

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.)

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Abstract Plant macrofossil (carpological) and morphometric analyses were carried out on plant remains from the medieval castle of Miranduolo, Siena, a rural settlement in central Italy with a long sequence of occupation between the 8th and the 11th centuries A.D. The presence of *Triticum aestivum/durum* and *Vicia faba* var. *minor* from the first phase of the Lombard farming village suggests continuity with the agricultural tradition of the preceding Roman world, and the use of good cultivation techniques that allowed quality yields to be obtained from rather poor soils. At the same time, the significant presence of the primitive cereal *T. monococcum*, compared with the archaeobotanical literature of north-central Italy, allows us to consider it as a “cultural” element of Lombard farming. In the next cultural phases, with the Carolingian manor and then with the feudal castle, the stable presence of *T. aestivum/durum* and the reduction of *T. monococcum* in favour of more productive cereals such as *Secale cereale* and *Hordeum vulgare* indicate a further improvement in productivity. This is also confirmed by the appearance of fruits and nuts such as *Castanea sativa*, *Vitis vinifera* and *Prunus persica*. The increase in caryopsis sizes of *T. monococcum* and *T. aestivum/durum* in the transition from the village to the manorial phase is a consequence of the improvements

in farming. The decrease in caryopsis size of *T. monococcum* from the manor phase to that of the castle testifies the decreasing importance of this cereal. The good date resolution of this research allows us to detect the crops, the storage and the processing practices, as well as the changing role of crop plants in the rural economy. This highlights the geographical, historical-cultural and political factors of the medieval transition from the Lombard to the Carolingian and then to the feudal period in central Italy.

Keywords Farming history · Middle Ages · Seeds/fruits · Morphometric analysis · *Triticum aestivum/durum* · *Triticum monococcum*

Introduction

Since 2001 the castle of Miranduolo, 40 km from Siena, southern Tuscany, Italy, has been the focus of archaeological investigations by the University of Siena (Fig. 1a; Valenti 2006, 2009, 2011). This excavation belongs to a wider research programme which has been carried out for decades on the settlement history of west-central Italy between the end of the late Roman period and the middle centuries of the medieval period. In the province of Siena, archaeological investigations have shown that after a first phase of spontaneous occupation of the hilltops during the 7th century A.D., a reorganization of settlements started from the 8th century A.D., due to the presence of the Lombard and Carolingian aristocracies (Augenti 2000; Francovich and Hodges 2003; Valenti 2004; Bianchi 2010), which held their power by land ownership and management.

For central Italy, historians have always considered the medieval farming economy as backward in comparison

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Fig. 1 The archaeological site of Miranduolo. **a** Location map of the site, **b** Aerial view of the castle of Miranduolo (Source <http://archeologiamedievale.unisi.it/miranduolo>); **c** The landscape surrounding the site: arable field along the river Merse and hills of the Colline Metallifere; **d** Plan of the archaeological features of the village phase, second half of the 8th century A.D. to first half of the 9th

century A.D. (Source modified <http://archeogis.archeo.unisi.it:8080/pmapper/map.phtml>); **e**, Plan of the archaeological features of the manor phase, second half of the 9th century A.D. to last quarter of the 10th century A.D.; **f** Plan of the archaeological features of the castle phase, last quarter of the 10th century A.D. to first quarter of the 11th century A.D.

with the preceding Roman economy. Medieval farming was characterized by subsistence agriculture, mainly aiming to diversify farming to avoid the consequences of poor harvests (Montanari 1979). Even though the medieval agricultural system was characterized by a surprising variety of crops, historians consider it inadequate because of the decline of wheat cultivation and the predominance of minor cereals and small grains (Montanari 1979, 2002; Andreolli 1981; Cortonesi 2002). In spite of the great

potential for archaeobotanical analysis, the data relevant to the Italian peninsula are mostly published in grey literature, which is often difficult to trace (for a review of archaeobotanical studies in the Middle Ages, see Grasso and Fiorentino 2009).

The archaeobotanical data from northern Italy show an agricultural world in crisis both in urban and rural sites (Castelletti and Maspero 1988; Castelletti and Motella De Carlo 1999; Castiglioni et al. 1999; Nisbet 1999; Augenti

et al. 2006). Only from the 10th c. A.D. did farming again become rich and diverse, reaching the quality of the Roman period, and supplying food to urban markets in Firenze/Florence (Buonincontri et al. 2007a; Mariotti Lippi et al. 2013), Ferrara (Bandini Mazzanti et al. 2005; Bosi et al. 2009) and Parma (Bosi et al. 2011) between the Communal Age, based on allegiances between city states, and the Renaissance.

The geographical distribution of cultivated cereals does not fully agree with those reported by historical sources. Indeed, the high spatial resolution of archaeobotanical data detects the peculiarity related to local environmental conditions such as climate and soils, and to different socio-cultural factors. Archaeobotanical research shows that crops of the Roman period persisted in those areas subjected to strong political-ecclesiastical controls, where the climate was favourable and soils were fertile (Castelletti 1977; Costantini et al. 1983; Van der Veen 1985; Bakels 2002; Caracuta and Fiorentino 2009). The analysis of the botanical remains from Miranduolo provides a special opportunity to improve our knowledge of plant husbandry during the Middle Ages in central Italy, providing information about the crops, the storage and the processing practices. One particular feature of interest, due to the long time span covered, is to detect the roles and the changes of crop plants in the economic agrarian system.

Study area

The territory of Miranduolo is located on the eastern slopes of the hilly area of the Colline Metallifere, between 350 and 750 m a.s.l., 40 km southwest of Siena (Fig. 1a), and it is crossed by the river Merse on the plain located to the north. The closest meteorological station of Pentolina (450 m a.s.l.) indicates minimum average temperatures of the coldest month (February) of 2 °C and maximum average temperatures of the hottest month (August) of 29 °C; rainfall is around 1,000–1,100 mm/year.

Mixed deciduous woodlands, mainly of *Quercus cerris* L. (turkey oak) and *Q. pubescens* Willd. (downy oak), cover the surrounding area; abandoned *Castanea sativa* Miller (chestnut) stands with several ancient trees are also present. On the tops of the hills, evergreen vegetation is dominated by *Q. ilex* L. (holly oak). In the plain close to the river Merse, natural vegetation is represented by isolated trees of downy oak and *Fraxinus oxycarpa* Bieb. (ash), as well as by riparian vegetation with *Populus nigra* L. (poplar), *Salix alba* L., *S. caprea* L. and *S. eleagnus* L. (willows).

The soils on the hillsides are rather infertile; the plains consist of fluvial deposits (Fig. 1c) and locally of sandy and clay soils, with some chalk, which are a limiting factor

for the yields of crops (Costantini et al. 2006; Regione Toscana unpublished).

The presence of the castle, located on a hill at 411 m a.s.l. (Fig. 1b), is attested by historical sources from the end of the 10th century A.D., but archaeological excavation has shown that there had been three earlier phases of settlement (Valenti 2006). Miranduolo was firstly settled in the Lombard period in the 7th century A.D. as a mining village of huts with a church. In the second half of the 8th century A.D. it became a farming village, consisting of peasants' huts with silo pits for crop storage (Fig. 1d). From the second half of the 9th century A.D., during the Carolingian period, the village developed into a manor (Fig. 1e). In this phase, the top of the hill became the manorial court, defended by two ditches and a fence, with several barns and other buildings related to crop processing. This area was controlled by a lord who directed agricultural production. The village was located on the lower part of the hill (Fig. 1e). The stone castle was built from the last quarter of the 10th century; in this phase, the settlement arrangement did not change. The defended area of the hilltop was still used for food processing and storage (Fig. 1f). Several fires affected the site and these caused charring and the preservation of a great quantity of botanical material in the stores.

Materials and methods

Samples were taken from 20 archaeological layers which are referred to here as stratigraphic units (SUs), consisting of fills of silo pits and occupation surfaces, related to ten archaeological structures and 13 contexts (Table 1). With the term “archaeological structure” we indicate the presumed function of the features, such as storehouses, huts or silos, in each phase of the settlement. Every archaeological structure includes a “context”, consisting of various SUs, showing the activities and events there. The remains from SUs relating to floors, storage areas and the collapsed remains of the same archaeological structures (hut C24, storehouse C01, ditch F06 and storehouse C12) were analyzed together. In the silo pits, only sediments from the bottom were sampled.

Sediment samples were labelled according to the SU. Structure identification follows the same numbering system as the excavation webgis (<http://archeogis.archeo.unisi.it:8080/pmapper/map.phtml>). SUs cover three chronological ranges: the village, the manor, and the castle phases (Table 1). The total volume of the treated sediment was 408 l and the volume per sample ranged from 2 to 60 l (Table 1).

The samples were processed with an “Ankara” type flotation machine equipped with a 0.5 mm mesh in the floating tank. Floated-out macroremains were recovered from mesh sizes 4, 2, 1, 0.50 and 0.25 mm. After the flotation, the heavier

Table 1 List of samples from Miranduolo

Chronology	Archaeological structure	SU	Sample vol. (l)	Feature
Village phase 2nd half 8th–1st half 9th c. A.D.	Hut C24	95	2	Layer from the floor
		97	2	Layer from the floor
Manor phase 2nd half 9th–last quarter 10th c. A.D.	Hut C26	320*	20	Fill of the silo pit
	Hut C28	125	4	Fill of the silo pit
	Warehouse C01	150	60	Layer from the storing surface
		162	24	Layer from the storing surface
		238	12	Layer from the storing surface
		239	12	Layer from the storing surface
		400	24	Layer from the storing surface
	Ditch F06	211	24	Collapse of the warehouse C01
		212	12	Collapse of the warehouse C01
	Warehouse C12	1215*	12	Layer from the surface of storing
	Storage area SF11	1228	5	Fill of the silo pit A
		1344*	40	Fill of the silo pit B
		1361*	9	Fill of the silo pit C
		1364	29	Fill of the silo pit D
Castle phase Last quarter 10th–1st quarter 11th c. A.D.	Warehouse EDM04	558	24	Layer from the storing surface
	Warehouse C12	1103	24	Layer from the storing surface
		1193*	60	Layer from the storing surface
	Crop processing area SF08	1153	9	Layer from the floor

Sequence of the stratigraphic units (SU) sampled, grouped by archaeological context of provenance and chronological phase of settlement. The volume of sediment sampled is indicated for each sample. The *asterisks* indicate the SU of provenance of caryopses submitted for biometric analysis: with regard to the village phase the caryopses come from the silo pit of hut C26; with regard to the manor phase they come from the silo pits B and C of the storage area SF11 and from the surface of storehouse C12; with regard to the castle phase, they come from the surface of the warehouse C12

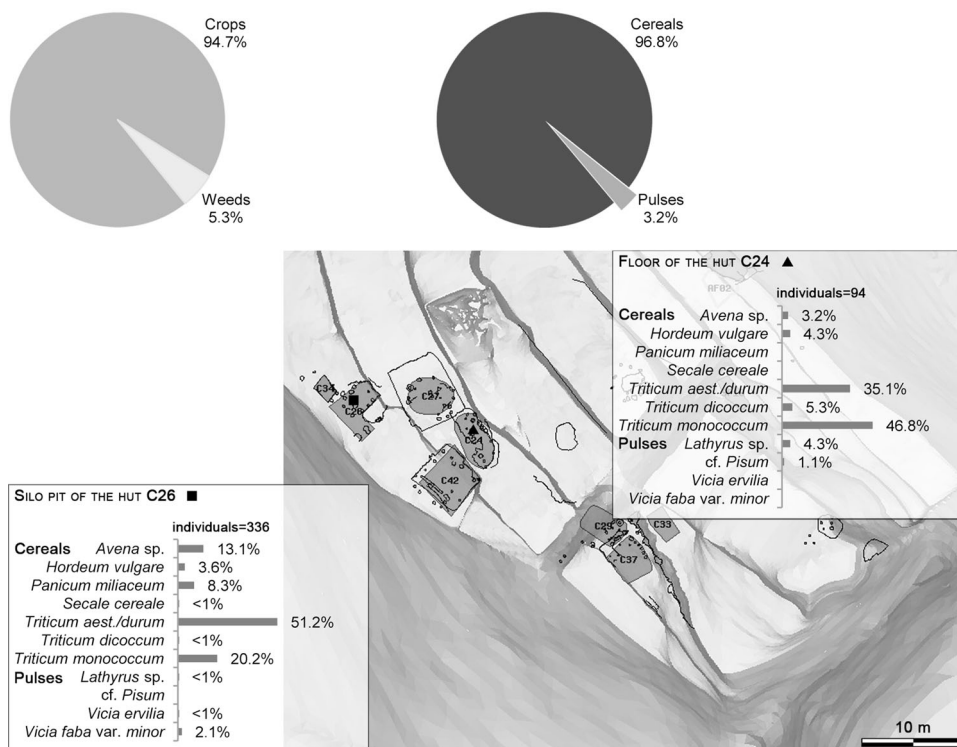
residues were screened for other organic remains. All recovered plant remains were observed; subsamples were analysed only in five cases (50 % of each fraction from SUs 320, 1215 and 1228; 75 % from SUs 1103 and 1193). Seeds and fruits were separated into “individuals” and “fragments” and then counted. We use the term “individual” when the fragments had diagnostic features that allowed us to count them as entire, following the principle of the “minimum number of individuals” (Jones 1990; Antolin and Buxò 2011); for cereals this was when the embryo end of the grain was preserved, for pulses when the hilum was preserved, and for grape pips when the stalk was preserved. Identified fragments without these characteristics were counted and named as fragments.

The taxonomical identification was carried out by comparing with a reference seed collection, atlases and specialist literature (Renfrew 1973; Schoch et al. 1988; Viggiani 1991; Hubbard 1992; Maier 1996; Sadori and Susanna 2005). Since grain remains of naked wheat cannot be identified to species (Maier 1996; Alonso Martinez 2005; Ruas et al. 2005; Jacomet 2008), the term *Triticum aestivum/durum* is used in accordance with Jacomet (2008).

All percentages and frequencies were calculated for each taxon considering only the individuals and excluding the fragments; rachis forks were included in percentage calculations for cereals; similarly grape pedicels were considered in the calculations for fruits. When only fragments were available for specific taxa, these were considered as individuals.

The archaeobotanical record is an obvious source of data for examining changes in plant morphology associated with the cultivation process (Lepofsky et al. 1998). For each studied settlement phase, the length, the width, and the thickness of 50 caryopses belonging to *T. aestivum/durum* and *T. monococcum* were measured following Van Zeist (1970) and Hubbard (1992). Caryopses from central Florence dated to the 13th–14th centuries were also measured, so as to provide an external comparison (Buonincontri et al. 2007a; Buonincontri unpublished data). The comparison with remains from a different chrono-cultural context provided the opportunity to obtain important information about the capabilities and the changes in medieval crop growing. For these measurements we used only intact caryopses without any deformation or protrusions deriving from charring. The

Fig. 2 Crop plants from the village phase (second half of the 8th century A.D. to first half of the 9th century A.D.): graphs by phase and archaeological context. *The pie graphs* show the percentages of each taxonomic group out of the total individuals recovered; *the bar graphs* show the percentages of the individuals of the taxa from the total sum of cereals and legumes; for raw data see ESM 1 (Plan: <http://archeogis.archeo.unisi.it:8080/pmapper/map.phtml>)



length, the width and the thickness data were used to estimate the volume of each caryopsis, assuming their shape as an ellipsoid. The significance of differences between settlement phases was assessed by one-way analysis of variance (ANOVA) using the Duncan test ($P \leq 0.05$) as a post hoc test for separation of means. One-way ANOVA is a statistical tool that examines the significance of difference in the means of a quantitative parameter among two or more groups defined by a categorical variable (treatment). In our study the quantitative parameters were the caryopsis length, width, thickness and volume, and the categorical variable was the “settlement phase” that divided our individuals into four groups (village, manor, castle and Florence). The term “one-way” refers to the fact that only one categorical variable was included in the analysis. Since ANOVA does not provide information about the significance of the difference between specific couples of means, we used the Duncan’s multiple range to test the significance of the difference between any pair of means. All the statistical analyses were performed using the SPSS statistical software package (IBM SPSS Statistics, IBM Corporation, Somers, NY, USA).

Results

The results are given as absolute counts and grouped by archaeological structures and related contexts in ESM 1; silo pits were kept separate to show information about storage techniques.

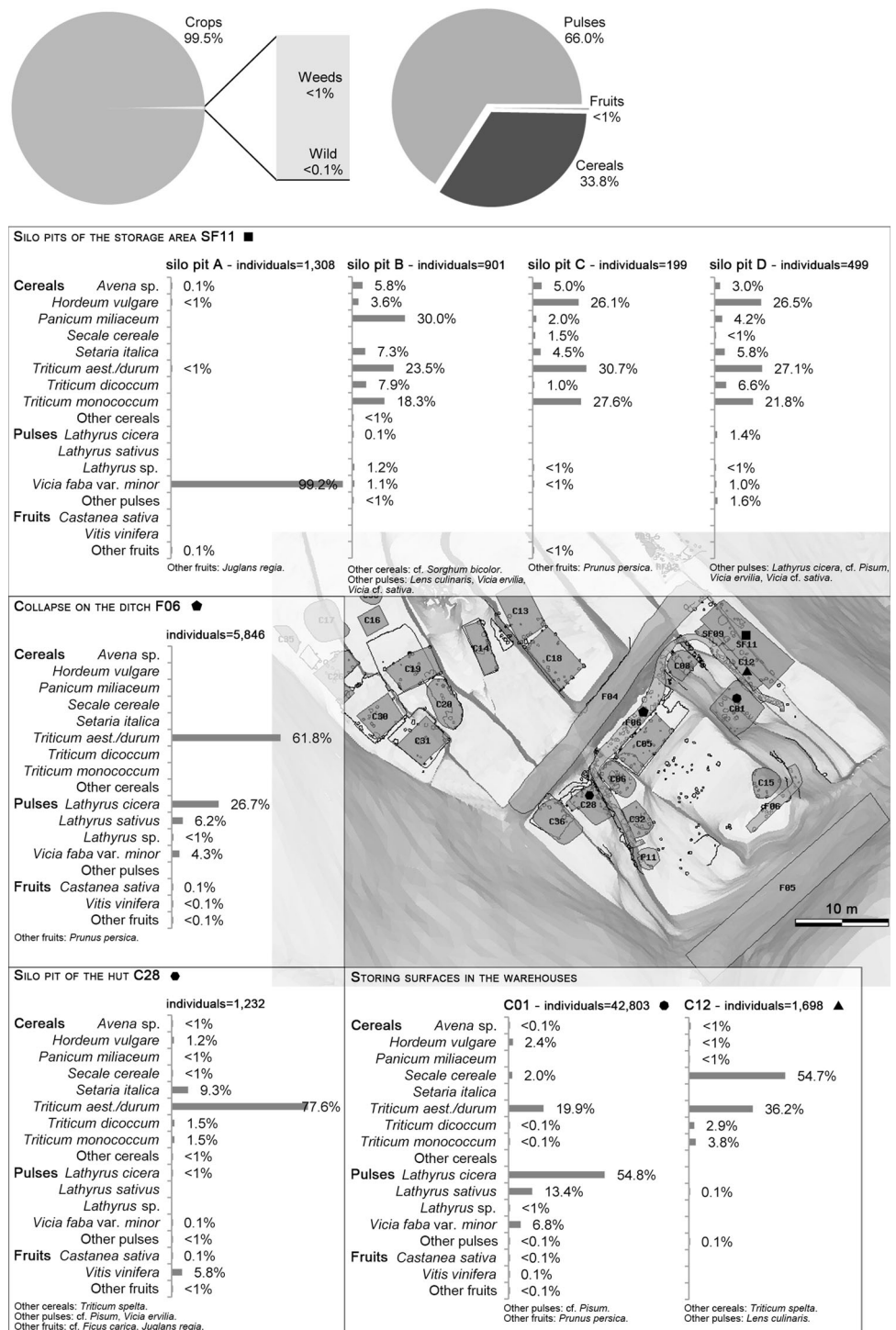
A total of 104,878 charred remains were recovered; a total of 39 taxa were identified and these included 25 cultivated or cultivable taxa, 13 weed taxa and one taxon of woody wild plants (ESM 1). Crop plants were the most common remains found in all the studied phases. In the 8th–9th centuries A.D. village, crops represented 94.7 % of the remains (Fig. 2), 99.5 % in the 9th–10th centuries A.D. manor (Fig. 3) and 95.8 % in the 10th–11th centuries A.D. castle (Fig. 4).

Crop plants

The village phase: from the 2nd half of the 8th century A.D. to the 1st half of the 9th century A.D.

Eleven taxa, all crop plants, including seven cereal taxa were identified (ESM 1; Fig. 2). The data from the floor represent what was used during the period of occupation of the hut: cereals were predominant, but only three taxa were present. *T. monococcum* was the most represented cereal (46.8 %) followed by *T. aestivum/durum* (35.1 %), whereas hulled *Hordeum vulgare* (4.3 %) and *Avena* sp. (3.2 %) were less abundant. In the silo, where all seven taxa were found, *T. aestivum/durum* was most common (51.2 %), followed by *T. monococcum* (20.2 %), *Avena* sp. (13.1 %), *Panicum miliaceum* (8.3 %) and hulled *H. vulgare* (3.6 %); *Secale cereale* and *T. dicoccum* were less than 1 %.

Fig. 3 Crop plants from the manor phase (second half of the 9th century A.D. to last quarter of the 10th century A.D.): *graphs* by phase and archaeological context; silo pits were kept separate to collect information about storage techniques. The *pie graphs* show the percentages of each taxonomic group out of the total individuals recovered; the bar graphs show the percentages of the individual taxa from the total sum of cereals, legumes and fruits. In contexts where only fragments of a taxon were found, these specimens have been included, for raw data see ESM 1 (<http://archeogis.archeo.unisi.it:8080/pmapper/map.phtml>)

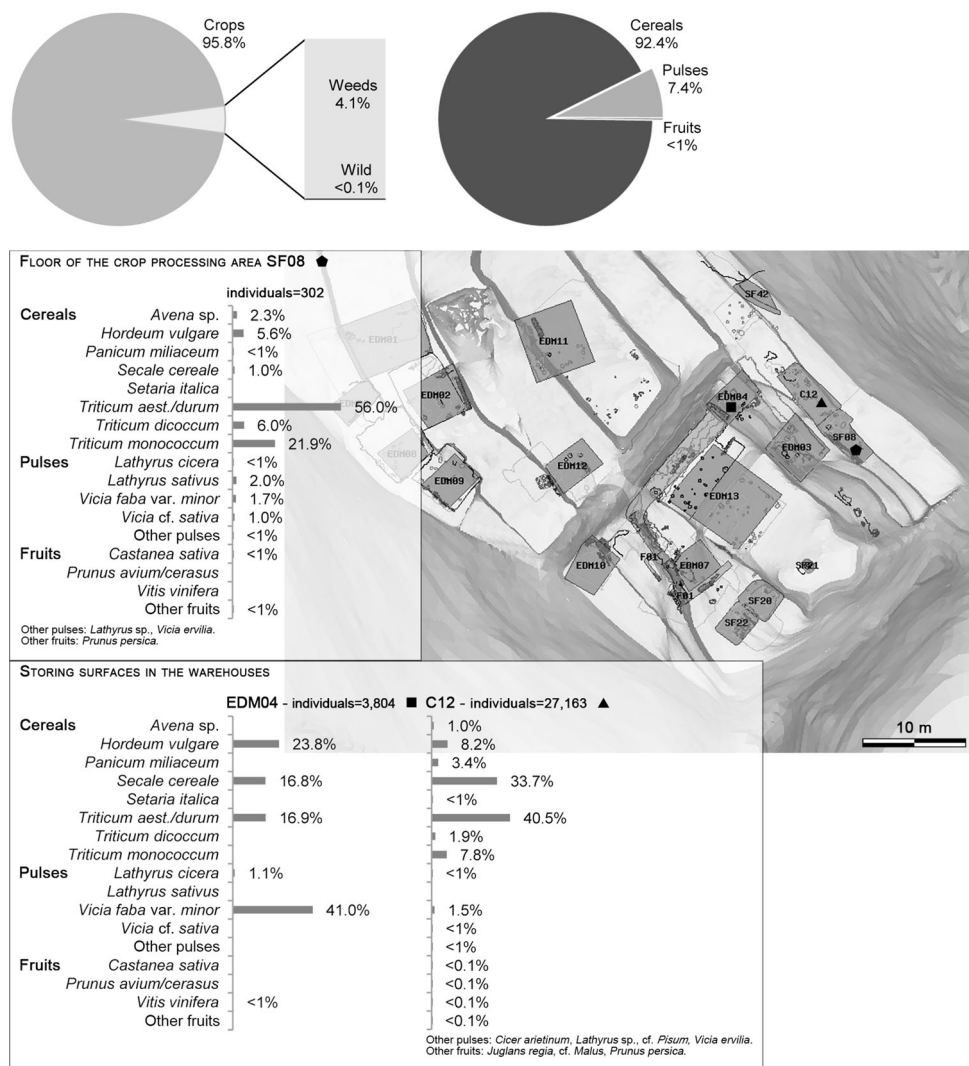


Four taxa were identified among pulses (Fig. 2). Sporadic remains of seeds of *Lathyrus* sp. were found in both the contexts. *Vicia faba* var. *minor* and *V. ervilia* were found only in the silo pit, whereas cf. *Pisum* was found only in the hut.

The manor phase: from the 2nd half of the 9th century A.D. to the last quarter of the 10th century A.D.

Preliminary results from the storehouse C12 and the floor in SF08 have already been reported by Buonincontri et al.

Fig. 4 Crop plants from the castle phase (last quarter of the 10th century A.D. to first quarter of the 11th century A.D.): *graphs* by phase and archaeological context. The *pie graphs* show the percentages of each taxonomic group out of the total individuals recovered; the *bar graphs* show the percentages of the individuals of the taxa from the total sum of cereals and legumes and fruits. In contexts where only fragments of a taxon were found, these specimens have been included; for raw data, see ESM 1 (Plan <http://archeogis.archeo.unisi.it:8080/pmapper/map.phtml>)



(2007b); in this study we are presenting the complete dataset. 21 taxa among the 33 identified were crop plants (ESM 1; Fig. 3). Cereals predominate in the seed assemblage with ten taxa (Fig. 3). In the silo pits located in the storage area, *T. aestivum/durum*, *T. monococcum*, hulled *H. vulgare* and *P. miliaceum* were the most common cereals, followed in percentage by *Avena* sp., *Setaria italica*, and *T. dicoccum*. *Secale cereale* and cf. *Sorghum bicolor* were also present in small amounts. In the storehouse C01, cereals represented less than 25 % of the seed assemblage, which was mostly *T. aestivum/durum* (19.9 %), followed by hulled *H. vulgare* (2.4 %) and *S. cereale* (2.0 %). In the storehouse C12, *S. cereale* (54.7 %) was the predominant species, followed by *T. aestivum/durum* (36.2 %). In both storehouses, *Avena* sp., *T. monococcum*, *T. dicoccum* and *P. miliaceum* were also found in low percentages, whereas *T. spelta* was sporadic. In the silo pit of hut C28, *T. aestivum/durum* (77.6 %) predominated, followed by *S. italica*

(9.3 %); *T. dicoccum*, *T. monococcum*, *Avena* sp., *S. cereale* and hulled *H. vulgare* also appeared. The collapse of the C01 on the ditch F06 yielded only *T. aestivum/durum* (61.4 %).

Six pulse taxa were identified (ESM 1; Fig. 3). *V. faba* var. *minor* and *Lathyrus* were the most common remains; in details (Fig. 3), in the storage area SF11, *V. faba* var. *minor* (99.2 %) was the only taxon in the filling of silo pit A, whereas *L. cicera* and *L. sativus* were the most represented in C01 (54.8 and 13.4 %, respectively) and in the collapse on the ditch F06 (26.7 and 6.2 %, respectively). The remaining taxa, such as cf. *Pisum* and *V. ervilia*, were present in more than half of the sampled contexts, although they were found in very small amounts. Four fruit taxa appeared in this phase, including mainly *Vitis vinifera*. *Castanea sativa*, *Juglans regia*, *Prunus persica* and *Ficus carica* were also present (ESM 1; Fig. 3).

Table 2 Length (L), width (W) and thickness (T) of caryopses of *Triticum aestivum/durum* and *T. monococcum* (in mm) collected at three settlement phases of Mirandulo and at Florence

Phase	<i>Triticum aestivum/durum</i>			<i>Triticum monococcum</i>		
	L	W	T	L	W	T
Village	4.70b	3.30b	2.67b	5.40ab	2.68ab	2.83ab
Manor	5.12a	3.58a	2.90a	5.55a	2.83a	2.91a
Castle	5.02a	3.56a	2.86a	5.27b	2.53b	2.73b
Florence	4.98a	3.52a	2.94a	5.15b	2.22c	2.54c

Within columns, any couple of means followed by different letters are significantly different according to the Duncan test ($P \leq 0.05$). This means, for instance, that the length of *T. aestivum/durum* caryopses was significantly smaller in the village phase (mean value followed by the letter “b”) than in the other two phases and Florence (mean values followed by the letter “a”). Similarly, the length of *T. monococcum* caryopses in the village phase (mean value followed by the letters “ab”) was not different from those in the manor phase (mean value followed by the letter “a”) and, at the same time, it did not differ from those from the castle phase and Florence (mean values followed by the letter “b”)

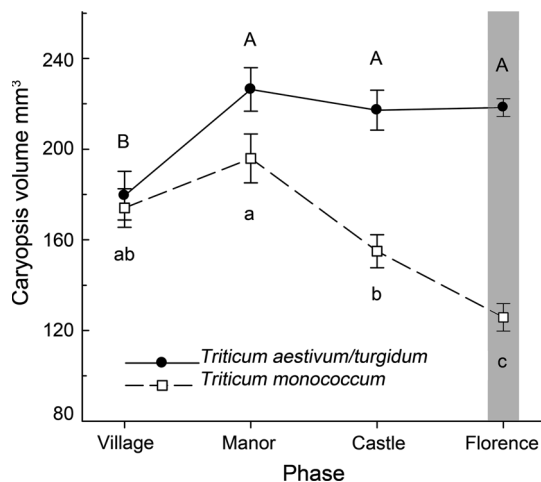


Fig. 5 Changes in caryopsis volume of *Triticum aestivum/durum* and *T. monococcum* between the 8th and the 11th century A.D. at Mirandulo, compared with the 14th century caryopses from Florence (grey area). Vertical bars represent standard errors of the means. Different letters indicate means significantly different according to the Duncan test ($P \leq 0.05$). Upper case and lower case letters were used for *T. aestivum/durum* and *T. monococcum*, respectively

The castle phase: last quarter of the 10th century A.D. to first quarter of the 11th century A.D.

There were 31 identified taxa, including 21 crop plants (ESM 1; Fig. 4). Cereals dominated the seed assemblage and eight taxa were identified among them (Fig. 4). Only three cereal taxa were present in the storehouse EDM04: hulled *H. vulgare* (23.8 %) was most abundant, followed by *T. aestivum/durum* (16.9 %) and *S. cereale* (16.8 %). Seven cereal taxa were identified in the storehouse C12:

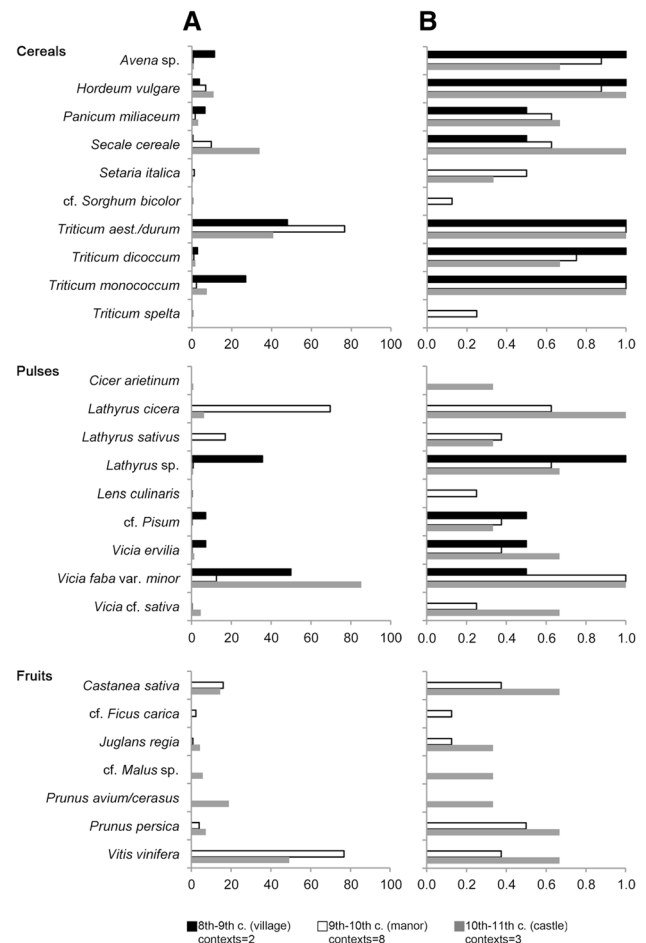


Fig. 6 Column A Comparison of the percentages of cereals, legumes and fruits out of the total of the reference group, in the three chronological phases between the second half of the 8th century A.D. and the first quarter of the 11th; Column B comparison of the frequency index of cereals, legumes and fruits out of the total of the reference group, by archaeological contexts in the three chronological phases between the second half of the 8th century A.D. and the first quarter of the 11th. The percentages and the frequencies are calculated on the basis of the individuals found, but in the contexts where only fragments of a taxon have been found, these have been included

T. aestivum/durum (40.5 %) was the main taxon, followed by *S. cereale* (33.7 %); hulled *H. vulgare* and *T. monococcum* appeared below 10 %; finally, *Avena* sp. and the minute grains of *P. miliaceum* and *Setaria italica* were present in very low percentages. Seven cereal taxa were found in samples from the floor of the crop processing area SF08, where *T. aestivum/durum* (56.0 %) and *T. monococcum* (21.9 %) were most abundant, followed by *T. dicoccum*, hulled *H. vulgare* and *Avena* sp.

Seven pulse taxa were identified (ESM 1; Fig. 4). *V. faba* var. *minor* was the main one, especially in EDM04 (41.0 %). *V. cf. sativa* and *Lathyrus*, with *L. sativus* and *L. cicera*, were found in more than half of the contexts; *Cicer*

arietinum, *V. ervilia* and cf. *Pisum* were present only in the assemblage from the storehouse C12.

Six fruit taxa were found (ESM 1; Fig. 4). *Vitis vinifera* and *Castanea sativa* were the commonest, while *J. regia*, cf. *Malus* sp., *P. persica* and *P. avium/cerasus* appeared in low amounts.

Weeds and wild plants

Thirteen wild plant taxa were identified (ESM 1). Caryopses of Poaceae were found in the village phase, while in the manor and castle phases, 11 and 13 taxa were found, respectively. The identified taxa belonged mainly to ruderals and weeds of cultivated fields and among cereals. The only taxon belonging to wild woodland vegetation was *Quercus* sp.

Caryopsis size of *T. aestivum/durum* and *T. monococcum*

Caryopsis length, width, thickness and volume of *T. aestivum/durum* from the village phase were significantly smaller compared to both the other settlement phases and the caryopses from Florence dated to the 13th–14th centuries A.D. (Table 2; Fig. 5). No significant difference was found in the caryopsis size of *T. monococcum* between the village and the manor phases (Table 2; Fig. 5), whereas the length, width, thickness and volume of *T. monococcum* caryopses decreased significantly passing from these phases to the castle phase and from this to the 13th–14th centuries A.D. in Florence (Table 2; Fig. 5).

Discussion

The village

The samples from the floor levels of hut C24 indicate what was cultivated during the period of its occupation (Fig. 2), thus they can provide a good idea of the agricultural economy of the village. The storage silo pit in hut C26 had a very low concentration of plant remains (24.3 per litre) and the finds were not homogeneous. Thus we can suppose that the seeds were probably related to residues of the products stored during its use, from the bottom of the pit. However these data were very similar to those from the floor of hut C24. All the identified crops were cultivated in Italy during the Roman period (Castelletti et al. 2001; Forni 2002), thus we can hypothesize that there was high quality farming in this phase; the noticeable presence of *T. monococcum* (einkorn) represents an element of discontinuity with Roman agriculture (Fig. 6).

According to historians, agriculture in the High Middle Ages experienced difficulties because of the collapse of Roman agrarian organisation together with incapacity and technical deficiency (Montanari 1979, 2002; Sadori and Susanna 2005). However, our data suggest a good knowledge about both crop requirements and soil properties. Indeed, although soils were not very fertile, because of the presence of sand, clay and chalk, farming was mainly based on the cultivation of cereals and also of naked wheats (*T. aestivum/durum*), which represented the best choice for achieving good crop yields and quality from the farming of the settlement (Fig. 6). Furthermore, farmers used crops which were more resistant to environmental adversities. Indeed, *H. vulgare* (barley) and *P. miliaceum* (common millet) are suitable for growing on poor soils and under severe drought, completing their life cycle in a short time. Einkorn adapts better than naked wheats to poor soils because of its hardness (Zohary and Hopf 2004).

Morphological features did not allow differentiation between *Avena fatua* (wild oat) and *A. sativa* (cultivated oat), but we hypothesize that these caryopses can be attributed to the cultivated species because it was present with high frequency and percentages (Fig. 6) especially in the silo destined for domestic foodstuffs (Fig. 2). In this phase, *T. dicoccum* (emmer) and *S. cereale* (rye) were present only in the silo pit (Fig. 2) and in amounts that were too small to infer their cultivation and deliberate storage (Fig. 6). Indeed, it was reported that low levels of minor cereals can contaminate the dominant cultigens because of their similar growing habitat and harvest time (Jones and Halstead 1995). Similarly, some Fabaceae found in the silo pit, *V. ervilia* (bitter vetch) and *Lathyrus sativus/cicera* (grass/red pea), and on the floor surface, *Pisum sativum* (pea), could be contaminating taxa (Fig. 2). However, at Miranduolo, grass/red pea was found on the floor surface in the same amounts as the hulled barley (Fig. 2), and thus it can be hypothesized that it was also cultivated, and it could have been grown on the poorest soils thanks to its hardness.

Even *V. faba* var. *minor* (broad bean, horse bean) was found in the silo pit in sufficient quantity to be considered a cultivated plant (Fig. 2). According to Castelletti et al. (2001), in Italy during the High Middle Ages, bitter *V. ervilia* lost its importance and *V. faba* predominated together with *Pisum* and *L. sativus/cicero*.

In general in this phase, we observed that the crops were carefully processed before storage, since small amounts of spikelet forks and glume caryopses were found (Fig. 2). Seed sizes of Poaceae and Fabaceae weeds or contaminants are generally very similar to those of cultivated cereals, and this complicates their elimination from the grain during both sieving and hand cleaning (Hillman 1981, 1984; Jones 1984).

The discontinuity with the Roman world was shown by the important role of *T. monococcum*, and although it produces bread with characteristics comparable to the best wheat breads, it is rarely found in remains from the Roman period and always in smaller amounts than *T. dicoccum* (Castelletti et al. 2001). At Miranduolo, in addition to *T. monococcum*, we found crops such as *Secale*, *T. dicoccum* and *Hordeum* which are more productive under adverse growing conditions and also easier to process than wheats. Thus it becomes important to understand the role of *T. monococcum*. Between the 6th and 10th centuries A.D., einkorn characterized the cereal assemblages both in urban and rural sites in northern and central Italy, often being more abundant than naked wheats, rye and barley. In the north, this was observed in the towns of Brescia (Castelletti and Maspero 1988; Castiglioni et al. 1999), Alba (Castelletti and Motella De Carlo 1999) and Parma (Bosi et al. 2011); in central Italy, in the village of Montarrenti, a site 20 km from Miranduolo (Cantini 2003). It is interesting to note that these areas of northern Italy and Colline Metallifere were mainly settled by Lombards (Brogiolo 1993; Micheletto 2000; Azzara 2004; Valenti 2012), a Scandinavian population found in Italy from A.D. 569 until 774. Thus we wonder whether *T. monococcum* should be considered a cereal cultivated by the Lombard people for cultural reasons and/or eating preference. This possibility has an interesting parallel in the Iberian Peninsula where *T. monococcum* was used for making bread during the time of Arabian dominance (Peña-Chocarro and Zapata Peña 1998). On the other hand, archaeological sources suggest a domestic and subsistence crop production in the High Middle Ages, as indicated by the absence of buildings for crop storage in the settlements (Bianchi and Grassi 2012). The historical sources show that the local aristocracy did not interfere with the economic choices and the management of agricultural resources of the villages (Wickham 2005). Thus, the low productivity of *T. monococcum* does not disagree with these low-income economic contexts; in fact, the agrarian economy during the village phase of Miranduolo had a domestic and subsistence character, as suggested by the storage in silo pits for the needs of single family units.

The manor

The assemblages from the manorial phase, between the 9th and 10th centuries A.D., showed that the farming of the settlement was intended to produce valuable crops (Fig. 6). The fillings of silo A and the remains in hut C28 mainly contained single stored crops, *V. faba* and *T. aestivum/durum*, respectively (Fig. 3). According to historical sources, these crops were sown, harvested and stored separately from other cereals and legumes (Montanari 1979). As in

the previous phase, the fills of silo pits B, C and D consisted of pit bottom residues from several goods successively stored during their use, mainly *T. aestivum/durum*, *T. monococcum*, hulled *Hordeum* and *P. miliaceum* (Fig. 3). These cereals were the same as those of the previous phase, thus the manor continued and stabilized crop production in the village.

The storehouses were the most important structures for storage in the manorial court: the differences between the records from the silo pits and the storehouses were significant (Fig. 3). The similarity among the layers of ditch F06 and storehouse C01 (Fig. 3) is explained by the fact that the layer sampled in the ditch was located close to the storehouse and it was therefore affected by the scattering of seeds caused by fire and the collapse of this building. In fact, in the storehouses, the predominance of large seeds and free-threshing grains (*L. sativus/cicera*, *T. aestivum/durum*, *Secale cereal* and *V. faba*), suggests that they had probably been selected before being stored in the manorial court. In late medieval Ferrara, the archaeobotanical record suggests that some taxa with unusually large seeds or fruits were considered to be better quality foods for the table of the Este family court (Bosi et al. 2009). For Miranduolo, our hypothesis is that the lord asked for grains of quality not only for food, but also to be marketed elsewhere. The small percentage of other crops (hulled *Hordeum*, *P. miliaceum* and *T. monococcum*) could be interpreted as contaminants as suggested by Jones and Halstead (1995).

Our data show that among pulses, *V. faba* was common in all the contexts and held a major role in farming (Fig. 6). Among the species within the genus *Lathyrus*, *L. sativus* (grass pea) is very similar to *L. cicera* (red pea), a weed of cereals. The character used to differentiate between the two species in the charred seeds of Miranduolo was the position of the small oval hilum as previously described (Helbæk 1969; Renfrew 1973; Sadori and Susanna 2005). In medieval sites the role of *L. sativus* and *L. cicera* as crops is often ambiguous (Ruas 2005). Sadori and Susanna (2005) indicated the use of *L. sativus* in a poor late Roman settlement, suggesting either poor cultivation techniques or the harvesting of wild plants. In Miranduolo, *L. sativus* and *L. cicera* can be interpreted as cultivated because they were found in large amounts in the storehouse (Fig. 3). These pulses could be grown on the poorest soils and this indicates the will to cultivate even the most difficult soils. *L. sativus* is currently cultivated in central Italy and in Spain both as fodder and as food (Peña-Chocarro and Zapata Peña 1999).

Other minor cereals found in this phase were *T. dicoccum* and *Avena*, and these could be considered as contamination of the cereal crops, where they were tolerated by farmers (Fig. 6; Castelletti et al. 2001). In general, our data confirmed the lack of interest in emmer and oat

cultivation as inferred from both historical sources and previous archaeobotanical studies in Italy (Montanari 1979; Costantini et al. 1983; Castelletti et al. 2001).

Other pulses were found in so low percentages that our data cannot certainly support the hypothesis of their cultivation (Fig. 6); nevertheless, because of their characteristics, it is also conceivable that they were probably sown on the poorest soils. It is noteworthy that until few decades ago in central Italy, the “*Mociarino*” (the local name of *V. ervilia*) was often considered the only alternative to growing *Secale*. It was still sown between the ditches and on the trampled borders of the fields.

Remains of charred fruit came from several contexts related to the manorial court (Fig. 3); this evidence suggests that their consumption was probably reserved for the leading social class. Fruit and nut growing appears in this phase; *Juglans regia* (walnut) and *Prunus persica* (peach) are sporadic in the manor as well as in the castle, but in this latter phase they were present in more than half of the contexts (Fig. 6); the presence of luxury foods confirms the abandonment of subsistence farming. *P. persica* stones from the early Middle Ages are very rare in Italy and mainly linked to urban sites (Sadori et al. 2009). Our data show that during the High Middle Ages, peach trees were even cultivated far from the towns. *Castanea sativa* (chestnut) finds follow a similar pattern to *P. persica* and *J. regia*; however, the charcoal analyses carried out on material from the site revealed that *Castanea* was widely used as timber in the village phase (Di Pasquale, unpublished data). This indicates a change in the management of *Castanea* which leads us to suppose that *Castanea* growing started locally in the second half of the 9th century A.D. These data disagree with the idea that *Castanea* cultivation developed in the Roman period, and highlights the fact that in central-southern Italy *Castanea* was used mainly for timber until the early Middle Ages (Di Pasquale et al. 2010; Allevato et al. 2012). In wider terms, the quality of the fruit taxa seems to show awareness of good cultivation practices, and this does not support the common hypothesis that during the Middle Age the gathering of wild plants was more common than cultivation (Montanari 2002). Only a few seeds and pedicels of *Vitis vinifera* ssp. *vinifera* (grapevine) were found, and we hypothesize that its cultivation was limited to the production of the wine required for church purposes at the site.

In this phase the amount of weed seeds was larger than in the previous periods even though it remained low (Fig. 3). In addition, a small number of spikelet forks were found and this allows us to suggest that careful cleaning operations were carried out before storage. In addition, the presence of *Secale*, *Hordeum* and the dominant *T. aestivum/durum* shows the selection of productive crops, suggesting an improvement in farming management and in

resource selection (Fig. 6). *T. monococcum* cultivation did not disappear, but cereals with better yields and easier processing were preferred at that time. The low productivity of *T. monococcum* and the difficulty in dehushing it probably conflicted with the new economic system.

The Lombard dominion in Italy was ended in central-northern Italy by the Franks of Charlemagne in A.D. 774; the transition from the village to the manorial court coincided with the diffusion of the Carolingian feudal economic system, when the great landlords began to control the economies of the villages (Wickham 2005). In the Colline Metallifere, archaeological sources show that storehouses were built in the settlements between the 9th and the 10th centuries A.D., in parallel with the new farming system (Bianchi and Grassi 2012). In Miranduolo, a clear-cut change in crop management happened: at this time the largest pulses and the most productive and free-threshing of the cereals were selected to be stored in the barns of the manor court; this centralization of the best products was part of the manorial economy.

The castle

The transition from manorial court to the castle coincided with the establishment of the feudal economic system (Wickham 2005). Cereals and pulses kept in storehouses were analogous to the previous phase (Fig. 4), confirming the preference for keeping stocks of major economic importance in barns, and this is in agreement with this new economic system. In one of the storehouses, *V. faba* was the predominant pulse; *L. sativus/cicera*, *V. sativa*, *V. ervilia* and *Pisum sativum* continued to be present, while *Cicer arietinum* (chick pea) appeared (Fig. 4). These pulses were often present in more than half of the contexts, but their small percentages cannot fully support their cultivation in this phase (Fig. 6).

The data from the floor of the crop processing area show that cereals were processed there (Fig. 4). The role of *T. monococcum* in local farming is evident, but it was absent from the storehouse.

Grapevine was indicated by grape pips and also by charred pruning remains (Di Pasquale, unpublished data), confirming the presence of a vineyard. The use of fruit and nuts increased; *Castanea* and *P. persica* remains were present in more than half of the contexts (Fig. 6).

In this phase, the presence of weeds was greater than in the preceding phase (Fig. 4) and clearly this was due to less care in the post-harvest cleaning. We wonder whether this could be interpreted as the consequence of the new economic structure in this area, which led to the necessity to satisfy quickly and abundantly the rising demand from the markets for agricultural products.

Dimensional variation of caryopsis size of *T. aestivum/durum* and *T. monococcum*

The analysis of the size changes variation of the grains of naked wheat and einkorn reinforces the interpretative picture already discussed. A significant increase in caryopsis length, width and thickness of *T. aestivum/durum* was found in the transition from the village to the manorial phase, whereas from the manorial to the castle phase the caryopsis size remained similar (Table 2; Fig. 5). This size increase can be considered a consequence of improvements in farming. This improvement in grain quality, since large fruit size is among the most desirable traits, could be the result of human selection for specific plant attributes (Lepofsky et al. 1998), by the intentional harvesting of the best quality wheats to satisfy the lord's request (Bosi et al. 2009). Furthermore, the size of *T. aestivum/durum* grains from Miranduolo was even similar to those found at Florence from the Communal Age (13th–14th centuries A.D.) (Table 2; Fig. 5). This similarity is especially noteworthy because it is known that in this period, Florence had an advanced urban structure and thus excellent food resources (Buonincontri et al. 2007a; Mariotti Lippi et al. 2013). This indicates that the selection of wheats with larger grains took place in the rural settlements of the manors and castles before the Communal Age. Production surplus and trade were probably possible because of the use of these crops; caryopsis sizes between the 9th and the 11th centuries A.D. were probably the most which could be achieved, at least until the 13th–14th centuries A.D.

On the contrary, grains of *T. monococcum* significantly decreased in size from the beginning of the manor phase, with values similar to those from Florence in the 13th–14th centuries (Table 2; Fig. 5). Size reduction suggests a change in the role of this cereal, which became more marginal, starting from the Carolingian phase. On the other hand, its continued presence in the assemblages shows continuity in the choice of this cereal. Thus, this size reduction could be a further confirmation of the cultural significance of *T. monococcum* during the Lombard period.

Between the 9th and the 11th centuries A.D. and then during the whole late Middle Ages in central Italy, *T. monococcum* appears in such small quantities that it is considered to have been a weed (Costantini et al. 1983; Clark et al. 1989; Castiglioni and Rottoli 1997; Buonincontri et al. 2007a), or it is absent from the archaeobotanical records (Nisbet 1999; Bandini Mazzanti et al. 2005; Fiorentino et al. 2007). The range of *T. monococcum* has receded to such a point since then, that today in Italy it is grown only in tiny areas of the Daunian Apennines as a local crop, often for bulgur or as animal feed (Perrino and Hammer 1982; Hammer and Perrino 1984). These lands belonged to the Duchy of Benevento, which survived as

Lombard up to the Norman conquest in the 11th century A.D. A decrease in *T. monococcum* was also found in the southwest French Massif Central, where from the 9th century A.D., *T. monococcum* was found in such small quantities that it was considered as a subsidiary crop or even a tolerated weed (Ruas 2007).

Conclusion

This study has allowed us, for the first time in central Italy, to understand from a deep and detailed time sequence, from the middle of the 8th to the first quarter of the 11th century A.D., the cultivation of crops by a rural settlement during its transition from a Lombard farming village to a Carolingian manorial court, and finally to a feudal castle under the strong control of a landlord.

The presence of valuable crops such as *T. aestivum/durum* and *V. faba* suggests continuity with the agricultural tradition of the Roman world. Already from the 8th century A.D. the inhabitants were able to produce good quality yields on unfavourable soils, thanks to careful cultivation techniques.

The constant presence of hardier cereals such as *T. monococcum*, *Hordeum*, *Secale* and *P. miliaceum* shows the will to grow a wide range of crops in order to manage any bad harvests, and it indicates the inhabitants' awareness of the low agricultural potential of the land. *T. monococcum* can be considered a “cultural” element of Lombard crops.

In the Carolingian period, the reduction of *T. monococcum* in favour of more productive crops such as *Secale* and *Hordeum* indicates a further improvement of productive capacity as also confirmed by the appearance of luxury fruit trees. The final phase of the Carolingian empire and of the period under a feudal economic system is characterized by greater attention to an economy devoted to achieving a production surplus.

Morphometric analysis validated the supposed improvements of the productive processes from the village to the manorial phase and the following significant loss of importance of *T. monococcum*. This confirmed the cultural significance of this crop in the Lombard period.

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