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Avoiding crop failure in the Iron Age: maslins and emergency crops on the loess soils of western continental Europe, with a special note on oat (*Avena sativa*) and foxtail millet (*Setaria italica*)

Corrie Bakels

Discussed is the possibility that the Iron Age farmers on the loess soils of western continental Europe combated crop failure by growing maslins and emergency crops. This research indeed identified maslins, which consisted of mixtures of emmer wheat and barley or emmer wheat and spelt wheat. Two possible emergency crops were detected: oat and foxtail millet. A relation with the deterioration of the climate around 850-800 BC could not be proven.

1 Introduction

The failure of a crop is one of the worst nightmares for a farmer. This applies to the present, but also holds true for the past. Staple crops, in particular, should never fail.

Farmers have a range of methods at their disposal for preventing this. All aim to obtain the best crop possible. Farmers can apply drainage in case of high water-tables, irrigation in case of drought, manure in case of lack in nutrients, sow more seed per unit of land to improve yields etc., but still adverse conditions can arise causing severe crop damage. An abnormal spell of bad weather or a sudden outbreak of a plant disease may bring about significant losses.

To cope with this kind of failure the farmer may want to spread his risks, for instance by sowing and planting a range of different crops, each plant with quite different requirements. However, if space is limited, and the choice in staple crops is not that large, diversification encounters problems. Such might have been the case in the period and region considered in this article: the Iron Age lasting from 800-20 BC, and the region with loess or comparable soils in the western part of Germany, the Netherlands, Belgium and northern France.

The landscape was shaped by the activities of a farming population. Pollen diagrams show that the presence of humans was felt almost everywhere. The more or less untouched forest which would have covered the land without human interference is no longer in existence. If not actually cultivated, the land was used for pasturing livestock and as a source of wood. Farming combined crop cultivation and animal husbandry.

The land was densely populated with farmers living dispersed throughout the landscape. Only towards the end of the period did farms in the German Rhineland tend to cluster into a kind of proto-hamlets (Simons 1989; Malrain *et al*. 2002, 11; Bakels 2009, 146-147). Most establishments were of moderate size, run by single families. Although in the last centuries BC some hierarchy in farms, with regard to size of yards and number of outhouses, did appear in northern France (Malrain *et al*. 2002, 143), this phenomenon was not recognized elsewhere.

In the period best known, i.e. the last centuries BC, and in the areas archaeologically best known, the distance between individual farms or the proto-hamlets mentioned before is around 1 km (Simons 1989; Thouvenot and Gransar 2000; Bakels 2009, 153). Earlier periods are less well documented, but distances may not have been much larger. This implies that the space available to individual farming households was limited to c. 1 km^2. This space falls surprisingly well within the range mentioned by Chisholm (1968, 46) for modern farms, but it must be kept in mind that this land also had to provide pasture for livestock, areas for cutting fodder to dry as winter fodder, and a load of wood.

The same surface could be used for combinations of these different purposes, but the acreages of land belonging to one household that were destined for crop cultivation could have been lower than one might think. However, it is generally assumed that 1-5 ha was needed for one household (Brinkkemper and van Wijngaarden-Bakker 2005, 508), and even when allowance is made for periods of fallow, the necessary land was available.

Staple crops were mainly cereals. These were emmer wheat (*Triticum dicoccum*), spelt wheat (*Triticum spelta*), bread wheat (*Triticum aestivum*), hulled barley (*Hordeum vulgare*), and broomcorn millet (*Panicum miliaceum*). A sixth cereal, einkorn wheat (*Triticum monococcum*) was a staple of minor importance, only to be found in limited areas. The pulses horse bean, also know as Celtic bean (*Vicia faba* var. *minor*) and pea (*Pisum sativum*) played a role as minor staple as well. Oil was obtained from gold of pleasure (*Camelina sativa*) and linseed (*Linum usitatissimum*), though the latter may have been cultivated mainly for its fibres. Next to these plants, a range of other crop plants was available (Bakels 2009). At first sight there was choice enough. However, true staple crops, the success of which determined the presence or absence of famine, were restricted to only five cereals. But as there must have been regional varieties of these adapted to local conditions, in terms of choice the farmers may not have been badly off. And choices they made, as V. Matterne has demonstrated for the wheats (Matterne 2001; Matterne in Malrain *et al*. 2002).

The conclusion must be that the space for laying out fields was limited, but that a prudent choice of crops should have warded off crop failure. However, a choice may always turn out badly.

One way to anticipate trouble is to sow more than one kind of plant on one and the same field. If one plant fails, the other may still do well. The product of such a crop is called ‘maslin’. Sowing maslin is a kind of diversification. According to historical sources from Europe, most maslins are a combination of two cereals (Slicher van Bath 1963, 262). Another way to cope with crop failure is to try for a second crop on the same field, i.e. to sow an emergency crop on the bare patches. Such crops can be harvested in the very same year, as they grow and ripen fast.

2 Maslins

How to detect a maslin in the archaeological record? As it is obviously impossible to study the standing crops on the ancient fields, the products have to be looked for. In practice these are carbonized remnants of harvests. Unfortunately, true remnants of harvests are rare. Most plant remains retrieved during excavations are mixtures of several kinds of waste, combining more than one product. What is needed are closed finds, and even then is not every closed find suitable. The contents of a vessel, for instance, may represent a meal or the ingredients for a meal, and therefore a mixture of a different kind than the one looked for.

The best information comes from stocked harvests charred *in situ* in their place of storage. Such situations are found in underground silos, where in rare cases a black layer of carbonized grain is found on the bottom (fig. 1). In many such cases the surrounding soil shows traces of burning *in situ*. Second choice are burnt-down granaries, provided their contents were smothered by the collapse of the structure. Of course, if several products were stored in the granary, some mixing may have occurred, but careful excavation generally can detect this.

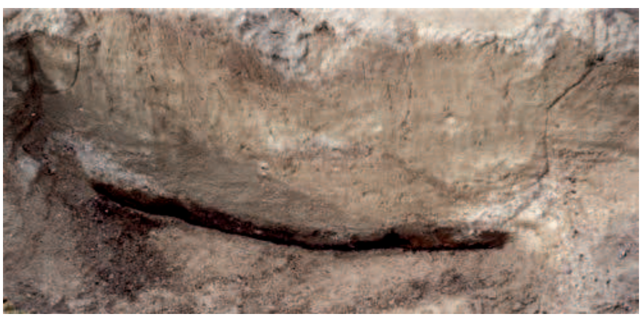

Figure 1 Underground silo with a layer of grain burnt *in situ*.

As already remarked, remnants of single harvests are rare, but in those cases known to me, I looked for maslins. Table 1 summarizes the result. Monocrops prevail. Stored crops of hulled barley, emmer wheat, spelt wheat and, in one instance, horse beans were found. They are not always ‘clean’, as other products are found mixed in. An explanation may be that many fields contain plants from the crop sown the year before. Some grain may have dropped on the field during harvest, germinated the year after and turned up in the next crop. The spelt wheat and einkorn wheat in the Gondreville samples may derive from such instances: a wheat crop in year one, followed by a barley crop in year two. Another possibility is that some grain got mixed in during the handling of the crop before storage. And, of course, if one component of a maslin failed entirely, the lot will look almost like a monocrop.

Nevertheless, monocrops are not the only crops stored. Some finds clearly represent maslins. A maslin of emmer and spelt wheat and three instances of hulled barley and emmer wheat were found. The high percentage of oat in the Maisnil 7 crop will be discussed below.

All in all, the result of the analysis of the contents of stored products must be that maslin sowing was practised during the Iron Age.

3 Emergency crops

Three of the crops listed in table 1 contain oat, but oat (*Avena* sp.) always gives rise to identification problems. Grains of a wild oat, *Avena fatua*, are indistinguishable from those of cultivated oat species, the most common of which is *Avena sativa*. The wild plant is a common weed in cereal fields. Identification is only possible when a distinct part of the chaff, the floret base, is preserved. In the Neerharen-Rekem and Maisnil samples the chaff remains identify the oat as the cultivated oat *Avena sativa*. In the Compiègne crop the chaff remains found are from the wild weed *Avena fatua*. However, only five floret bases were found there and they may represent a minority of wild oat hidden in a lot of cultivated oat.

Is the oat part of the maslin in the Compiègne and Maisnil crops, and a remnant of a former crop in Neerharen-Rekem? Or are we dealing with another phenomenon: an emergency crop? The history of oat as a crop does not go back as far as wheats and barley, and its origin does not lie in the Near East (Zohary and Hopf 2000). Oat appears first in Europe.

The cultivar is genetically very close to the weedy oat and very probably evolved from the weed that infested wheat and

	context	barley	emmer	spelt	oats	einkorn	horse bean		
		%	%	%	%	%	%		
Acy-Romance 3596	silo	100		-	-	-	-	monocrop	Matterne 2001
Compiègne	granary	86	-	12	2	-	-	monocrop	Bakels 1984
Forest-Monthiers	granary	-	100	-	-	-	-	monocrop	Matterne 2001
Frouard HP	silo	-	-	-	-	-	91	monocrop	Hingh 2000
Gondreville 4214	silo	93	-	2	-	5	-	monocrop	Hingh 2000
Gondreville 4219	silo	90	-	9	-	1	-	monocrop	Hingh 2000
Jaux	granary	-	100	-	-	-	-	monocrop	Matterne-Zech 1996
Louvres Le-Vieux-Moulin 71	silo	69	31	-	-	-	-	maslin	Casadei et al. 1997
Maisnil 7	granary	12	69	-	19	-	-	maslin	Matterne 2001
Maisnil 17	granary	-	100	-	-	-	-	monocrop	Matterne 2001
Menneville	silo	-	50	50	-	-	-	maslin	Bakels 1984
Neerharen-Rekem 123	silo	47	53	-	-	-	-	maslin	Roymans 1985
Neerharen-Rekem 132	silo	6	85	-	9	-	-	monocrop	Roymans 1985
Sittard-Geleen-Hof van Limburg	granary	1	-	99	-	-	-	monocrop	Bakels 2012

Table 1 The composition of stocked harvests.

barley fields. According to Zohary and Hopf (2000, 82) "… such weeds [were] picked up and planted intentionally". Why were they picked up? The general opinion is that farmers saw that they survived when the intended crop failed. They were picked up as an emergency crop.

Oat is regularly found in the region and period considered here, although it is not always clear whether the finds concern cultivated or wild oat. But the cereal was never found as a monocrop. However, instances of monocrops are known from other regions, at least from the second century BC onwards. An example is the carbonized lot retrieved from a silo at Rullstorf, Kr. Lüneburg, Germany, dated to the first century BC (Kroll 1980). This proves that oat was considered a crop plant. In the loess region of western continental Europe oat was possibly seen as second or third rate, a cereal only to be sown on patches in fields where the intended wheat or barley had failed. It may be imagined that such patches were re-sown with a spring-oat. This oat was then harvested together with the main crop. Such practices may explain the occurrence of oat as part of the stored harvest.

Oat is not the only cereal that may have had the status of emergency crop. The second suspect is foxtail millet (*Setaria italica*). Contrary to that other millet, broomcorn or proso millet (*Panicum miliaceum*), it never turns up as a main crop. Its wild forebear is *Setaria viridis*, a field weed. Crosses between the species produce semi-fertile or even fertile hybrids (Jusuf and Pernes 1985). The two resemble each other closely and as a result it is difficult to distinguish between these *Setaria*s where archaeobotanical material is concerned, especially when only a few carbonized grains are available. However, the detection of large numbers of grains in, for instance, the sites of Nettesheim-Butzheim, Köln-Blumenberg and Sittard 'Hof van Limburg' stresses the presence of the cereal foxtail millet (Knörzer 1971; 1992; Bakels 2012).

It is a widely held belief that this small-seeded millet was domesticated in China, where it belongs to the first plants to be cultivated. But genetic analysis has demonstrated that there are clearly distinguishable genetic groups, closely related to geographical origins. Those results are in favour of the hypothesis of two independent centres of domestication, one in Asia and one in central Europe (Schontz and Rether 1999). As a matter of fact, the European foxtail millet may have followed the same path of domestication as oat, starting as a weed, tolerated, valued and subsequently set up as emergency crop. Foxtail millet is spring-sown, has a short growing season and is therefore ideal for combating crop failure.

4 Discussion

It looks as if the Iron Age farmers used maslins to cope with possible crop failure and emergency crops to cope with actual crop failure. Were these measures new inventions? The answer is not easy to provide. The right conditions for detecting maslins are rarely encountered. There is an instance of an Early Neolithic, Linearbandkeramik silo. The Linearbandkeramik is the first farming culture in the region.

The silo excavated at Geleen-Urmonderbaan revealed a mixture of 92% emmer wheat and 8% einkorn wheat (Bakels and Rousselle 1985). This is hardly a maslin. The next instances are dated to the Late Bronze Age, 1100-800 BC. The silo Cuiry-lès-Chaudardes 807, Dept. Aisne, France, was filled with a mixture of 54% hulled barley and 46% oat, and Cuiry-lès-Chaudardes 830 with 20% hulled barley, 32% emmer wheat and 48% broomcorn millet (Bakels 2009). The percentages refer to numbers of grains, not to weight, and as broomcorn millet grains are much smaller than those of the other cereals, they are overrepresented in this kind of calculations. The silo Frouard HP 2091, Dept. Meurthe-et-Moselle, France (De Hingh 2000) revealed a mixture of 50% naked barley and 50% hulled barley, interpreted as maslin because the two varieties of barley were obviously sown, and subsequently harvested and stocked together. These finds show that maslin growing did not start in the Iron Age, but was already practised earlier. The lack of suitable remnants makes it difficult to determine how much earlier.

The same is true for emergency crops. Even the Linearbandkeramik culture mentioned previously is reported to have known an emergency crop, in this instance a brome species (*Bromus secalinus*-type), possibly rye brome (*Bromus secalinus*), though there are indications that field brome (*Bromus arvensis*) is involved as well (Knörzer 2007, 72). These bromes are weeds in cereal fields with grains almost as large as cereal grains, and the large numbers of this wild grass have led Knörzer (1967) to the conclusion that the farmers tolerated, harvested and possibly even promoted the plant. However, brome never developed into a true crop plant.

A Late Bronze Age crop retrieved from a burnt-down granary at Langweiler, Kr. Jülich, Germany, shows an instance of an early presence of oat (Knörzer 1972). Although the crop stored, with 91.5% hulled barley, 3% spelt and/or emmer wheat and 5.5% oat (and two grains of foxtail millet), is strictly speaking a monocrop, the oat is remarkable as half of it belongs to cultivated oat and the other half to wild oat. This site represents, perhaps, a turning point in the history of the crop oat. The oat in Cuiry-lès-Chaudardes 807 mentioned before shows another early instance of this crop.

The broomcorn millet in Cuiry-lès-Chaudardes 830 may be part either of the original maslin or the result of an intervention including a second sowing with an emergency crop. Just like foxtail millet, broomcorn millet has a short growing season and is therefore quite suitable as emergency crop. However, a third explanation of the presence of millet in stocks of larger sized grain is that it was deliberately added to fill space between the cereals, thereby reducing the air content of the silo. As the success of storage underground depends on the lack of oxygen, reducing space would help (Marinval 1992). If this was practised at Cuiry-lès-Chaudardes, the broomcorn millet may represent a separate crop, not necessarily originating from the same field as the other cereals. Indeed, in the Bronze Age broomcorn millet was known as a staple crop in its own right (Bakels 1984, 7; 2009). In that case silo 830 was possibly filled with a maslin of hulled barley and emmer wheat.

The presence of foxtail millet in the Langweiler granary mentioned earlier does not stand alone. Foxtail millet turns up regularly in Late Bronze Age contexts (De Hingh 2000, 188; Zerl 2010). The most important finds belong, however, to the Early Iron Age, 800-500 BC, examples being the lots retrieved from Köln-Blumenberg and Sittard 'Hof van Limburg' (Knörzer 1992; Bakels 2012).

It is often suggested that the rise of oat was triggered by the climate change occurring around 850-800 BC. At that time the climate changed towards the wetter and colder (Van Geel *et al.* 1996; Van Geel and Renssen 1998; Magny 2004). As oat is a crop that does well under such circumstances, its adoption may have been promoted by this climatic turn. However, in the region considered here, oat was already grown before that time. Also, oat had not yet been developed into a main crop. Sowing oat as a main crop was not practised before the Middle Ages, when it became a common cereal (De Vroey 1989; Verhulst 2002, 65; Bakels 2005).

Foxtail millet shows the same pattern as oat, a truly remarkable fact as foxtail millet is not especially fond of cold and wet climates. This small-grained millet never became a main crop in the loess region of western continental Europe. Worldwide it is an important crop, for seed and for fodder and hay, but not here. Taken all together, it looks as though the climate change has nothing to do with the start of oat and foxtail millet growing. Nevertheless, their gaining importance during the Iron Age, i.e. after 800 BC, may have some relation with the 'new' climate. If the change caused the main staple crops to fail more often, farmers may have had to resort more to emergency crops. One of these, oat, was presumably more of a success than the other, foxtail millet, because it stayed whilst the millet disappeared again.

The question whether the sowing of maslins was also promoted by the change in climate cannot be answered at the moment due to a lack of sufficient data. But maslin growing survived the Iron Age as well. It was common practice even in historical times (Slicher van Bath 1963; Bieleman 1992).

Conclusion

Although Iron Age farmers seem to have had a sufficient acreage of arable land, and a reasonable number of crop plants at their disposal, they resorted to two methods of combating crop failure. Both maslin and emergency crop growing were practised. To which extent they applied these methods is unknown because true remnants of harvests are rare in the archaeological record. The practice predates the Iron Age and a link with the deterioration of the climate which set in at the beginning of the period is therefore unlikely. Nevertheless, the use of the methods may have increased, though this could not be proven due to the lack of data.

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