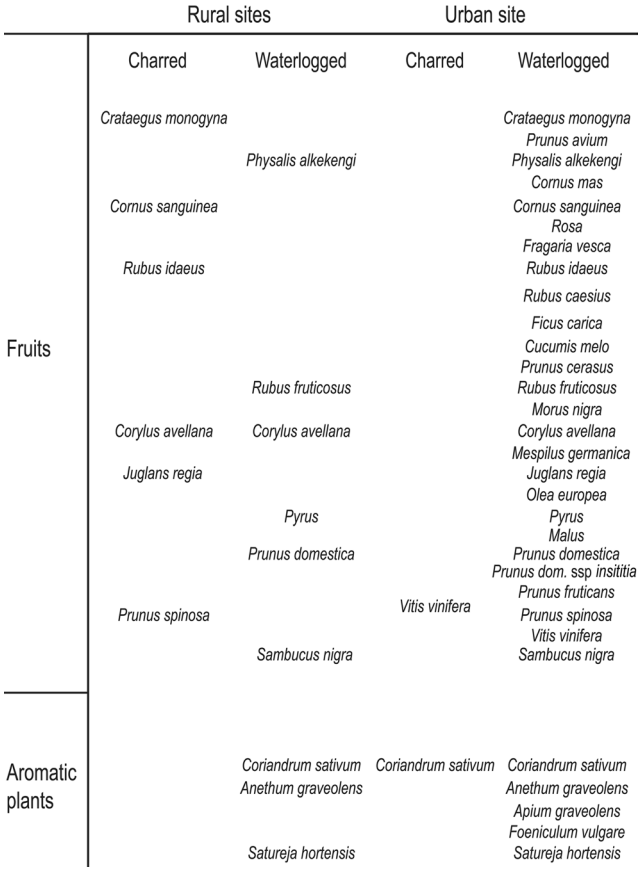

Fig. 7 Roman Era—Mention of fruits and aromatic plants per type of settlement (rural or urban) and type of preservation

New cereal crops, and the rise of viticulture—Early Middle Ages (475–1000 AD)

Archaeobotanical data come from nine excavations (Fig. 2f) and 113 samples that delivered 18,809 charred, 5,384 waterlogged, and 3 mineralised, remains. All excavations concern small rural settlements. As for Roman times, cultivated species are present in waterlogged assemblages. They are presented separately from the results of charred assemblages.

After a strong decline in the population during the 5th century, expansion resumes in rural places during Early Middle Ages (EMA), while there is no evidence for urban settlements (Marchaisseau 2018).

Early medieval agriculture is driven by hulled six-row barley and naked wheat cultivation (Fig. 8a). Naked wheats are becoming more and more important over time (Fig. 8b, c). Two cereals, oat and rye, are definitively put into cultivation (Wiethold et al. 2016). These plants are mentioned since the LBA in the Plain of Troyes and interpreted as weeds in cereal fields till the Roman era, as in most parts of northern France (Zech-Matterne et al. 2017). Their frequency rises sharply during the Merovingian period (6th/8th century Fig. 8b). Correlated to also increasing quantities, and to the identification of floret bases of a cultivated species of oat (*Avena sativa*), this rise supports the hypothesis that oat and rye have gone from weed to crop status. They stay minor crops during the Merovingian period, then oat cultivation further increases during the Carolingian period (8th/10th century, Fig. 8b, c), exceeding that of hulled wheats. Those are represented mainly by einkorn, which is back after its Roman abandonment. Emmer is still mentioned but spelt has disappeared.

There is no new plant crop among pulses. Common vetch, pea and lentil are the main cultivated species. Mentions of oil plants are few, but gold-of-pleasure and opium poppy are still present. Hemp (*Cannabis sativa*) appears for the first time, in a waterlogged assemblage from a well at the site of Ruvigny, dated to the 8th-10th century AD (Fig. 9). The analysis of waterlogged material reveals the growing, in rural places, of fruit and herb species that were only attested in the urban settlement during Roman times: cherry (*Prunus avium/cerasus*), grape (*Vitis vinifera* ssp. *vinifera*), apple (*Malus domestica*), celery (*Apium graveolens*). New species

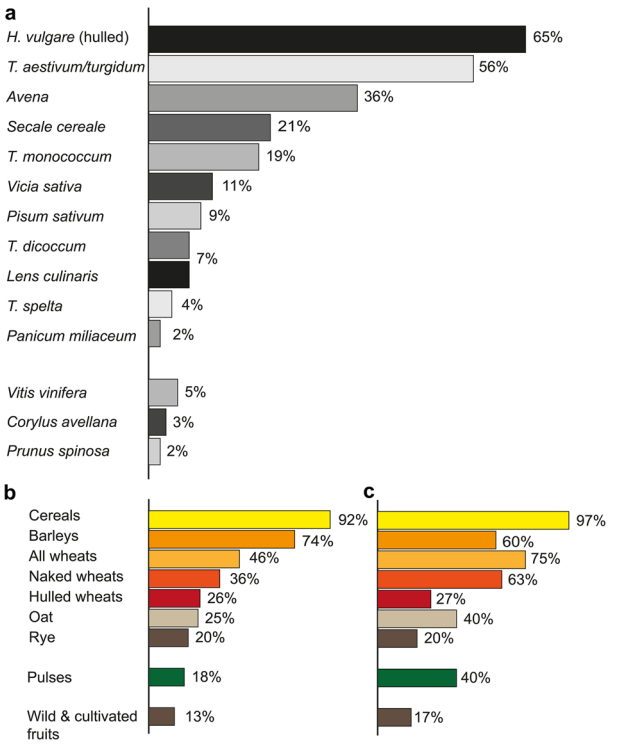

Fig. 8 **a** Ubiquity of plants (by species) cultivated or gathered (charred material) during Early Middle Ages calculated from 113 samples **b** Ubiquity of plants (by categories) cultivated or gathered during the Merovingian period (6 to 7/8e century AD) calculated from 39 samples **c** Ubiquity of plants (by categories) cultivated or gathered from the Carolingian period (8e/9e century AD) to the 10e century AD calculated from 63 samples

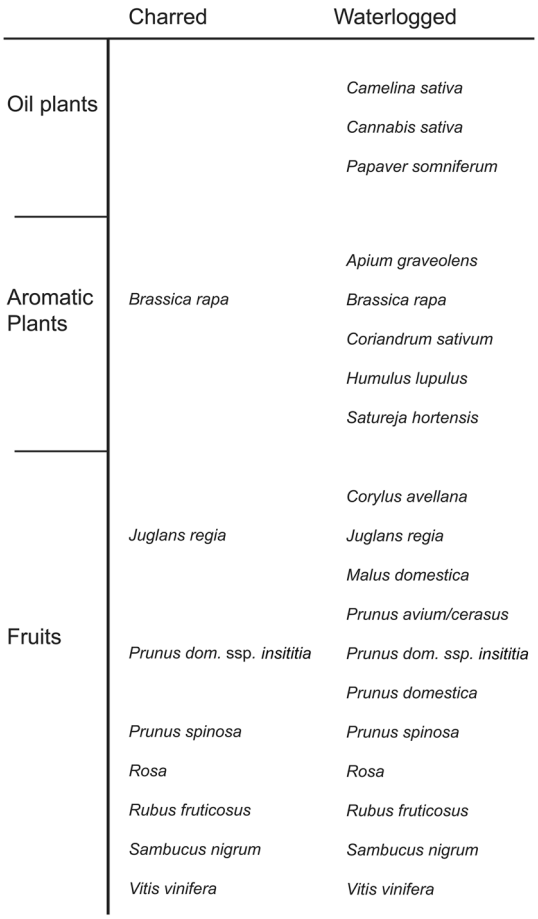

Fig. 9 Early Middle Ages—Mention of oil plants, fruits, and aromatic plants per type of preservation

listed by Charlemagne as plants that must be cultivated in his gardens, in the *Capitulare de villis vel Curtis imperii* (Strank and Meurers-Balke 2008), are also mentioned, among which are hemp (*Humulus lupulus*) and turnip (*Brassica rapa*).

One of the most important rises in crop development, during the EMA, is that of vine growing, driven by needs for religious rituals, namely the celebration of Eucharist in Christian masses. Nearly half of the rural settlements have delivered charred, and a few mineralised, grape pips, pollen evidences are present in Champagne region, if not around Troyes (no pollen analysis), and texts confirm the existence of vineyards around Troyes and Reims (Bonnaire and Zech-Matterne 2013; Bonnaire 2017).

Synthesis and perspectives

The dynamism of archaeological and archaeobotanical research in the Plain of Troyes has enabled the reconstruction of farming practices in this small area of the Seine valley. This offers a local version of the history of domestic plants in western Europe, over more than 6,000 years.

First farmers settled in the Plain of Troyes around 5,200 BC, in the favourable environment of the Champagne wetlands. They cultivated a small range of plants, hardy cereals mainly, such as emmer and einkorn. Gathering was still important in their diet, as testified by the numerous finds of hazelnut, only survivor of a probably larger set of wild plants, hardly preservable.

After a gap of nearly three millennia, crop husbandry is totally transformed. During the Bronze Age, more especially the LBA, a large set of new staple crops—including millets, spelt, bitter vetch, Celtic bean and gold-of-pleasure—had been put into cultivation (Fig. 10). Driven by hulled barley, hulled wheats, and broomcorn millet, crop production is intensive, more diversified and balanced, and reliable than previously, as suggested by decreasing gathering.

Stability in crop production characterizes the end of LBA and the EIA. A taste for einkorn develops as a local trend, increasing further during LIA. Common vetch is the only new plant cultivated, innovations in agriculture during Iron Ages being no longer based on new crops. During LIA, the

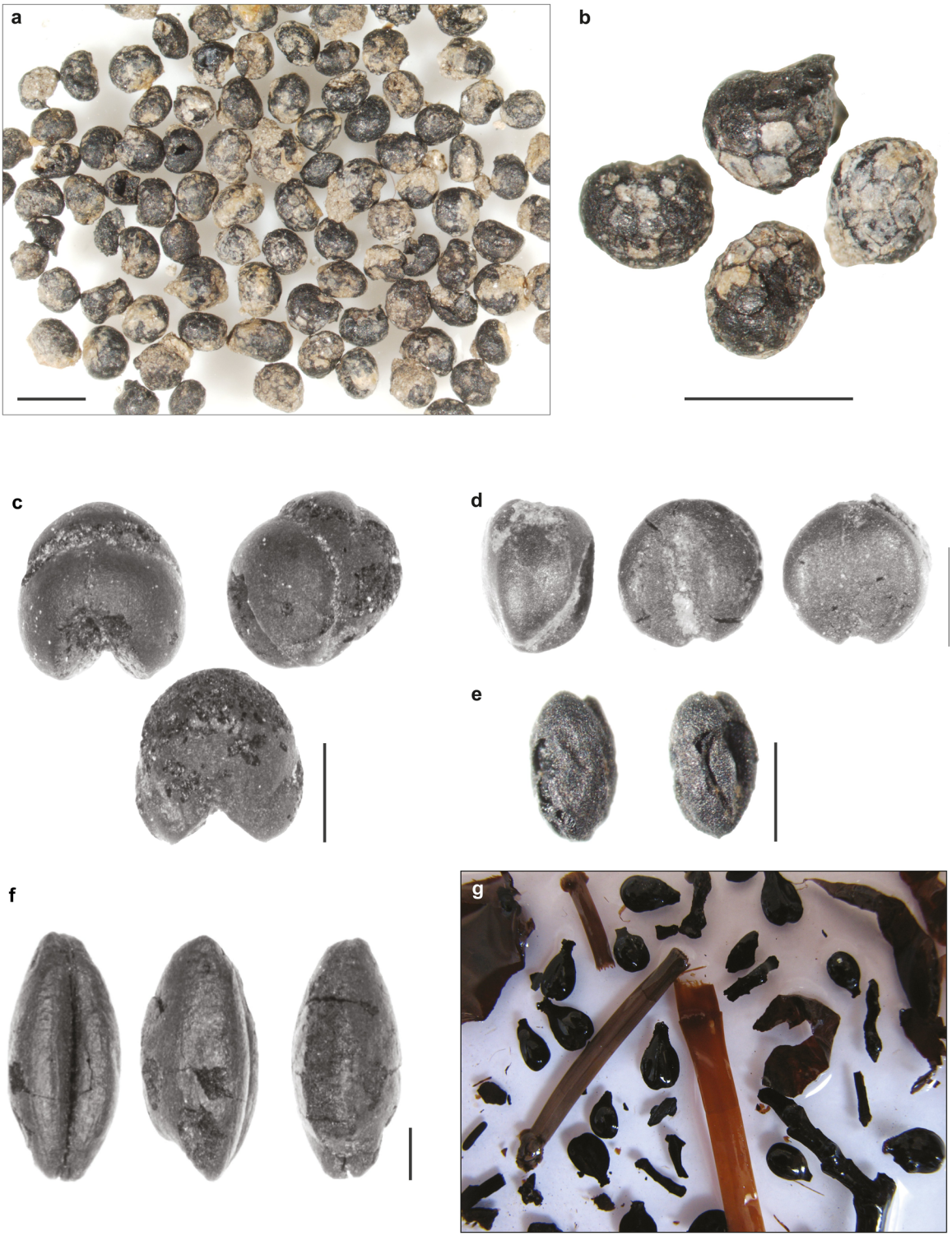

Fig. 10 **a, b** Charred poppy seeds (*Papaver somniferum*), Buchères, Early Neolithic (Cl. F. Toulemonde) **c** Charred seed of broomcorn millet (*Panicum miliaceum*) **d** Charred seed of foxtail millet (*Setaria italica*) **e** Charred seed of gold-of-pleasure (*Camelina sativa*), Buchères, Late Bronze Age (Cl. F. Toulemonde) **f** Charredseed of einkorn (*Triticum monococcum*), Buchères, Iron Age (Cl. F. Toulemonde) **g** Marc-like grape residues in Troyes Place de la Libération, Early Roman (Cl. V. Zech-Matterne), scale = 1 mm

modest rise of naked wheats echoes more important transformations in neighbouring regions. The correlative decline of millets seems to signify the end of a polyculture mainly driven by risk reduction. Improvement in agricultural tools have probably helped to secure crop production.

During Roman times, trends in crop production are accentuated, with the ongoing rise of naked wheats. But main innovations are not for staple crops, they concern fruit growing. New fruits, vegetable and aromatic plants are imported, and when possible, put into cultivation. Walnut trees are planted in rural settlements, while imported luxury foods such as olives are mostly available in urban places. For some species it is difficult to state on the origin, local or imported. This is the case for cultivated grape, eaten and maybe transformed in urban contexts, while evidences of a local viticulture in rural places only slowly emerge.

During the EMA, evidences of viticulture multiply. Innovations include new staple crops, oat, and rye. Production of naked cereals, wheats and rye, has definitively supplanted that of hulled wheats, while hulled barley remains an important staple crop. Most surprising is the resilience of einkorn. Cultivated since the Early Neolithic, this pioneering cereal has taken off during the Iron ages, before experiencing an abandonment during the Roman era. It is back at the EMA, as a perennial marker of the agriculture and food heritage of the Plain of Troyes.

Our investigations stop after the 10th century AD. However, despite a gap of a millennium and the many changes that have transformed agriculture since then (plants from new worlds, industrialisation…), we can observe some heritages of the past in today's agriculture of the Plain of Troyes. Champagne region—most notably the Aube department—is one of the biggest national producers of hulled barley and bread wheat. If gold-of-pleasure is no more cultivated, the production of its "cousin", rapeseed (*Brassica napus* ssp. *napus*), is important in Champagne. Thanks to its climate, this region is also one of the main growing areas of poppy in France, the French production representing 20% of legal opium poppy in the world. The importance of viticulture in Champagne is known worldwide. The big absent from past traditions is einkorn. In France, this prehistoric wheat mainly exists as a relict culture in south-eastern France (Protected Geographical Indication: "Petit épeautre de Haute-Provence"). Today it experiences a modest revival, thanks to new food trends that highlight its low gluten and high protein content. Global warming and subsequent necessary changes in farming practices may eventually bring back to light this hardy and undemanding cereal.

In addition to the work presented here, other studies deliver information on ancient agriculture in the region. It should indeed be emphasized that the Plain of Troyes is at the heart of an area (upper Seine valley, Champagne region, and a large part of north-eastern France beyond), where research on farming practices is very dynamic. Works include syntheses on animal husbandry such as the one carried out within the same framework as that on crop husbandry. The two share convergent elements, like the decline in the exploitation of wild resources after the Neolithic, but they follow different patterns, with few new species introductions in animal husbandry, changes concerning mostly composition of the herds, breeding practices, development of secondary products… (Auxiette and Hachem 2017; Auxiette and Toulemonde 2018; Hachem and Toulemonde 2018). Research on agriculture in north-eastern area also include numerous transdisciplinary syntheses. These are either diachronic like that concerning the Plain of Troyes, or targeting a theme or a period, such as the Rural Landscape in North-Eastern Roman Gaul (Rurland project, Lepetz and Zech-Matterne 2017) or the evolution of practices in north-eastern France during the first millennium BC (Toulemonde et al. 2017b). Archaeobotany is now opening to new methods such as isotopic studies, either to compare its conclusions on diet with those of isotopic analyses performed on human and animal bones (Goude et al. 2016), or to directly analyse carpological material in order to understand manure practices (Aguilera et al. 2017). Much has been studied and much more remains to discover. Ongoing projects may soon bring new knowledge on viticulture (ANR Viniculture), or on the sudden revival of human occupation and agriculture at LBA (PCR Bronz'Pal).

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