Food production and food procurement in the Bronze Age and Early Iron Age (2000-500 BC)

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PART THREE: THE ANALYSIS

9 The arable weeds: the nature of the arable fields and the appropriation of land

9.1 Introduction

The presence of arable weeds in the field results from human actions. "The type of the weed flora present in the fields is not determined by the time of sowing, the type of crop or the inherent soil conditions but largely by the actions of the farmer her/himself, in the form of the amount of soil-disturbance, manuring and weeding" (van der Veen 1992, 143, citing from Bannink et al. 1974). The analysis of the arable weeds produced by the botanical samples from the Moselle and the MDS regions forms a principal part of the study of the developments in agriculture. It is not so much the analysis of the arable weeds in relation to each other but rather the analysis of the individual species in relation to its environment. The latter implies not only biotic or a-biotic factors, but anthropogenic factors in particular (see below). With the help of the results from this analysis we can reconstruct the nature of the arable fields that were in use and understand the agricultural techniques employed at working the arable soil. I refer to the intensity of the preparation of the fields, ploughing, manuring, the intensity of care paid to the arables during the growing season and the method of harvesting, but also the length of fallow periods and the size of the plots. In brief, the focus is on the attitude of the farmers towards their fields and the influence of their daily agrarian practices on the nature (quality) of the arable soil and on the vegetation (flora) growing on it. We will employ the trends resulting from this analysis to conclude whether certain agrarian activities or modes of agricultural production formed an important or ever-recurring part of the agricultural regime on particular/individual sites or in the subregions as a whole in the Bronze Age and Early Iron Age. Furthermore, we will attempt to clarify the connection between the agrarian productive methods and systems and a possible change of appropriation of land in prehistoric society.

Methodological programme

In the analysis of the weeds, the starting point is to conclude in what way the agricultural techniques and regimes affect the arable weed flora. The principal aspects with regard to the agricultural regime and the arable fields are the following:

- the use of manure,
- the length of the fallow period,
- the extensity or intensity of soil working,
- the use of implements like the plough,
- the size of fields,
- land use systems.

In this analysis only charred macro remains are involved. For the analysis of the weeds I made use of several information sources, the most important of which are: the *Heukels' Flora van Nederland* (van der Meijden 1996), the *Flora van Belgie, het Groothertogdom Luxemburg, Noord-Frankrijk en de aangrenzende gebieden* (De Langhe et al. 1988), *Onkruidassociaties in Nederland* (Sissingh 1950), *Akkeronkruidvegetatie als indicator van het milieu, in het bijzonder de bodemgesteldheid* (Bannink et al. 1974) and *Een nieuwe indeling in ecologische groepen binnen de Nederlandse Flora* (Runhaar et al. 1987). The principal characteristics of the arable weeds retrieved from the samples under study had to be collected and brought into one single scheme (see below). These characteristics relate to their preference for specific environmental conditions, e.g. manured loamy soils or dry sandy soils, trampling, or long fallow periods etc.

For the purpose of a fruitful analysis of the arable weeds recovered from the seed assemblages under study, in the next sections I will argue the following successive methodological considerations:

1. that all locations studied are production/consumption sites, and that no import of crops took place
2. that the majority of the samples contain the remains of roughly the same crop processing stages
3. that all the charred weed seeds found originate from weed plants on the arable fields

Furthermore, I will discuss the issue that, in my opinion, it is not fruitful to order the weeds to phytosociological or traditional ecological groups. I will therefore propose that the weed species be allocated to different ecotope groups (following the scheme of Runhaar et al. 1987). The arable weeds thus treated form an archaeological source of evidence with regard to the nature of arable fields, agrarian modes of production and agrarian strategies.

9.2 The first analysis of the arable weeds

In this section, some methodological considerations are pointed out, before we begin analysing the single arable weed species and then characterise and identify the arable fields.

All locations studied are producer and consumer sites, and no import of crops took place

Drawing a distinction between consumption and production sites has been an important theme in archaeobotany for quite some time now.

Ethnographic investigations in present-day Turkey and Greece have yielded one method of establishing consumer and producer sites (Hillman 1981, 1984; G. Jones 1984). Conclusions were drawn here on the basis of establishing various crop processing stages of hulled wheats as well as free-threshing cereals (see also chapter 10). The main conclusions from these ethnographic studies are the following. On producer sites the early crop processing stages of cereals (i.e. winnowing and coarse sieving) take place. Therefore the presence of the remains from these early processing stages is associated with producer sites, i.e. esp. (large fragments of) cereal stems (Hillman 1984). Hulled wheat grains, such as emmer, are stored and preferably transported in their hulled, unthreshed form. Consumer sites will therefore obtain the grains of glume wheats in the form of semi-cleaned spikelets. The presence of the remains from the final processing stages (parching, pounding and fine sieving) is associated with consumer sites where no production of cereals takes place. In the case of free-threshing cereals the grains will be imported in a fully processed form.

Brinkkemper (1991, 133) justly pointed to some of the shortcomings in the ethnographic models. First of all, stems of cereals are very seldom found on prehistoric sites, probably because they were rarely harvested with the cereal ears. This makes the presence and/or absence of cereal stems a highly unreliable criterion for local production. Also, botanical investigations of crop samples from the Roman period have demonstrated that hulled cereals were not always transported nor stored in their chaff (Brinkkemper 1991, 134). Finally, it should be noted that the distinction producer/consumer is not appropriate to prehistoric communities, which are by definition very likely to be producers and consumers at the same time. Consumption of cereals therefore also takes place on sites where cereals are produced. Brinkkemper noted this conceptual problem and suggested to use the expression “import” for consumer sites (1991, 134).

In addition to ethnographic observations, numerical analysis of botanical data can be applied in order to establish whether the arable crops present were grown by the inhabitants themselves or whether they were imported from elsewhere. According to M. Jones (1985), producer and consumer assemblages can be distinghuished by stating quantitative proportions of cereal grains, chaff and weed seeds. The principal departure points of defining consumer (i.e. import) and producer sites are the following. The presence of large quantities of grain is normally associated with producer sites, or to be more precise, producer assemblages are characterised by large quantities of plant remains per litre of sediment and by relatively high proportions of cereal grains in the samples. The assemblages consist of over 30% of cereal grains and less than 50% chaff remains or 70% weed seeds. Consumer (i.e. import) assemblages are characterised by low quantities of plant remains per litre of sediment and by small proportions of cereal grains in the samples. These assemblages consist for more than 50% of chaff remains and the proportion of weed seeds may be up to 100%. Summarized in brief, the presence of grains point to local production, the presence of weeds principally to import/consumption (M. Jones 1985).

I believe that the quantitative method used to discern producer and import sites is unworkable for the present study, as the numbers of seeds from our samples are generally very restricted. The majority of the samples yielded only 1 to 10 identifiable remains per litre of sediment. According to the criteria mentioned above, this implies that these assemblages would all derive from consumer (i.e. import) sites. Only a limited number of samples produced high absolute numbers of seeds, of which the proportions grains: chaff: weeds could be established (see table 9.1). If we would take these quantitative proportions as a departure point, the assumption would be that part of these sites should be identified as consumer (i.e. import) sites.

This quantitative approach apparently demonstrates some shortcomings. Taphonomic processes greatly influence the composition of botanical assemblages and especially the number of seeds per litre of sediment. Many investigations have demonstrated that producer sites may also produce samples with low numbers of seeds. Indeed, previous analyses and studies demonstrated that prehistoric sites comparable to those in the present study are almost by definition producer/consumer sites at the same time. Indications for distribution or trade of agricultural products are seldom found for pre-Roman prehistoric periods. On the basis of these former studies, we could assume that all our study locations were indeed producer sites which cultivated crops for local consumption and that no import of food crops took place.

We only find final stages of crop processing in the assemblages under study

Identifying crop processing stages has been an important subject of study in archaeobotany (Hillman 1981; 1984; G.Jones 1984; 1987; 1992). When interpreting arable weeds present in crop assemblages, it is important to take note of the fact that the processing of the crop after harvest alters the original composition of the seed assemblage and therefore the relative proportions of crop grains, chaff remains and weed seeds. Second, we should bear in mind that the botanical samples contain weed seeds from only a fraction of the weeds that originally grew among the crops in the field. Some plants will have been weeded out, others will not have been harvested and at the processing stages themselves weed seeds will have been removed. It has been demonstrated in ethnographic studies that the representation of different weeds could vary according to the stage in the crop processing sequence at which they were extracted (e.g. G. Jones 1992).

We consider weed seeds to be highly informative on former agriculture as they reflect the cultivation regime and growing conditions prevalent in the fields. During the crop processing stages this association will be modified, but as long as comparisons are carried out between samples of the same crop processing stages the association should remain identifiable (i.e. comparing like with like; G.Jones 1987; van der Veen 1995, 336). Therefore, it is important that crop stages of archaeological crop assemblages should be identified before interpreting the weeds found.

For this study, all samples have been screened in order to establish the crop processing stage they represent. Therefore, the ratios between number of grains and number of weeds were calculated (table 9.1). As mentioned earlier, the data sets available for this study are not very appropriate to quantitative or statistical analyses, because of the low numbers of seeds generally retrieved. Although no strict rules can be given, numerical analyses cannot, in my opinion, be fruitful when the majority of samples contain 1 to at most 25-50 identifiable botanical remains as is the case for our study material. Although this limit is taken rather arbitrarily, in the archaeobotanical literature roughly a comparable minimum number is used. [9]

Of the 23 samples for which a meaningful ratio could be calculated, the majority had a grain: chaff/weeds ratio of well over 1 (cleaned products) or 1 (semi-cleaned products) (see table 9.1). A few exceptions can be presented. The assemblage of ARL-3124 contained more weeds than grains. Also, the samples Ay-356 and Ay-362 contained more weed seeds and glume bases of emmer wheat than grains of emmer wheat, suggesting it consists of a cleaning residue (cleaning by-product). The same can be said of single samples from Jouy, Woippy, Rémerschen, Budersberg and Geldrop, consisting of proportionally large numbers of weed seeds and chaff of cereals, suggesting we are dealing here with (small) quantities of cleaning residue.

With reference to the earlier assumption that all sites are producer/consumer sites, and not import sites, I propose here to assume that virtually all samples studied reflect the products of the final stages of crop processing, that is the (semi-) cleaned grain, or in some cases the by-products of cleaning.

All weeds from the investigated samples are arable weeds

In the present analysis it is of main importance that we assume that all weeds found are indeed **arable** weeds. Therefore we will reject the traditional ecological classification of weeds (speaking roughly) in species from e.g. arable fields, grasslands and wetland habitats. In this chapter I will plead for a “single origin” interpretation.

Ethnographical investigations have demonstrated that “uncommon” arable weeds regularly occur on primitive fields: fields that are not drained and/or worked with non-mechanized implements. Hillman (1991, 31) observed *Phragmites australis* and *Scirpus maritimus* on Turkish arable fields with inadequate drainage. This phenomenon was indeed also archaeologically attested e.g. for the arables of the Iron Age site of Wateringen situated in the coastal areas of the Netherlands (de Hingh 1994). In modern French arable fields it is frequently observed that shrubs of *Sambucus ebulus* would grow among the cereal crops (Kuijper, pers comm). Charred seeds of this species are indeed regularly found in prehistoric cereal assemblages.

When in our (cereal) seed assemblages species are retrieved which normally do not grow on arable fields but are known as ruderals, wetland species or grassland species, we have to rely on other clues detecting their mode of arrival in the archaeological seed assemblage. In general “some of the most important clues come from the site context of the seeds found and the patterns of correlation between finds of the seeds types of uncertain origin and items such as cereal remains and the seeds of obligate segetals whose origin is less equivocal” (Hillman 1991, 35). Hillman (ibidem) mentions as an example of the most important clues, the intimate association of uncommon arable weeds with cereals in grain-storage facilities. Seeds of *Eleocharis palustris*, for example, a species of damp grassland, commonly occur with carbonized cereals and have also been found in specific archaeological contexts which suggest a very close association with grain storage (Groenman-van Waateringe/Pals 1983; M.Jones 1988, 45).

In chapter 4, I presented a list of archaeological contexts that occur in this study. The majority of the samples under study derive from storage contexts (pits, silos, underground storage pots, granaries), yet we should note that although some of the seed assemblages represent a reflection of (by products of) later processing stages, many other samples could probably consist of so-called “settlement noise”, that is a mixture of discard of domestic refuse (see above). In theory, based on their site context, it is therefore possible that the seeds in the assemblages derived from different origins.

	grains	chaff	weeds	proportions grains:chaff:weeds				proportions grains: (chaff+weeds)		
ARL C 3124	35	10	57	34,3%	9,8%	55,9%	P/C	34,3%	65,7%	<1
Ay 356	79	462	1108	4,8%	28,0%	67,2%	C	4,8%	95,2%	<1
Ay 362	12	96	10	10,2%	81,4%	8,5%	C	10,2%	89,8%	<1
Betting 1	156	0	5	96,9%	0,0%	3,1%	P	96,9%	3,1%	>1
Crevechamps 1064	thousands	thousands	75	equal proportions of grains and chaff; small proportion of weeds			P			>1
Crevechamps 2625	317	65	0	83,0%	17,0%	0,0%	P	83,0%	17,0%	>1
Crevechamps 5083	104	0	0	100,0%	0,0%	0,0%	P	100,0%	0,0%	>1
Crevechamps 5084	hundreds	15	3	high proportion of grains			P			>1
Crevechamps 5085	hundreds	7	7	high proportion of grains			P			>1
Crevechamps 5086	71	3	3	92,2%	3,9%	3,9%	P	92,2%	7,8%	>1
Frouard HP 2035	thousands	1	0	high proportion of grains			P			>1
Frouard HP 2091	thousands	0	7	high proportion of grains			P			>1
Frouard SG 61	23	31	hundreds	equal proportions of grains and chaff; high proportion of weeds			C	42,6%	57,4%	1
Gondreville 4214	thousands	hundreds	172	high proportion of grains			P			>1
Gondreville 4219	thousands	4	93	high proportion of grains			P			>1
Jouy 1005	77	59	242	20,4%	15,6%	64,0%	P/C	20,4%	79,6%	<1
Woippy 111	148	dozens	hundreds	high proportion of weeds			C			<1
Yutz 1301	hundreds	16	39	high proportion of grains			P			>1
Yutz 1321	341	0	27	92,7%	0,0%	7,3%	P	92,7%	7,3%	>1
Budersberg pit	165	116	509	20,9%	14,7%	64,4%	C	20,9%	79,1%	<1
Remerschen 430	69	50	201	21,6%	15,6%	62,8%	C	21,6%	78,4%	<1
Remerschen 457	38	55	74	22,8%	32,9%	44,3%	P/C	22,8%	77,2%	<1
Remerschen 470	144	83	136	39,7%	22,9%	37,5%	P/C	39,7%	60,3%	<1
Geldrop 112 (893/894)	778	18	162	81,2%	1,9%	16,9%	P	81,2%	18,8%	>1
Geldrop 262 (904/905)	47	68	135	18,8%	27,2%	54,0%	P?	18,8%	81,2%	<1
Geldrop granary 6 (903)	235	2	29	88,3%	0,8%	10,9%	P	88,3%	11,7%	>1
				(M. Jones 1985)				(Hillman 1984/G.Jones 1984)		

Table 9.1 Ratios grains - chaff - weeds for a selection of assemblages. P = producer site, C = consumption site

The patterns of correlation are, however, much stronger. In this study, no samples were included consisting of merely weeds. The botanical assemblages retrieved from wells, regularly consisting merely of weed species deriving from the immediate surroundings of the well, are excluded. The consequent association of weeds with cereal grains or other crop species is very powerful.

The only (important) uncertainty with regard to the association between the crops and the arable weeds in the assemblages is that we cannot beforehand establish which specific crop is associated with which specific arable weeds.

To conclude, the prehistoric locations under study can be regarded, without exception, as agrarian (self-sufficient) production and consumption sites. Import of food crops is not likely to have taken place in this period. The human influence on the composition of the samples is considerable. The sample compositions probably reflect the final stages of crop processing: the (semi-)cleaned product. Some of them probably represent the (fine-sieving) by-products. They all derive from antropogenic structures in settlement contexts. There is a powerful association between crop species and weed species. Hence, all the samples from the sites under study can be used in the analyses of the arable weeds. The conclusion should be that the biggest number of the context correlations point to the arable fields as the origin of all species of weeds found. This approach is not new, as a widespread idea in archaeobotany is that carbonised macro remains, unlike waterlogged ones, derive predominantly from a single category of plant communities, that of arable fields (e.g. M. Jones 1988, 44). In the next section this inference will be elaborated upon further.

9.3 Different approaches of the interpretation of weeds

In this section, a short sequence of different approaches of the study of fossil (arable) weeds is presented. Only the principal outlines will be discussed here; for more extensive reviews see for example van der Veen (1992), Küster (1991) and many more. In the following, I will discuss 1) the phytosociological approach, 2) the auto-ecological approach, and 3) the eco-tope approach. It will become clear that I prefer to employ the latter approach for the analysis of our plant material. This is strongly related to my view on archaeobotany and the role of the discipline in the present study. Botanical material remains are seen as material culture. And archaeobotany is regarded as a means to present answers primarily to archaeological questions, and only secondarily to biological ones.

The phytosociological approach

At the core of this first approach lies the detection of plant associations which are defined by their floristic composition. The phytosociological approach finds its roots in the work of Braun-Blanquet, and is also called the Zürich-Montpellier School (see Küster 1991; M. Jones 1988, for a brief historical background to this Braun-Blanquet tradition). The phytosociological approach emphasises the study of plant communities and is based on the collective appearance of species in the field. The device for this approach is: "a single plant species can grow in very many different habitats, but a total plant community is much more typical of one specific habitat" (see for example Ellenberg 1978).

The definition and identification of plant communities and their **character species** (or so-called diagnostic species) is based on recording the presence and abundance of plant species in a series of stands (chosen areas). The Braun-Blanquet method was to make detailed descriptions of a number of pieces of vegetation that seemed to conform to a general pattern, and then to compare the descriptions in search of common denominators. The importance of species is measured by its abundance, in the sense of the number of plants that are present per unit area, but also by the plant's size, i.e. the cover-abundance index (Colinvaux 1973, 63). The species are categorised into a classification of plant communities in a hierarchical system, formed by formations, classes, orders, alliances and associations. The analytical units of the formations refer to certain types of vegetation like water plants, forests or grassland.

It seems that applying the phytosociological analysis to macrofossil assemblages or to translate phytosociological into archaeobotanical results is highly problematic (Küster 1991, 19; M.Jones 1988, 44). As more often in archaeology, our seed assemblages will only be a sample of their original stand(s), and in most cases it is not possible to identify or reconstruct plant communities from only one or a few species. The application of characteristic or diagnostic plant species for certain vegetation communities in archaeological seed assemblages therefore appears to be problematic or even irrelevant. This is demonstrated in the archaeobotanical study of Jacomet and Karg of the site of Zug Sumpf, for example (Jacomet/Karg 1996). Here, the attempt of *a priori* defining and applying character species to interpret the Late Bronze Age cereal assemblages (like *Conringia orientalis*, *Anthoxanthum puelii, Raphanus raphanistrum* and many more) caused reasonable analytical problems, as the character species were all absent, rather than present (Jacomet/Karg 1996, 283-89; pers comm Jacomet).

Besides, the phytosociological approach leaves no room for the view that charred seed assemblages are made up primarily of species from one single origin, i.e. arable fields, and that the presence of typical grassland, forest or wetland species points to the fact that past arable weed communities were different from those of today (van der Veen 1992, 104). Or, to put it more optimistically, our

medium	(terrestrial; aquatic)
vegetation structure and succession stage	(grassland, woodland and shrub, pioneer vegetation, tall herb vegetation, semi-aquatic helophytic vegetation, etc.)
salinity	(saline; brackish; fresh)
substrate	(stony; other)
moisture regime	(aquatic; wet; moist; dry)
nutrient availability	(low; moderate; high)
acidity	(acid; moderately acid to neutral; basic; calcareous)
dynamics	(under influence of sand drift, trampling; superficially disturbed)
polysaproby	(within aquatic groups)

Table 9.2 Characteristics and classes to define ecological groups (from Runhaar et al. 1987)

botanical data may be perfectly suited to a critical assessment of the presence — possibly in coherence — of taxa on the arable field in relation to human intervention (M.Jones 1988, 44).

The study of individual plant species
In this traditional arrangement of plant species in ecological groups, as for example in the Dutch "S*tandaardlijst*" (Van der Meijden et al. 1983), individual species are ascribed to one out of 37 types of vegetation. Each species is attributed to a certain single ecological group on the basis of the type of environment in which this particular species is most apparent. The main goal of this traditional approach is to **characterise individual plant species** according to the environment in which they occur most frequently.
In the present study, we assume that all weeds species derive from one single type of environment: the arable fields. This implies that insight as to where individual species most frequently occur in general (e.g. wetlands or grasslands) is not of much relevance. It is more important to discern what type of arable environment — which were obviously different from modern arables — they originate from.

The ecotope system
In the distribution of weed species according to eco-topes, the predominating wish is to **characterise the type of environment (habitat type)** with the help of the plant species that occur (Runhaar et al. 1987). Within this system, the types of environment (and a range of environmental factors) in which the plant species occur are described in the form of ecotope types. Ecotope is defined as: "A spatial unity that is homogeneous with regard to vegetation structure, stage of succession and a-biotical factors that are stipulative to the vegetation" (Runhaar et al 1987). The composition of the vegetation on a specific spot is one of the leading factors from which the prevailing environmental conditions (ecotope type) can be read from.
Plant species can be assigned to more than one group depending on the ecological amplitude of the species. The groups are of a purely ecological nature, that is, based on the relation with (a-)biotic factors. The stand of a plant species is a central concept. The composition of species within the eco-tope system is seen as a function of amongst others the moisture regime, salinity, acidity, dynamics of the substrate (disturbance), nutrient availability and other, i.e. anthropogenic, factors that determine the composition of the vegetation.
It is exactly these environmental and anthropogenic factors that archaeobotany is interested in. We do not primarily wish to reconstruct past weed communities but rather, with the help of the indicator values, reconstruct the anthropogenic environment they grew in, i.e. reconstruct the nature of the arable fields and the agrarian regimes. The advantage of this approach is that we can use all weed species present in our seed assemblages to characterise the arable fields, instead of using exclusively characteristic or diagnostic species.

9.4 The use of the ecotope system in the present study

Runhaar's scheme of ecotopes is built up in a hierarchical form. The characteristics and classes to define ecological groups are summed up in table 9.2. Some characteristics from the original Runhaar scheme are excluded for the purpose of this study. Those are the factors that do not relate to the material under study, or that are of no relevance to the analysis of agrarian modes of production. This choice is accounted for in the following.
Between the characteristics within the ecotope system a certain hierarchy exists (Runhaar et al 1987, 281). This hierarchy in characteristics is expressed in the classification of ecological groups, in which the main division concerning the characteristic medium is formed between terrestrial and aquatic systems. In the present study material, (virtually) no aquatic plants occur. This first division therefore does not

have any applicability to this study. The characteristic salinity is disposed of in the analysis, as there are no indications for the presence of plant species from saline or brackish environments. Also, the substrate is left out of the analysis, as the two characteristics (stony and other) are not applicable to our material.

The characteristic **moisture regime**, in which four classes of characteristics are distinguished — aquatic, wet, moist and dry — is relevant to our analysis. The values within this characteristic offer information on the nature of the arable fields with regard to its moisture regime and could also be indicative of possible forms of "water management" as specific agrarian mode of production. In our data base the characteristic "aquatic" is virtually absent.

The characteristic **nutrient availability** is of particular interest to the analysis of the arable weeds that derive from the seed assemblages under study. The classification of nutrient availability implies to what extent macro nutrients (N, P and K) are available in the arable soils. Runhaar et al. distinguish three classes: low, moderate and high nutrient availability (Runhaar et al 1987, 284/301). This classification system enables us to determine the nutrient availability of the arable fields through the weeds that derive from those fields. As mentioned earlier, we are not so much concerned with the natural fertility of the (agrarian) soils, but the possible contrast between the expected weed flora from natural infertile soils and the weed assemblage actually found could be of interest to our study. This provides us with information on the way farmers intervened in the natural nutrient availability of their land with artificial fertilizers, to create, increase or guarantee the fertility of the soil.

The characteristic of acidity is directly related to the characteristic of nutrient availability in the ecotope system. A separate group of species of calcareous soils is distinguished (with an additional sub-characteristic) for pioneer and grassland vegetations on moist, moderately fertile soils.

Within pioneer vegetations, the additional characteristic of dynamics is indicated, where the influence of trampling is of especial interest to us, as this could well be indicative of the grazing of cattle, possibly on fallow fields. These "trampling" values are indicative of repeating processes (rather than singular events or changes).

In brief, the following characteristics were used:

- Vegetation structure and stage of succession. Symbols: grassland (G), woodland and shrub (H), pioneer vegetation (P), tall herb vegetation (R), semi-aquatic helophytic vegetation (V).
- Moisture regime. Values: aquatic (1), wet (2), moist (4), dry (6)
- Nutrient availability and acidity (additional within grasslands and pioneer vegetations: calcareous). Values: low nutrient availability, acid (1), low nutrient availability, moderately acid to neutral (2), low nutrient availability, basic (3), low nutrient availability (4), moderate nutrient availability (7), high nutrient availability (8), moderate to high nutrient availability (9), calcareous (kr)
- Additional within pioneer vegetations: dynamics, especially under influence of trampling (tr).

Finally, our file of archaeologically retrieved weed species is categorised according to the ecological groups of Runhaar et al, to determine their (a-)biotic characteristics, provided that they were identified to species level. In table 9.3, an alphabetical list of the various weed species and their ecotope characteristics is given, with a reference to the ecological groups they belong to. The ecological groups are indicated with the Runhaar codes. For example *Galium palustre* is classified in the ecotope groups G22 (grassland species on wet, moderately acid to neutral soils of low nutrient availability), G27 and R27 (grassland and ruderal species on wet soils of moderate nutrient availability), and G28 and R 28 (grassland and ruderal species on wet soils of high nutrient availability).

Specific characteristics and ecological groups within this system should receive our special attention. I especially refer to the groups P68, G68, and R68 (which include species like *Capsella bursa-pastoris*, *Lolium perenne*, and *Urtica dioica*). Weed vegetations on dry and at the same time very nutritive soils are concerned here. By nature, dry soils in our climate are never very nutritive, as the result of a rapid washing out of nutrients. These groups therefore imply artificially created environments on strongly manured soils (Runhaar et al. 1987, 295). Where composition of species is concerned the 68-groups resemble the groups P48, G48 and R48, i.e. the groups of humid, highly fertile soils (which include species like *Atriplex* spp., *Malva sylvestris* or *Galium aparine*). Identifying these groups within our arable weed inventory is interesting when attempting to define the extent of fertility of the arable fields, and the human interference with this fertility, in the form of adding extra manure (dung or other sources of nutrients). Special attention should also be paid to the additional characteristic kr (calcareous, e.g. *Buglossoides arvensis* or *Agrostemma githago*) and the group 48tr (trampling, e.g. *Plantago major*, *Polygonum aviculare*) when identifying the arable fields in use.

9.5 More ecological and anthropogenic information on arable weed species

Apart from the above described characteristics and groups of ecotopes there is more information enclosed in the individual arable weed species, regarding the agricultural methods and productive strategies. Much literature is available with regard to the study of arable weeds from prehistoric seed assemblages. For the purpose of this study I made an attempt to synthesize elements of this useful information.

ecological groups	**61**	**42**	**22**	**62**	**23**	**43**	**63**	**17**	**27**	**47kr**	**47**	**67**	**28**	**48**	**48tr**	**68**	**height**	**ann/perenn**
																	(cm)	
arable weeds																		
Adonis spec.																	15-50	Ta; Hemi
Agrostemma githago										P							20-100	Th
Agrostis spec.																		-
Anagallis arvensis											P	P		P		P	5-50'	Ta
Arenaria serpyllifolia							P/G			P		P					2-25'	Th
Atriplex patula														P			30-90?	Ta
Atriplex patula/prostrata	bP40													P			30-90?	Ta
Atriplex spec.																		Ta
Avena spec.																		Ta?
Brassica cf. campestris																	30-80	Hemi
Brassica spec.																		-
Brassica spec/Sinapis arvensis																		-
Bromus secalinus-type												P					40-100	Th
Bromus spec.																		-
Bromus sterilis/tectorum							P				P/R	P/R						Th
Buglossoides arvensis										P							10-70'	T
Capsella bursa-pastoris															P	P	5-60'	Te
Carex demissa																		Hemi
Carex spec.																		-
Centaurea spec.																		-
Cerastium spec.																	5-30'	-
cf. Juncus spec																		-
Chenopodiaceae																		-
Chenopodium album														P		P	15-120	Ta
Chenopodium cf polyspermum	bP40												P	P			10-80'	Ta
Chenopodium ficifolium														P		P	30-90'	T
Chenopodium hybridum														P			30-90'	Ta
Chenopodium polyspermum	bP40												P	P			10-80'	Ta
Chenopodium spec.																		T
Compositae																		-
Convolvulus arvensis											G			P			20-100	Hemi
Daucus carota						G	G			G		G					30-90	Hs, Hemi
Digitaria ischaemum														P		P		
Digitaria spec.																		Ta
Echinochloa crus-galli														P		P	10-120	Ta
Eleocharis palustris	bG20, V12, V18							V	G				G				10-60'	Helo (Geof)
Euphrasia/Odontites spec.																		-
Fallopia convolvulus	H69						H				P	P		P			-100	Ta
Festuca ovina s. lat.	G	G	G42	G/H								G					10-65'	Hemi
Festuca rubra	z20, b40, b60st			G		G	P/G				G	G					15-90'	Hc; Hemi
Festuca/Lolium spec.																		-
Fumaria officinalis											P	P		P		P	10-50'	Te
Fumaria spec.																		-
Galeopsis segetum												P					7-30'	Ta
Galeopsis spec.																		-
Galium aparine	H69													H/R			60-120	Th
Galium cf. palustre	G22		G						G/R				G/R					Helo
Galium cf. spurium														H/R				Th
Galium cf. verum				P/G			P/G										15-120	Hemi
Galium mollugo						G	G/H				G	G					30-120	Hemi (Cham)
Galium mollugo/verum				P/G		G	G/H				G	G						Hemi (Cham)
Galium palustre			G						G/R				G/R					Helo
Galium palustre spp. palustre			G						G/R				G/R					Helo
Galium spec.																		-
Galium spurium														H/R				Th
Galium spurium/aparine	H69													H/R				Th
Galium verum				P/G			P/G										15-120	Hemi
Glyceria/Molinia spec.																		-
Gramineae																		-
Hieracium spec.																		-
Iris pseudacorus	V17, V18							V	H/R				H/R				40-120	Geof; Helo
Juncus spec.																		-
Lamium purpureum														P			10-30'	Te
Lapsana communis														P/H			30-120'	Ta
Leucanthemum vulgare											G	G					30-60'	Hs
Linum catharticum		P/G				G											5-20'	Ther/Hemi
Lolium perenne	bG40													G		G	10-90'	Hemi (Hs)
Lotus/Trifolium spec.																		-
Malva sylvestris														G/R			30-120	Hs; Hemi
Matricaria maritima	bP40													P			10-50'	Ta (Cham)
Medicago lupulina											G	G					7-50'	Ta
Mentha arvensis									G		P/G							Helo,Hemi
Mentha aquatica/arvensis	bG20				G			V	G/H/R		P/G							Hemi?
Myosotis spec.																		-
Odontites spec.																		-
Orlaya grandiflora/Pastinaca sativa																	(60-90)	-
Papaver setigerum																		

Table 9.3 Arable weeds from the material under study and their values in ecological groups (from Runhaar et al. 1987)

ecological groups	**61**	**42**	**22**	**62**	**23**	**43**	**63**	**17**	**27**	**47kr**	**47**	**67**	**28**	**48**	**48tr**	**68**	**height**	**ann/perenn**
																	(cm)	
Papaver spec.																		-
Papilionaceae																		-
Persicaria hydropiper													P/H				20-80'	Ta
Persicaria lapathifolia														P			10-120'	Ta
Persicaria lapathifolia/maculosa														P			T	a
Persicaria maculosa														P			20-100	Ta
Persicaria spec.																		-
Phleum spec.																		-
Plantago lanceolata											P/G	P/G					5-45'	Hr (Rozet)
Plantago major															P		10-50'	Hr
Poa annua															P	P	5-40'	Te
Poa annua/Phleum spec.															P	P		-
Poa spec.																		-
Poa trivialis/pratensis				G			G		H		G/H	G	G/H	G/H		G		Hs/Grh
Poa-type																		-
Polygonum aviculare															P		2-40'	Ta
Polygonum spec.																		-
Potentilla erecta		G	G														7-45'	Hemi
Potentilla spec.																		-
Prunella vulgaris											G							Hemi
Ranunculus flammula																		Helo,Hemi
Raphanus raphanistrum											P	P					20-60'	Ta
Rhinanthus spec.																		-
Rumex acetosella	P			P								P					10-60'	Hemi (Gr/Hs)
Rumex cf. sanguineus											H						60-120	Hemi
Rumex crispus-type	bP40													P/G			100-150	Hemi
Rumex spec.																		-
Sambucus ebulus										G							60-150'	Hemi
Sambucus spec.																		-
Scirpus setaceus			P														2-20'	Ther; Hemi
Scleranthus annuus												P					5-20'	Th
Setaria spec.																		-
Setaria/Echinochloa spec.																		-
Silene spec.																		-
Sisymbrium officinale														P		P	30-80'	Ta
Solanum dulcamara								V	R/H								30-200	Phan, Cham
Solanum nigrum														P		P	5-70?	Ta
Solanum nigrum/dulcamara																		-
Solanum spec.																		-
Sonchus asper														P			30-60'	Ther (Gr)
Spergula arvensis												P					15-40'	Te
Stachys arvensis											P			P			7-30'	Ta
Stellaria graminea											G	G					10-90'	Hemi (Cham)
Stellaria media														P		P		Te
Stellaria spec.																		-
Teucrium scorodonia				G/H													30-60'	Hemi
Thlaspi arvense														P			15-50'	Te
Tilia cordata						H					H							Phan
Trifolium pratense											G			G				Hemi (mc)
Trifolium dubium-type											G	G					5-30'	Ta
Trifolium repens-type	bG20, bG40								G		G		G	G			5-25'	Chv; Hemi
Trifolium-type																		-
Umbelliferae																		-
Urtica dioica	H69												H	R/H		R	30-300	Hs
Urtica urens														P		P	15-60'	Ta
Valerianella dentata										P							20-30'	Ta
Verbena officinalis										G							30-75'	Hs
Veronica arvensis-type						G	G				P/G	P/G					2-30'	Th
Veronica chamaedrys											G/H						10-40'	Chr
Veronica hederifolia	H69											P					5-30'	Th
Veronica serpyllifolia											G						5-25'	Chr
Vicia cf. hirsuta												P					15-60'	Th
Vicia cracca											G/R						30-200	Hemi
Vicia hirsuta												P					15-60'	Th
Vicia hirsuta/tetrasperma											P	P					15-65'	Th
Vicia lathyroides							G										5-25'	Ther
Vicia sativa						G	G				G	G					10-100	Ther
Vicia sativa angustifolia						G	G				G	G						Th
Vicia sativa nigra						G	G				G	G						Ther
Vicia spec.																		-
Vicia tetrasperma											P						15-70'	Th
Vicia/Lathyrus																		-
Viola arvensis											P	P						Te
G=grassland														Ta, Th, Te = annuals				
P=pioneer														Hemi, Chr, Helo, Geof, Cham, Phan etc.= perennials				
R=ruderal																		

Table 9.3 continued

arable weeds		additional information
Adonis spec.	Ta; Hemi/Ther	especially on calcareous soils
Agrostemma githago	Th	loess, sandy clay; winter arables with T.spelta
Anagallis arvensis	Ta	liggende stengel, niet wortelend; cereals and hakvruchten
Arenaria serpyllifolia	Th	eutrophic, sunny (open) and dry, no infertile sandy soils, loess
Atriplex patula	Ta	group A van der Veen; aan de voet zijtakken
Atriplex patula/prostrata	Ta	group A van der Veen
Atriplex spec.	Ta	group A van der Veen
Avena spec.		A. fatua winter arables with T. spelta
Brassica cf. campestris	Hemi	B. rapa=Hemi
Bromus secalinus-type	Th	group B with van der Veen; winter arables with T. spelta, acid soils
Bromus sterilis/tectorum	Th	worked soils
Buglossoides arvensis	Ther	calcareous worked soils; short fallow, fast rotation cultivation
Capsella bursa-pastoris	Te	very nutrient soils; trampling; hard to extinguish
Centaurea spec.		calcareous soils?
Chenopodium album	Ta	group A with van der Veen; nitrogen-loving species, worked soils; short fallow (<2 y.)
Chenopodium cf polyspermum	Ta	nutrient sandy soils
Chenopodium ficifolium	Ther	nitrogen-loving species; only on worked, light soils; calcareous soils
Chenopodium hybridum	Ta	clay,calcareous sand
Chenopodium polyspermum	Ta	nutrient, sandy soils
Chenopodium spec.	Ther	
Convolvulus arvensis	Hemi	nutrient soils; winding stem
Daucus carota	Hs; Hemi	dry grasslands; resistant to ploughing and grazing (taaie penwortel)
Echinochloa crus-galli	Ta	nitrogen-loving species; very nutrient worked warm sandy soils
Eleocharis palustris	Helo (Geof)	manure, open standplaats; kruipende wortelstok
Fallopia convolvulus	Ta	nutrient, worked soils; winding stem, tall plant
Festuca ovina s. lat.	Hemi	sandy soils
Festuca rubra	Hc; Hemi	sods and ””pollen””
Fumaria officinalis	Te	nutrient, worked soils
Galeopsis segetum	Ta	winter cereal arables; moderately nutrient soils
Galeopsis spec.		nitrogen indicator?
Galium aparine	Th	group B with van der Veen; manured worked soils; shadow
Galium cf. palustre	Helo	wet
Galium cf. spurium		G. aparine
Galium cf. verum	Hemi	low nitrogen, sandy soils
Galium mollugo	Hemi (Cham)	
Galium mollugo/verum	Hemi	
Galium palustre	Helo	wet
Galium palustre spp. palustre	Helo	wet
Galium spurium		G. aparine
Galium spurium/aparine		G. aparine
Galium verum	Hemi	low nitrogen, sandy soils
Gramineae		group A with van der Veen
Iris pseudacorus	Geof; Helo	marshy
Lamium purpureum	Te	very nutrient soils; manure, intensive soil working
Lapsana communis	Ta	very nutrient worked soils; remains small plant on arables
Leucanthemum vulgare	Hs	nutrient grazy soils; lange taaie wortels; moderate nutreints; no cattle
Linum catharticum	Ther/Hemi	2-years; moisture; calcareous
Lolium perenne	Hs	manured, strong trampling
Malva sylvestris	Hs; Hemi	fallow-indicator; nutrients and moist
Matricaria maritima	Ta (Cham)	nitrogen indicator: highly eutrophic, heavy manuring
Medicago lupulina	Ta	sometimes overblijvend: matten
Mentha aquatica/arvensis	Hemi?	M. arvensis: uitlopers; resistant to soil working
Orlaya grandiflora/Pastinaca sativa		Pastinaca: Hemi (mc) nutrient soils

Table 9.3 continued

Persicaria hydropiper	Ta	nitrogen-indicator; verslemping; wet, nutrient soils
Persicaria lapathifolia	Ta	group A with van der Veen; absent on poor sandy soils; nutrient, worked soils
Persicaria lapathifolia/maculosa	Ta	
Persicaria maculosa	Ta	group A with van der Veen; moist, nutrient worked nitrogen-soils
Plantago lanceolata	Hr (Rozet)	trampled, nutrient soils; resistant to the ard; also on fallow land
Plantago major	Hr	trampled, very nutrient soils; dichtgetrapte grond
Poa annua	Te	group A with van der Veen; strongly trampled, very nutrient soils
Poa annua/Phleum spec.	(Te)	group A with van der Veen; Poa is resistant to uprooting
Poa spec.		group A with van der Veen; extensive agriculture acc. to Jacomet
Poa trivialis/pratensis	Hs/Grh	group A with van der Veen
Poa-type		group A with van der Veen
Polygonum aviculare	Ta	trampled, nutrient soils; stengels form matten
Prunella vulgaris	Hemi	group B with van der Veen; moderate nutrients; wortelt and vertakt; superficial, extensive cultivation
Raphanus raphanistrum	Ta	sandy, worked soils
Rumex acetosella	Gr/Hs	dry, acid but nitrogen houdende sandy soils; taaie wortelstokken, ploughing = uitbreiding
Rumex cf. sanguineus	Hemi	moist, moderate nutrients
Rumex crispus-type	Hemi	moist, nutrient soils
Sambucus ebulus	Hemi	calcareous, worked small arable fields
Sambucus spec.		small arable fields
Scirpus setaceus	Ther; Hemi	loamy, sandy soils
Scleranthus annuus	Th	winter arables with T. dicoccum; poor to moderately nutrient soils
Setaria spec.		acid sandy soils?
Silene spec.		S.gallica: winter arables with T. spelta
Sisymbrium officinale	Ta	extremely ruderal, nitrogen indicator; nutrient soils
Solanum dulcamara	Phan, Cham	winding woody stem; nitrogen
Solanum nigrum	Ta	high nutrient soils; short fallow (< 2 years), intensive soil working
Sonchus asper	Ther (Gr)	very nutrient worked soils
Spergula arvensis	Te	moderately nutrient, dry sandy soils; poor soils
Stachys arvensis	Ta	high nutrient availibility
Stellaria graminea	Hemi (Cham)	on sandy soils only with high humus, nitrogen and moist
Teucrium scorodonia	Hemi	low nutrient availibility
Thlaspi arvense	Te	worked soils
Tilia cordata	Phan	
Trifolium dubium-type	Ta	moderate manuring
Trifolium repens-type	Chv; Hemi	moist, intensive beweiding; manuring and trampling; kruipende stengel, wortelend op knopen
Urtica dioica	Hs	nitrogen indicator; wortelstok
Urtica urens	Ta	manured soils
Valerianella dentata	Ta	calcareous, moist soils; field rich in lime
Verbena officinalis	Hs	taaie stengel; calcareous, nitrogen soils
Veronica arvensis-type	Th	loess? worked soils
Veronica chamaedrys	Chr	loess? moist, nutrient soils
Veronica hederifolia	Th	loess? dry, nutrient soils
Veronica serpyllifolia	Chr	loess? moist, nutrient soils
Vicia cf. hirsuta	Th	dry, moderately nutrient soils
Vicia cracca	Hsc	moist, nutrient soils; underground uitlopers, no flowering after mowing
Vicia hirsuta	Th	winter arables; dry, moderately nutrient acid soils
Vicia hirsuta/tetrasperma	Th	moderately nutrient soils
Vicia lathyroides	Ther	dry, calcareous grazy sandy soils
Vicia sativa	Ther	stevige stengel, wortelstelsel
Vicia tetrasperma	Th	winter arables, acid soils, more moist than V. hirsuta

Harvest height

Archaeobotanists make use relatively often of the minimum- and maximum height of the flowering weed plants in the fields, to reconstruct the method of harvesting. The harvesting height of cereals, in particular, can be established in this way. The various ways of harvesting cereals are cutting or plucking just beneath the ear, half way up the stalk, just above the ground, or by uprooting. When weed seeds of tall plants only are found in the seed assemblages, it is assumed that the cereals were harvested by cutting or plucking the ears, or by cutting the stalks half way. When seeds of small arable weed plants are also found in the assemblages, the cereals were presumbaly harvested by cutting them close to the ground.

A few short comments should be made with regard to this evidence. Cultivation experiments showed that the growing height of weeds depends on numerous external factors, like the density of the crop plants in the field (Lange/Illig 1988, 60). Using the data on growing height for (modern) weed plants as presented in the various Floras could therefore be misleading. Moreover, it was noted in cultivation experiments that reaping the cereal crop just beneath the ear with a sickle could hardly be performed as the cereals are often too uneven in height to allow such a practise. Hand-plucking appeared to be much more effective. This harvesting method would however result in (virtually) weed free grains (Engelmark 1989, 182). Finally, it should be noted that the presence of seeds of small arable weeds (like *Rumex acetosella*, *Anagallis arvensis*, *Arenaria serpyllifolia*) could also point to a two-fold harvest. This implies that the cereal ears were harvested in a first stage by hand-picking for example, and the remaining straw was harvested separately afterwards. The cereal straw could have been used for fodder or for thatching. However, no remains of straw were discovered in the botanical samples in the sites under study.

In our material, small species (e.g. *Spergula arvensis, Thlaspi arvense, Plantago lanceolata*) as well as tall species (e.g. *Solanum dulcamara, Rumex crispus, Bromus secalinus*) and climbing species (e.g. *Fallopia convolvulus*) frequently occur. The side-notes described above demonstrate that establishing harvesting methods with the aid of the height of the weed plants present in the botanical material remains a complex affair.

Extensive and intensive agriculture, fallow periods and frequency of cropping

An increase of the frequency of cropping was mentioned as one of the aspects of the intensification of agriculture (chapter 3). Arable weeds retrieved from botanical assemblages can be ideal indicators for the frequency with which arable fields were cultivated. Various weeds are suitable to demonstrate a (semi) permanent cultivation on the field they derive from. Their presence or absence could help us to determine the length of a possible period of fallow (i.e. the frequency of cropping).

It is a general observation that intensified cultivation regimes result in the increase of annuals. Also, the use of manure results in the increase of annual weeds and deficient manuring consequently causes a reduction of annuals. Short-lived weed species furthermore demonstrate short fallow periods. An (abundant) presence of (summer and winter) annuals, expressed in number of species or frequency could point to a short fallow cultivation system or the absence of fallow periods (Jacomet pers comm; see also Jacomet/Karg 1996). The (abundant) presence of perennials could point to extensive cultivation systems, for example irregular crop rotations, and extensive soil working (e.g. with a spade?). An early 20th century (labour extensive) rotative cultivation regime in the Leningrad district described by Wasylikowa (1981) produced such assemblages, consisting of large numbers of perennial plants in the field and in the seed grain from the same field.

Annual species like *Chenopodium album* and *Solanum nigrum* in particular do not grow on land that has been under successive fallow for more than two years. *Buglossoides arvensis,* too, flourishes under a short rotation of cultivation and a short fallow period. On the other hand, some species can be indicative of a longer fallow, like *Malva sylvestris.* The presence of perennial grasses could point to a stage of grazing, in between two cultivation periods (Jacomet/Karg 1996, 250). As mentioned earlier, the presence of species from the category of "trampling indicators" can also be associated with cattle grazing on the fallow fields (e.g. *Plantago major* and *Plantago lanceolata*).

A further distinction between summer annuals (Ta=Therophyta aestivalia) and winter annuals (Th=Therophyta hivernalia) could also be of significance. Summer annuals are the weed species which germinate in spring and are traditionally associated with summer crops, like millet; winter annuals germinate in autumn and occur in winter cereal crops. Indeed, the presence of winter annuals especially can be highly significant in theory. In a summer crop field, winter-crop weeds present will be ploughed under in spring, just before the summer crop is sown. Therefore, they will not have sufficient time to recover and produce seed before the harvest of the summer crop. Whereas the presence (and therefore also the absence) of winter crop weeds can thus be highly informative and characteristic of winter cereal cultivation, the presence of summer crop weeds is not very characteristic. Investigations demonstrated that the (abundant) presence of summer annuals in archaeological seed assemblages is not associated with particular (winter or summer) crops but may reflect some rather more general aspects of cultivation. Knörzer (among others) observed an association between these species and the cultivation of pulses, which he interpreted as reflecting their cultivation as gardening crops (Knörzer 1970). The widespread abundance of summer annuals may therefore reveal a radically different cultivation regime based on intensive digging and hoeing of small garden plots rather than extensive (winter) agriculture (see also G.Jones 1992, 141-42). This contrast between nitrophile summer annuals and winter annuals, reflecting nutrient depletion and probable repeated extensive shallow cultivation, is also suggested by M. Jones (1988, 49; 1984).

Species of winding stalks could be interpreted as evidence of the fact that weeding and working of the crop fields was not too intensive. *Fallopia convolvulus* for example, is a common involuntarily-harvested weed of all crops and the large size of its seeds makes it much less obviously separable from a cereal crop (see e.g. Hubbard/Clapham 1992, 119). The information regarding the reproduction of arable weeds is of further relevance (figure 9.1). Some perennial weeds reproduce and spread from vegetative parts such as roots as well as buds, bud-rooting offshoots or growing in closed tussocks with offshoots (e.g. *Prunella vulgaris, Trifolium repens* and *Urtica dioica*). These particular species must have been difficult to destroy with, for example, the prehistoric ard. Some authors relate their presence, therefore, to a superficial soil management and an extensive soil regime (Jacomet pers comm; Jacomet/Karg 1996; Karg 1995). On the other hand, the obstinate resistance to the plough of these species could, in my opinion, also point to the reverse: the use of the plough and the hardiness and resistance of some of these weed plants to the plough (see below).

Absolute number of weed seeds and weed species

Willerding (1988) noted the increase of the number of weed species related to innovations in the agricultural regime such as manuring and other soil improvement methods, and the use of sickles (during the Roman period thus 41 new species appeared in Germany). Knörzer (1987) also related the appearance of metal in the Bronze Age and the associated development of metal cutting implements with a considerable increase of the number of weed species in this era. According to Knörzer, the cereal ears were cut close to the ground with these implements. Thus small weeds could have appeared in the cereal harvest and had the chance to spread rapidly (Knörzer 1987, 275).

Ploughing

Stating the introduction and widespread use of the prehistoric plough (ard) remains problematic in archaeology (see chapter 2). The presence of seeds of certain weed species in the assemblages could help us in reconstructing the use of the ard in the cultivation regime. Indications for the use of the ard could be found in the presence of *Rumex acetosella* that is known to develop under the influence of ploughing. Also, *Daucus carota*, *Mentha* spec. and *Plantago lanceolata* are resistant to soil-working and the use of the ard. A species like *Capsella bursa-pastoris*, indicative of very nutrient soils, is an annual that is hard to extinguish. Even the use of the ard would probably not be sufficient to loose this arable weed from the fields. The presence of perennials as described above could point to the absence of ploughing or less intensive ploughing practices. Perennial species with their specific root types in particular could be indicators for periods of fallow or extensive working of the soils.

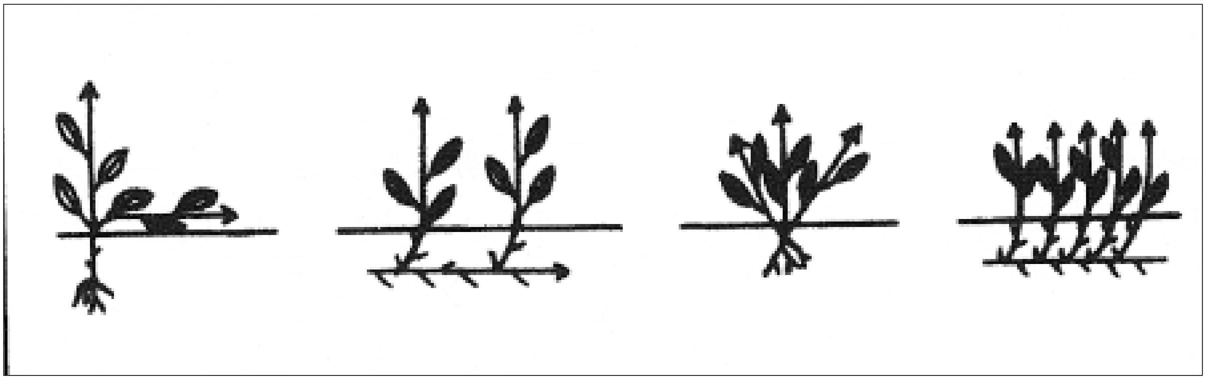


Fig. 9.1 Reproduction of weeds (from van der Meijden 1996)

Size of the fields

The plants that grow in hedgerows (like *Sambucus ebulus*) and which are found in or along arable fields belong to another relevant category. Charred seeds of these plants are sometimes found in botanical assemblages and may indeed be interpreted as the remains of "arable weeds". Some authors relate their (abundant) appearance to the presence of small fields, and they suggest that their disappearance from seed assemblages would point to the enlargement of the fields under cultivation (Jacomet pers comm). This is an interesting observation and further examinations should be carried out to see if this holds true.

We should also note that, according to some, plots of a Celtic field system are supposed to have been surrounded originally by some kind of windscreen, e.g. hedges (Groenman-van Waateringe 1979; but see Fokkens 1991, 161). The presence of species of hedges could demonstrate the presence of similar demarcations of the plots.

It should be noted however, that plants like *Sambucus ebulus* are nowadays found not only along the edges of arable fields, but also in the center of them, among the cereals (pers. comm. Kuijper). In that case, the increase or decrease of the number of *Sambucus* seeds in our botanical material does not necessarily point to any change of the dimensions of the arable fields.

Shadow loving species, like *Galium aparine* and *Lapsana communis* could theoretically also point to small fields (Bakels 1991, 280).

9.6 More on nutrient availability, soil fertility and the use of manure

Soil fertility is one of the principal aspects in this study of prehistoric agriculture. In chapter 3 soil fertility was described as a key concept in the Boserup model of agricultural intensification. According to this model, the agricultural intensification process caused by demographic pressure, comprises more frequent cropping of the same plots of arable land. This intensive cropping would result in the accelerated exhaustion of arable land, if not for the introduction of various types of soil improvement instruments or methods. In general, manuring can be seen as an indicator of agricultural intensification as it implies the possibility of relatively increasing the yield of a given amount of land (see chapter 3). In chapter 2, it was suggested that with the introduction of the longhouse (byre house) in the Middle Bronze Age, the possibility arose to begin using stable (cattle) dung as a soil fertilizer.

The possibility of indirect evidence of prehistoric manuring through the analysis of the arable weeds (using the ecotope system of Runhaar et al.) was described above. In this section, I will elaborate on the use of manure in general, (pre-)historical records of manuring, experiments with manuring and the archaeological evidence of soil manuring available in our regions.

Manure

All higher plants need (sun-)light, water and nutrients (the so-called growing factors) for their metabolism and building up of material. The main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is predominantly produced by the athmosphere (78% N). P- and K-suppliers are, for example, stones, which consist of minerals, present in the soil. In an agricultural system, nutrients are withdrawn from this cycle by the crop plants. Without any supplements, the system would become exhausted. Farmers are therefore forced to take supplying measurements to maintain the nutrient cycle. Through manuring, the shortage of nutrients is supplied. Through organic manuring (with cattle dung), the degraded organic mass is restored which serves as nutrients to soil organisms and encourages mineralisation. The moisture retention is also ameliorated through organic manuring.

Papilionaceae

Cereals store nitrogen and phosphorus in their grains during ripening, while potassium is stored in the stalk. Pulses (*Papilionaceae*), in contrast, can shorten the N-cycle through their characteristic as nitrogen fixer. Through symbiosis with nitrificating Rhizobium-bacteria in the root tubers, *Papilionaceae* have the ability to fix athmospheric nitrogen into the soil. The cultivation of pulses (or their inclusion in rotation systems) is a way of enlarging the nitrogen storage in the soil. Results from experimental rotation cropping showed that cereal yield is indeed higher where a cereal is grown after a legume crop than after a cereal (Palmer 1998). The most beneficial effects however, are experienced when 'green-manuring' is practised, that is, when the immature pulse crop is ploughed back into the soil. This method of "green-manuring" cannot be traced archaeobotanically, as the seeds of the pulses are lost in this way. When the plants are harvested at maturity (grain legumes) much of the nitrogen has been remobilised from the roots into the seeds and is removed with the harvest. A loss of nitrogen is certainly the case when the plants are harvested by uprooting.

Heavy manuring

Several examples of heavy manuring in (pre-)historic farming are known. Danish archaeologists presume that the arable fields in Celtic field systems were heavily manured. This could have lead to a rioting of the arable weed flora (pers comm Naesman). It is suggested that this may have been the reason that new fields had to be taken into use after a certain period of time. The exact length of this cultivation period as assumed by the Danish archaeologists is not known to the author.

Regular annual manuring is known to stimulate the growth of arable weeds. Dutch historical periods show that the fields were heavily manured only once at the beginning of a crop cycle. This would reduce the number of weed species and guarantee a gradual disposal of nutrients by a gradual humification and mineralisation (Bieleman 1992, 49).

The traditional method of crop production in most of North Sweden by contrast, was to use the field permanently and for as long as was possible. Through heavy manuring and intense soil preparation the field could indeed have been cropped for decades before the yield had dropped to an unacceptable level (Engelmark 1989, 181; Viklund 1998).

No manuring

Long-term agricultural experiments were conducted in Rothamsted (southern Britain) and Goettingen (Germany) to test cereal yields on manured and unmanured soils (Lüning 1980). Both experiments included soils of "superior quality", like loam and loamy löss. It was demonstrated that the cultivated plots without additional manure yielded considerable large harvests for decades. Even 70 years of monocultivation of wheats did not cause drastic declines in yields, but only a decrease to 60-80% of the level of departure (Lüning 1980, 121). Yield numbers from crop rotation regimes without additional manure exceeded the first yields even after 40 years. With regard to this experiment, it should be stressed that in both areas it is apparent that the general level of natural fertility is high. As is noted justly by Lüning, an assumed exhaustion of arable soils (in these particular regions of loamy and löss soils) cannot be regarded as the principal reason for the prehistoric custom of regularly deserting and shifting settlements (see also chapter 2).

On more "ordinary soils" natural regeneration of fertility is less likely to take place. In humid climates especially, there is, for example, a strong washing out of the soils and concurrence of weeds (Sigaut 1992, 398; Vink 1980). Under those circumstances human intervention (by manuring) can be required.

Archaeological and historical evidence of the use of manure in agriculture

According to Fenton (1981, 210), the introduction of manure (i.e. the realisation of the value of manure and the development of manuring techniques) is almost of the same order of importance to mankind as the discovery of fire. In North West European archaeology a wide, though fairly scattered, range of evidence exists for the addition of artificial fertilizers to arable soils and the practice of manuring from the Late Neolithic onwards (see for an overview Bakels 1997a; Fries 1995). Some examples of this evidence are presented here.

- The archaeological examples of the presence of domestic waste (pottery shards and fragments, charcoal etc.) in arable layers are widespread (see also Miller/Gleason 1994). In Bornwird (the Netherlands), domestic waste found in arable layers dating from the Late Neolithic was interpreted as manure (Fokkens 1982), as were pottery fragments and the domestic refuse in Middle Bronze Age/Late Bronze Age arables layers in West-Friesland (Buurman 1996).
- The use of (heather) sods, sometimes mixed with animal dung, as manuring practice has been attested with some regularity on prehistoric arable sites. Preparing a compost from sods and dung may solve certain deficiencies in a poor soil, especially nitrogen. This custom was demonstrated in Archsum (Sylt), among other places, from the Middle Bronze Age onwards (Harck 1987) and in Rantum, also on the isle of Sylt (Blume et al. 1987). Throughout historical periods, this custom is known to have been widespread, in the sandy regions of the Netherlands from the Middle Ages, for example (Bastiaens/Verbruggen 1996) and in the late 16th and 17th century (Bieleman 1996), up to the 20th century. As Bottema (1996/1997, 402) noted, heather sods do not offer compounds which are directly used as fertilizer but they can be used as the basic organical compound to raise the water-keeping capacity in poor sandy soil.
- Kelertas (pers. comm.) demonstrated that in Early Bronze Age Thy (Denmark) peat was added to the arable fields (see also Earle et al. 1998).
- Palynological investigations of ard marks on the Middle Bronze Age-B site of Eigenblok demonstrated the presence of plants from still, open water (Jongste/Koot in prep.). The use of mud as manure on these fields is suggested. In Middle and Late Bronze Age Haarlem, this agricultural practice was also demonstrated (Alkemade/Bakels/Vermeeren 1991). High percentages of algae and pond weeds point to the use of mud from the near-by swamp on the sandy fields. Bakels notes that manuring with mud was common practice in the Netherlands until quite recently (1997 citing from Bieleman 1992, 66).
- To my knowledge the oldest indications for the use of stable manure derive from the investigations by Troels-Smith of a Swiss Early Neolithic arable field (3785 cal. BC) in Thayngen-Weier (1984). Houses and places for stalling cattle were recovered in a Neolithic settlement. The remains of pupae of house flies (*Musca domestica*) were found in a space between two byres (interpreted as a pen). Interestingly, the arable field contemporary with the village of Weier and accessible via a plankroad, was also found. The outwash of the original top soil of the field contained charred seeds, charcoal and again, pupae of the house fly. As Troels-Smith noted, these fly eggs cannot have derived from cow pats of grazing cows in the fallow

fields because house flies do not lay their eggs in cowpats. This strongly suggsts that a well developed practice of using manure gathered from the stables was in use in agriculture and that cattle were probably stall-fed at this early a point in time (Troels-Smith 1984, 22-3) [10].

9.7 Moselle region

In this section the results on weed seeds from the seed assemblages of Lorraine and Luxemburg will be presented.

Introduction
According to the French archaeologists, the Bronze Age agricultural regime in this region was characterised by its ephemeral nature. In chapter 2, this system was referred to as *agriculture itinérante*. Over the course of the Late Bronze Age and the Early Iron Age, this system would develop into a cultivation regime that was somewhat more fixed to a certain territory, yet the fields would still be wandering through this territory, like an *agriculture rotative*. The reason for this rather loose system of land use is found (by the adherents of this model) in ecological circumstances (soil exhaustion), but also in socio-political or demographic developments (see chapter 2, Audouze/Buchsenschutz 1989; Blouet et al. 1992; Guilaine 1991). Others (Roymans 1996) assume that the "natural fertility" of the soils in this region caused cereal agriculture to be the dominant subsistence activity in these regions. The natural fertility of löss soils should not, however, be taken for granted, as there are indications that the original soils may have been less fertile than the ones at present (Langohr 1990). An analysis of the arable weeds from the botanical assemblages could possibly support or weaken views on land use in the Bronze Age and the (Early) Iron Age in this area.

General results
The assemblages from 23 sites from the Moselle region were investigated, of which one site did not produce any macro remains (see chapters 5 and 6). A total of 124 weed taxa (identifications up to species, genus and family level) was attested (see table 8.2). As was mentioned before the low absolute numbers of arable weeds in the samples from this region sometimes hampered a meaningful comprehensive interpretation. The majority of the samples from several sites yielded only single seeds from arable weeds (due, probably, to poor conditions for conservation or to sieving methods, see chapter 4) which was disadvantageous for an accurate numerical analysis.[11] Consequently, the decision was taken to demonstrate the general trends for this region first. In the last paragraphs, comments will be made on the few sites that yielded larger numbers of seeds.

Number of taxa
The first observation is the distribution of the number of different arable weed taxa over the successive time stages. High numbers could infer the existence of intensified, horticulture cultivation regimes, low numbers could point to extensive cultivation regimes (see above). The number of different weeds was presented in table 8.2 (see chapter 8). For the assessment of a possible increasing variety of weed species, all identifications were considered, including identifications up to family or genus level. The finds from samples that could not be attributed to a specific chronological group were not taken into consideration.
In group 1 (date before 1500 BC) 18 different weed taxa were present, in group 2 (1500-1100 BC) 52 taxa were found, the samples from group 3 (1100-750 BC) produced 60 different weed taxa, group 4 (750-450 BC) 73 different

ratio annuals/perennials in the Moselle region

	number of different annuals	S	W	number of different perennials
Stage 1	6	3	3	5
Stage 2	21	13	8	15
Stage 3	28	15	8	15
Stage 4	29	15	10	11
Stage 5	11	7	5	1

	frequency of annuals	frequency of perennials
Stage 1	20	8
Stage 2	33	16
Stage 3	81	19
Stage 4	110	26
Stage 5	14	1

Table 9.4 Moselle region - ratio annuals/perennials. S=summer annuals, w=winter annuals

ratio annuals/perennials in the MDS region

	number of different annuals	S	W	number of different perennials
Middle Bronze Age	20	11	5	5
Early Iron Age	22	12	5	10

	frequency of annuals	frequency of perennials
Middle Bronze Age	82	10
Early Iron Age	94	17

Table 9.5 MDS region - ratio annuals/perennials. S=summer annuals, w=winter annuals (see page 168)

taxa and in the samples belonging to group 5 (450-50 BC) 15 different taxa were found.

We must bear in mind that the numbers of samples available from the various periods vary considerably. Only four samples dating from the latest period have been investigated. In general, we may conclude that the increase of the number of weed taxa through time is considerable and may be related to a general intensification of agriculture and agricultural methods.

Fallow, frequency of cropping and land use in the Moselle complex

The criteria to identify the length of periods of fallow (or the frequency of cropping) were described above. When assessing short fallow or the absence of fallow cultivation, the number (or abundance) of annuals can be of great help. When we apply these to the material from the Moselle region the following results can be presented.

Annual species

The particular presence of annual species in assemblages can be related to the cultivation methods adopted and the frequency of cropping (see above). The presence of the different annual/perennial arable weeds distributed per chronological stage are presented in table 9.4 (see also figure 9.2). Where the number of different annual species present through time is concerned, the following picture emerges: the samples of the earlier period (period until c. 1500 BC) are composed of almost equal proportions of different annual species and perennial species. The relative share of perennial species is remarkably large. As was mentioned above, extensive cultivation favours the development of perennials. The overall image of the weed vegetation for the Moselle region up until the beginning of the 1st millennium, and at least until 1500 BC, deeply resembles the weed flora attested in Neolithic Switzerland (Baudais-Lundström 1984). It seems to point to the co-occurrence of an intensive small scale cultivation regime and a more extensive (perhaps more short-lived?) cultivation regime. The evidence for the later period (from 1500 BC but certainly from the beginning of the 1st millennium BC) suggests that an intensive cultivation regime becomes more dominant.

We should note that the **frequency** of both groups of weed species is more relevant to a possible change in agricultural regimes (frequency = occurrence in the samples under study). The absolute increase of the frequency of annual

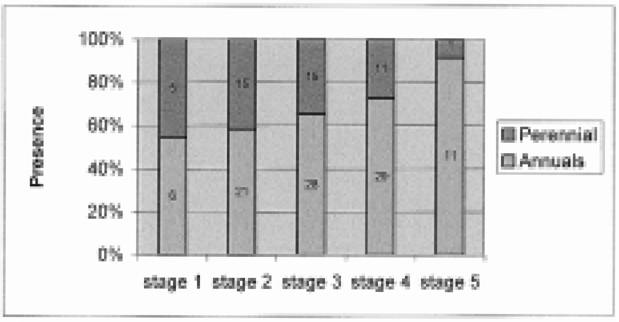


Fig. 9.2 Moselle region - ratio annuals/perennials (expressed in presence numbers)

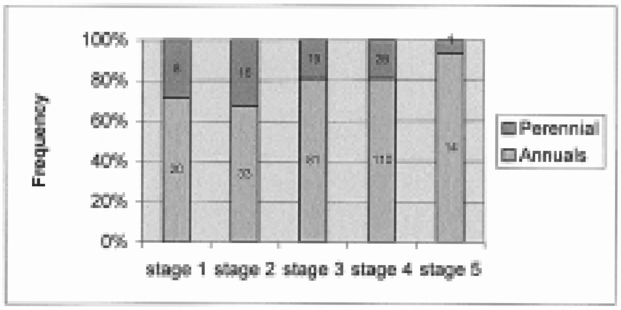


Fig. 9.3 Moselle region - ratio annuals/perennials (expressed in frequency numbers)

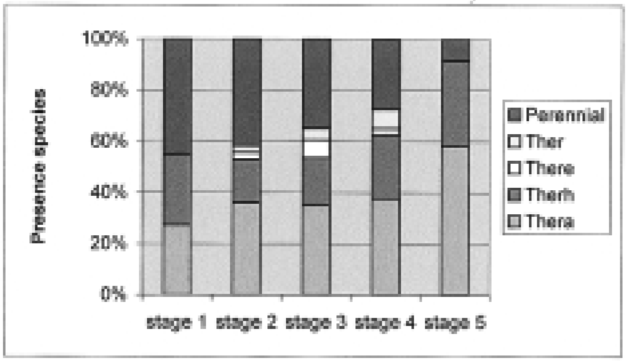


Fig. 9.4 Moselle region - ratio summer annuals/winter annuals/perennials (presence)

Moselle region-arable weeds	**stage 1**	**stage 2**	**stage 3**	**stage 4**	**stage 5**
Thera	13	21	55	61	9
Therh	7	10	20	39	5
There		1	3	1	
Ther		1	3	9	
Perennial	8	16	19	26	1
number of samples	n=61	n=10	n=62	n=102	n=4

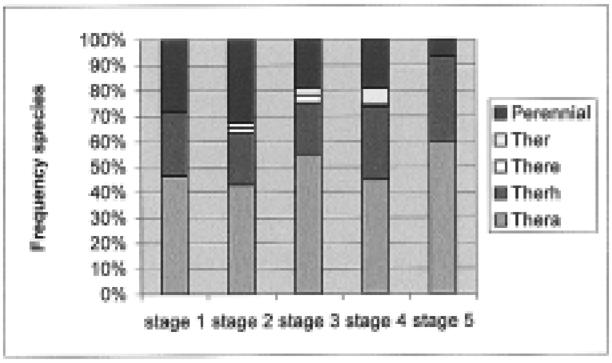


Fig. 9.5 Moselle region - ratio summer annuals/winter annuals/perennials (frequency)

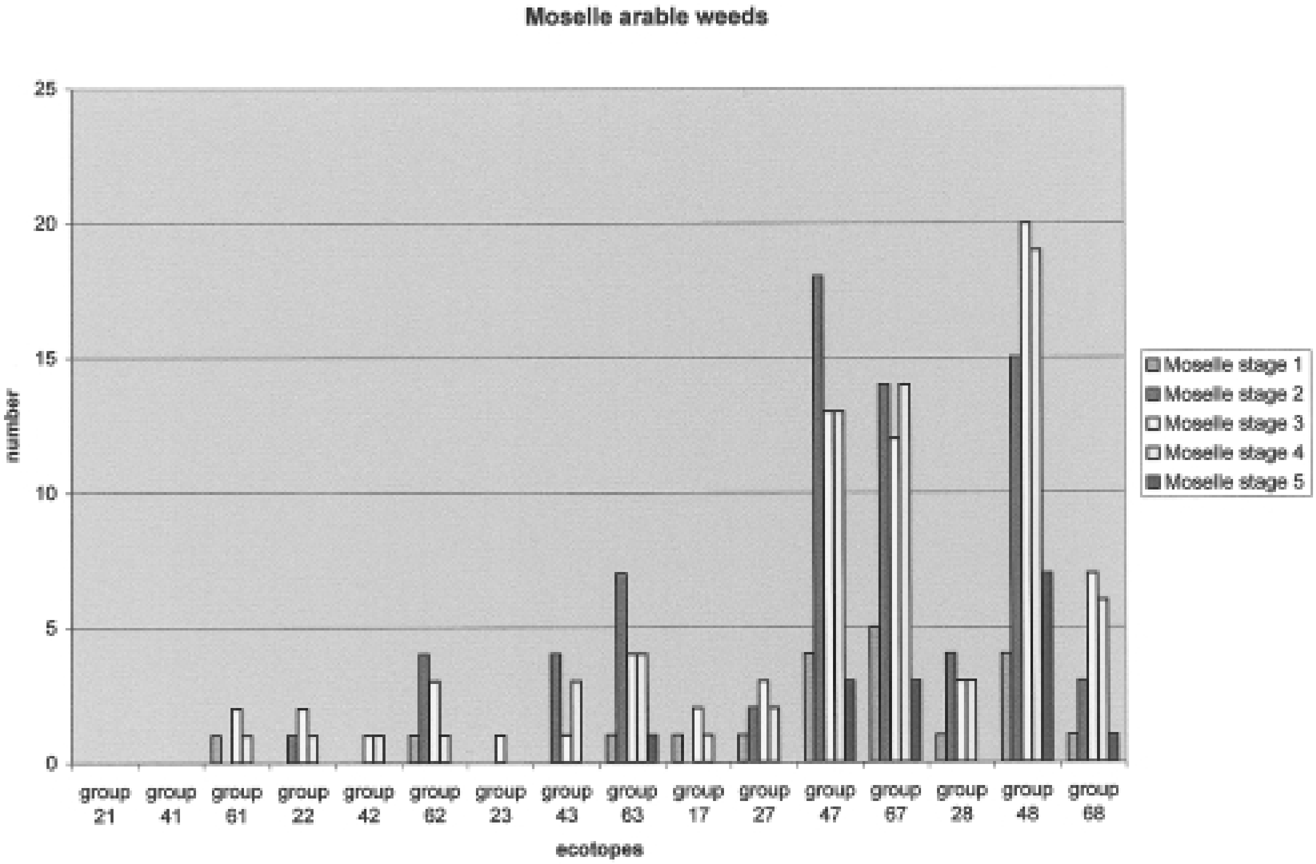


Fig. 9.6 Moselle region - distribution of arable weeds in Runhaars ecotopes. See text for legenda.

species may point to an intensifying agriculture and the use of manure (see above), whereas the perennials may demonstrate fallow periods and the existence of plots that are not intensively manured. Expressed in frequency, the annual species are clearly dominant in all stages, although this assessment should be prudent because our database is rather small (see figure 9.3). The share of the perennials decreases in the course of time. This development may be related to the rise of cultivation systems characterised by a higher frequency of cropping, i.e. a general shortening of the periods of fallow, or rather the disappearance of the fallow as integral part of the agricultural regime in the later periods (especially from 1100 BC onwards). A more permanent exploitation of the arable fields in the Moselle region seems to occur from the beginning of the first millennium BC.

Summer-winter annuals

Dividing summer and winter annuals can be conclusive on the cultivation regime, with regard to intensification (see above). Summer annuals appear to dominate over winter annuals in the seed assemblages from the Bronze Moyen period onwards (1500-1100 BC) in presence as well as in frequency (see figures 9.4; 9.5). On the basis of the evidence on the ratio summer annuals — winter annuals in our material, it is not implausible to suggest that an intensive "garden" cultivation was widespread in the Moselle region at least from c. 1500 BC onwards.

Nutrient availability and moisture regime

For the assessment of the fertility and the moisture regime of the arable fields, all weed species which could be identified up to species level were subjected to the characterisation of the Runhaar-ecotope classification (Runhaar et al. 1987; see above). In figure 9.6, the ecotopes values of the weed assemblages in the course of time are shown. Clearly, the emphasis during virtually all stages lies on the groups 47, 67 and 68, that is the groups of humid to dry, and (moderate to highly) fertile soils.

In figure 9.7, the frequencies per arable weed species are established and presented, grouped per stage, in three-dimensional bar diagrams, so that both nutrient availability and moisture regime are visible in one glance. Several methodological considerations should be noted. As demonstrated above, the individual species can be attributed to more than one ecological group. For example, *Fallopia convolvulus* belongs to five ecotopes: P47, P48, P67, H63 and H69. Species that occur in more than one ecotope group were similarly recorded in more than one group in the diagrams. Therefore, the number of data in the diagrams does not necessarily correspond to the number of species found. Secondly, the classifications referring to vegetation structure and succession stage (G, P, R etc.) were added together, as all species are interpreted as arable weeds. Finally, the results for the individual sites are grouped per chronological phase, since their species lists are comparable.

The frequent occurrence of moderately eutrophic weed species (groups 47 and 67) could be related to the possibly more fertile löss soils in this region. There are however, a number of weed species which are not only indicators of moderately fertile soils, but which are true indicators for the use of manure (nutrient availability-values 28, 48 and 68), like *Atriplex* spp., *Capsella bursa-pastoris*, *Urtica urens*, *Solanum nigrum*, *Sisymbrium officinale*. Their presence evidences improvement of the soil by addition of extra fertilizer, like cattle dung or other manuring. They are especially abundant in the Moselle-assemblages dating from the beginning of the first millennium BC (stage 3 and 4).

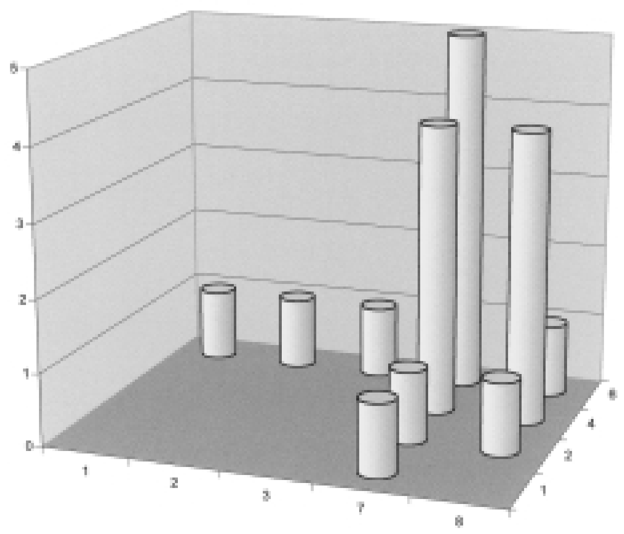
Results on some individual sites

The general impression of the seed assemblages from the Moselle region is of a rather unmanageable data set. Only a few assemblages from specific sites and specific contexts offer more possibilities to further analysis. These specific sites were characterised with the help of the information presented above (regarding the ecotope values, indicators of fallow vs intensive land use, dynamics, working the soil, and the use of manure). Provided that an identification up to species level could be offered, the characteristics for the different weed species in the sites are presented, that is, the ratio annuals: perennials, indications of soil fertility and other information regarding the use of land and the agricultural methods employed. In the diagrams of figures 9.8 and 9.9, the final results are presented from the sites that were suitable for such an analysis. The earliest site from this series, Budersberg (Bronze final I), shows moderate nutrient availability values and a relatively large proportion of perennial weeds. From the Bronze final IIa-b period onwards, the indications for the use of manure become stronger and the annual weeds predominate. These results also point towards an intensifying agriculture around the beginning of the 1st millennium BC.

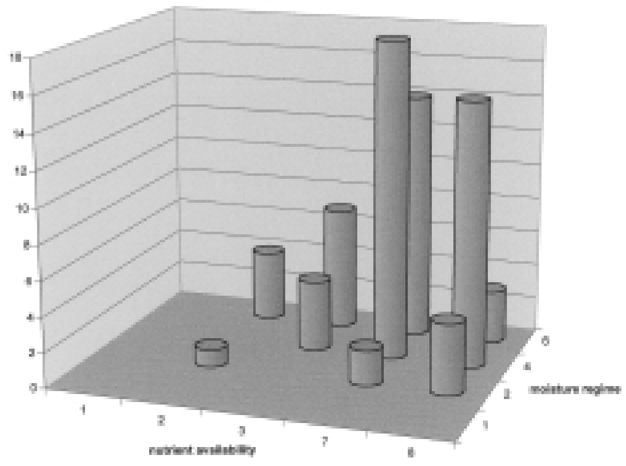
Specific archaeological questions

From an archaeological point of view, some explicit questions with regard to the nature of the arable fields in use by the inhabitants of specific sites in this region, should be commented upon.

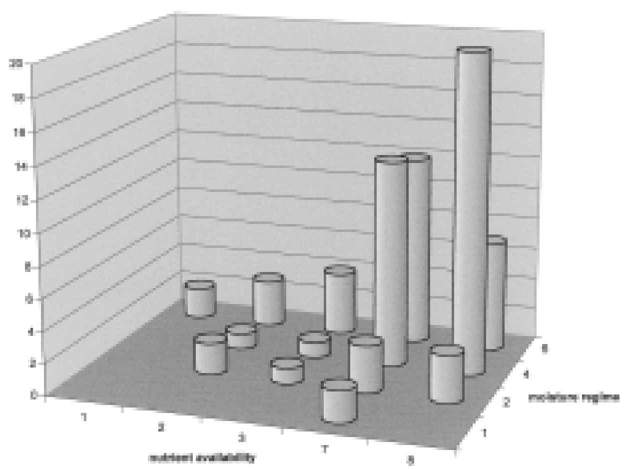
It was mentioned before that the river Moselle played an important role in this area. According to the French archaeologists, the ancient, cut off river arms of the river Moselle could well have served as arable soils or as demarcations of arable fields (Blouet et al. n.d., Guilaine 1991). Indeed, at the site of Crévéchamps, it was assumed that the ancient river arm (palaeo-channel) with its rather moist and fertile arable weeds Moselle region (stage 1) moisture regime and nutrient availability



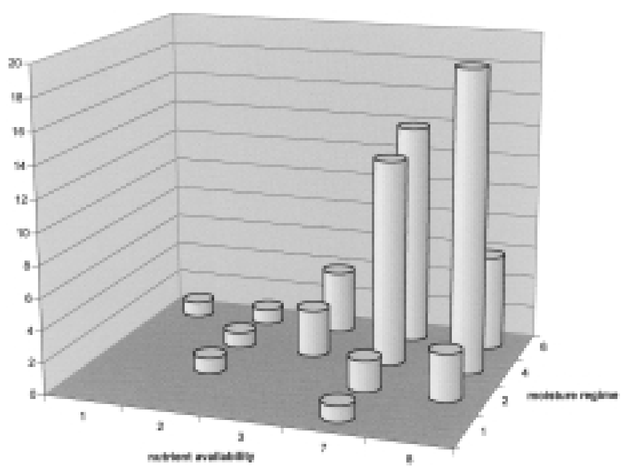
arable weeds Moselle region (stage 2) moisture regime and nutrient availability



arable weeds Moselle region (stage 3) moisture regime and nutrient availability



arable weeds Moselle region (stage 4) moisture regime and nutrient availability



arable weeds Moselle region (stage 5) moisture regime and nutrient availability

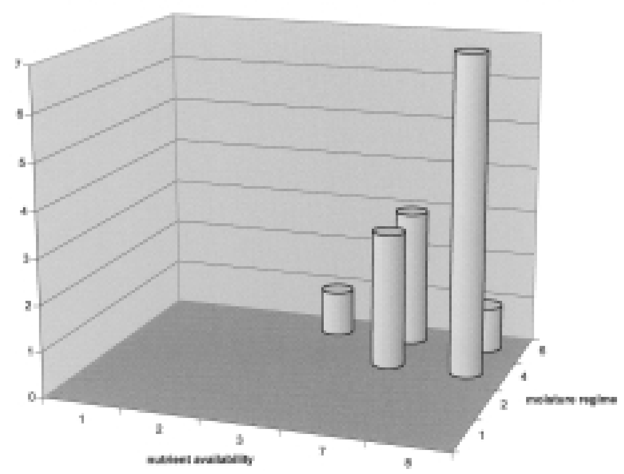


Fig. 9.7 Moselle region - distribution of arable weeds according to moisture regime and nutrient availability-values through the five chronological stages. See text for legenda.

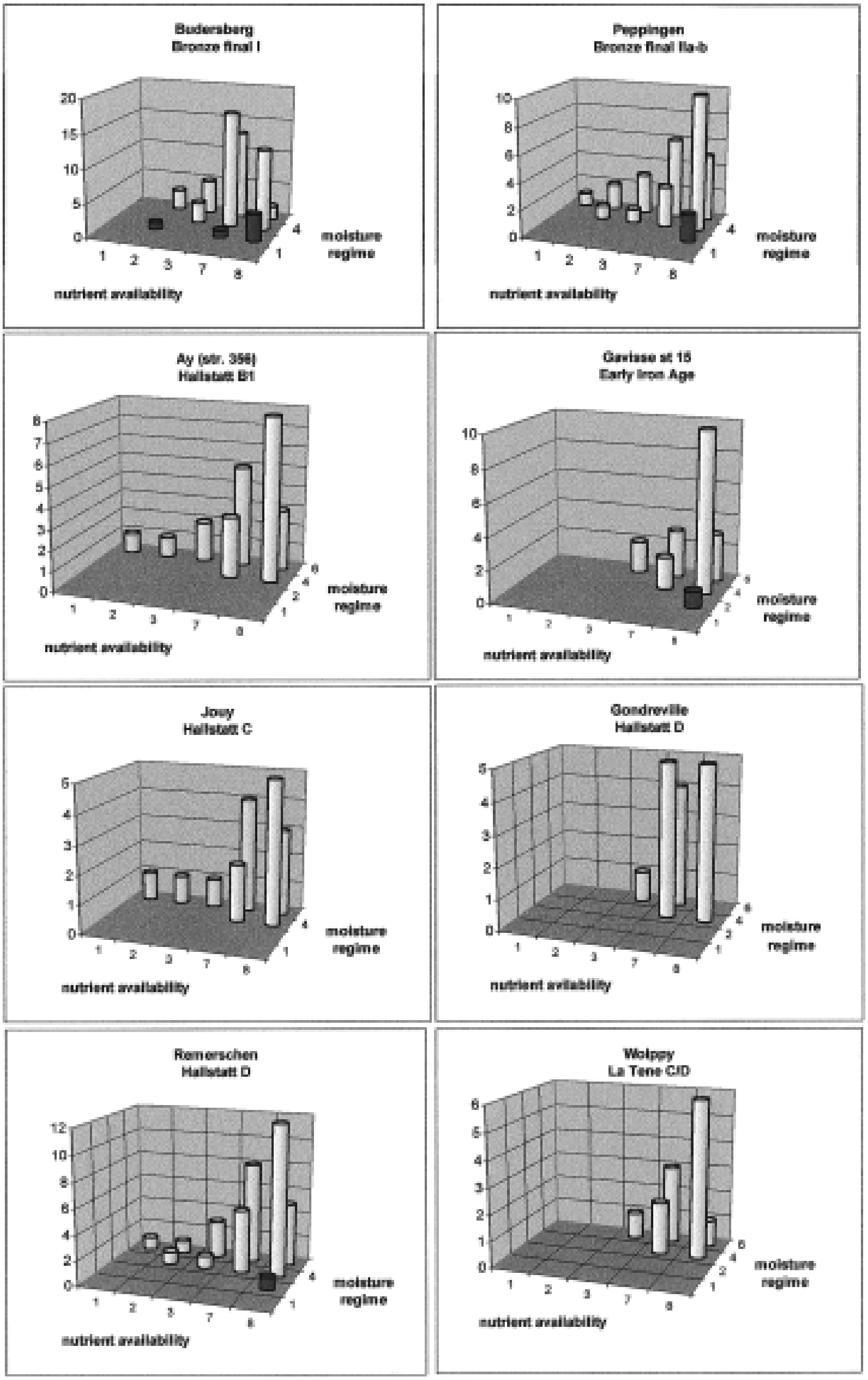


Fig. 9.8 Moselle region - selection of 8 sites, distribution of arable weeds according to moisture regime and nutrient availability - values. See text for legenda.

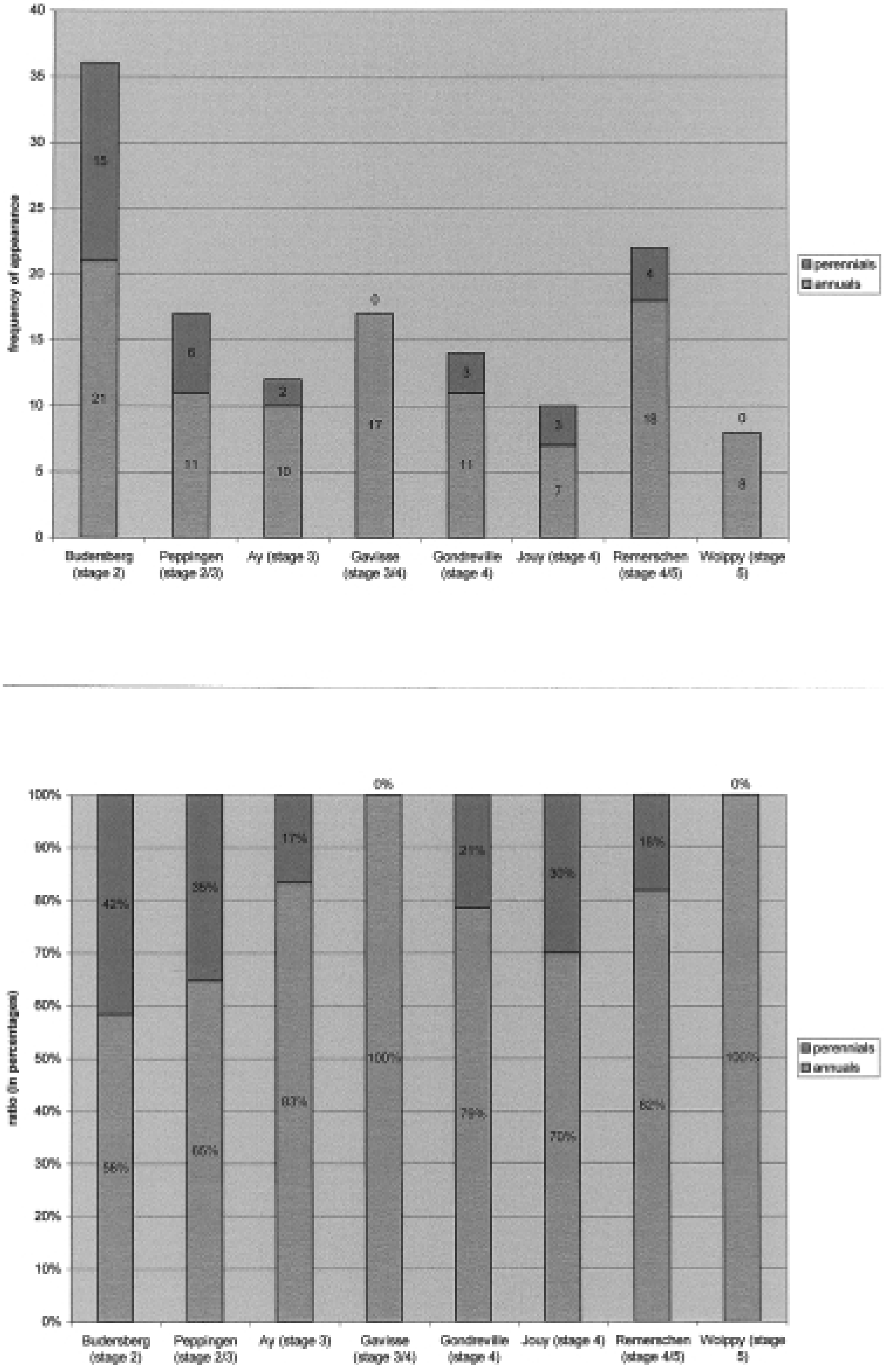


Fig. 9.9 Moselle region - selection of 8 sites, ratio annuals/perennials (expressed in frequency numbers)

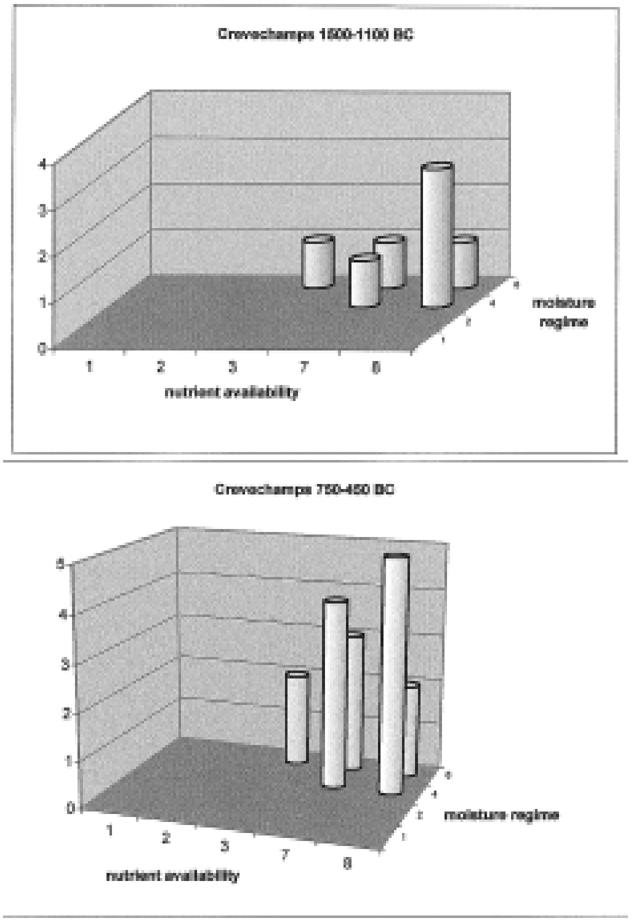


Fig. 9.10 Crévéchamps - moisture regime and nutrient availability values

sediments, was in use as arable land from the Bronze Age onwards (Koenig pers comm, see chapter 5). The character values of the arable weeds from this site were calculated (fig 9.10). This demonstrated that only the groups 43, 47, 67, 48 and 68 were present in the weed flora, characteristics of dry to moist soils and low, moderate to high nutrient availability. It should be noted that this calculation was based on a low number of seeds. Any clear indications for wet soils in the arable weed data sets of this site are relatively weak. The fertility of the soils must have been relatively high which does not exclude the use of the old river arm as arables.

The Hallstatt D-site of Gondreville appears to represent a relatively innovative phenomenon. A concentration of large numbers of storage structures, like granaries and especially large numbers of silos and storage pits were excavated here (see figure 5.22). This type of concentrated (possibly central) storage is typical for this period, the late Hallstatt and La Tène. The results of the analyses of the samples from the site of Gondreville deserve some further remarks (esp. sample 4214). Seven species of arable weeds were found exclusively at this location. These are *Adonis* spec., *Agrostemma githago*, *Agrostis* spec., *Buglossoides arvensis*, *Convolvulus arvensis*, *Malva sylvestris* and *Orlaya grandiflora/Pastinaca sativa*. These "uncommon" species are accompanied by the more usual species (*Galium* spp., *Rumex* spec., *Vicia* spp.). This list of arable weed species of Gondreville is comparable to e.g. Late Hallstatt/Early La Tène Wierschem (Mayen-Koblenz) (Kroll 1998). According to Kroll, this list of species (consisting of among others *Buglossoides arvensis*, *Adonis* spec. and *Agrostemma githago*) is actually characteristic of Roman-type seed assemblages (1998, 354). They are all indicative of (winter-)cereal cultivation on fertile, basic, loamy-humus rich soils, with moderate nitrogen addition. *Adonis* is a warmth-loving species. *Agrostemma githago* especially, is a typical Roman weed that is seldom found in (late-) prehistoric contexts. According to Kroll, it is due to specific favourable locations of sites that these species could develop at such an early stage (1998, 355). The assemblage of Gondreville seems to form a forerunner of "typical" Roman winter cereal cultivation. However, some earlier botanical assemblages — from the Urnfield-site of Wiesloch (Rhein-Neckar), for example — yielded comparable weed combinations. According to Rösch (1992, 97) the species *Adonis*, *Orlaya grandiflora*, and *Veronica polita* all point to clayey, calcareous soils.

The Luxemburgian archaeologists emphasised the fertility of the löss soils as a determinant factor of settlement choice (see above chapter 6). To see if this assumption was correct, the results on the fertility of the Luxemburgian arable fields were once again shown separately. The nutrient availability values of the weeds found in the samples from the sites Budersberg (Bronze final I and La Tène), Peppingen and Remerschen Schengerwis are given in the diagrams (see figure 9.11). The values are indeed relatively high. The data on the sites dating from the end of the Bronze final could further point to the use of extra fertilizer. Indications of infertile soils are virtually absent.

9.8 The site of Geldrop and the MDS region

In this section, the results of the analysis of the arable weeds from Geldrop and the other sites in the MDS complex will be presented.

General results

Seven MDS sites were considered suitable for an analysis of the arable weeds. These are the sites of Geldrop, Son-en-Breugel and Boxmeer for the Middle Bronze Age, Boxmeer for the Late Bronze Age and Riethoven, Someren and Neerharen for the Early Iron Age. A total of 65 weed taxa (identifications up to species, genus or family level) were attested in these MDS sites (see table 8.5).

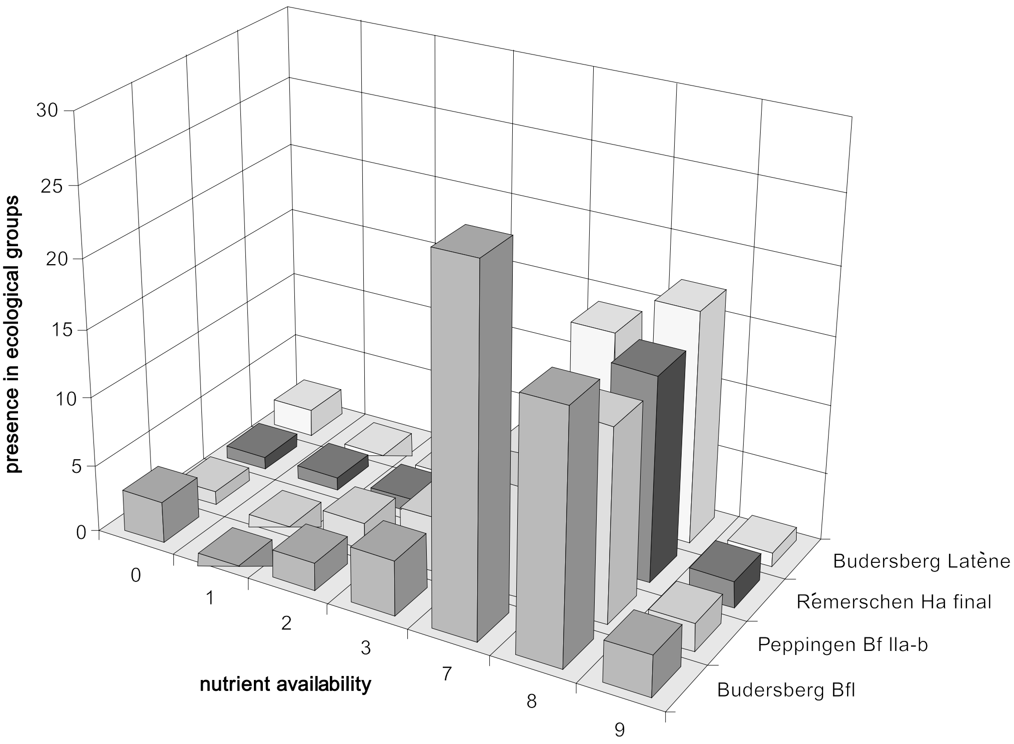


Fig. 9.11 Luxemburg sites - nutrient availability

Number of taxa

As described above, it may be of relevance to observe the distribution of the number of taxa over the successive chronological stages. For the assessment of a possibly increasing variety of weed taxa, all identifications were considered (including identifications up to genus or family level) (see previous chapter, table 8.5).

In the samples of the Middle Bronze Age (1800-1100 BC), 38 different taxa were present, 10 different weed taxa were found in the Late Bronze Age material (1100-800 BC), and in the Early Iron Age (800-500 BC), 44 different taxa of weed plants were found. The Middle Iron Age assemblages from Geldrop yielded 12 different weed taxa. When establishing a possible increase of weed taxa, we have to be aware of the fact that only one sample dating from the Late Bronze Age and only nine samples dating from the Middle Iron Age (Geldrop) were suitable for an analysis of the arable weeds. In general, we may assume that a gradual increase of the number of different weed species took place in the MDS region, which could be related (according to e.g. Willerding, see above) to an increasing intensification of agriculture.

Fallow, frequency of cropping and land use in the MDS complex

The criteria to identify the length of periods of fallow (or the frequency of cropping) were described above. When assessing short fallow or the absence of fallow cultivation, the absolute number and abundance of annuals can be of great help, as shown earlier in this chapter. When we apply these to the material from the MDS region the following results can be presented.

Middle Bronze Age

For the Middle Bronze Age, 80% of the regularly retrieved weed species are (summer or winter) annuals (table 9.5 on page 161/figure 9.12). Expressed in frequency, the annual species are even more dominant (89%) (table 9.5/figure 9.13). This could be the evidence for the absence of fallow periods, or for very short fallow periods. The presence of *Solanum nigrum* and *Chenopodium album* is explicitely indicative of fallow periods shorter than 2 years.

The only exceptions on the dominance of the annuals that relatively regularly occur in the samples from this region are *Lolium perenne*, *Solanum dulcamara*, *Eleocharis palustris*, *Plantago lanceolata* and *Rumex acetosella*. These are perennials that overwinter in arable fields and flower again in the next season.

These perennial species all bear their own additional information. *Lolium perenne* is indicative of manuring and strong trampling. Its presence in the seed assemblage could point to one year of fallow, during which the cattle was left grazing

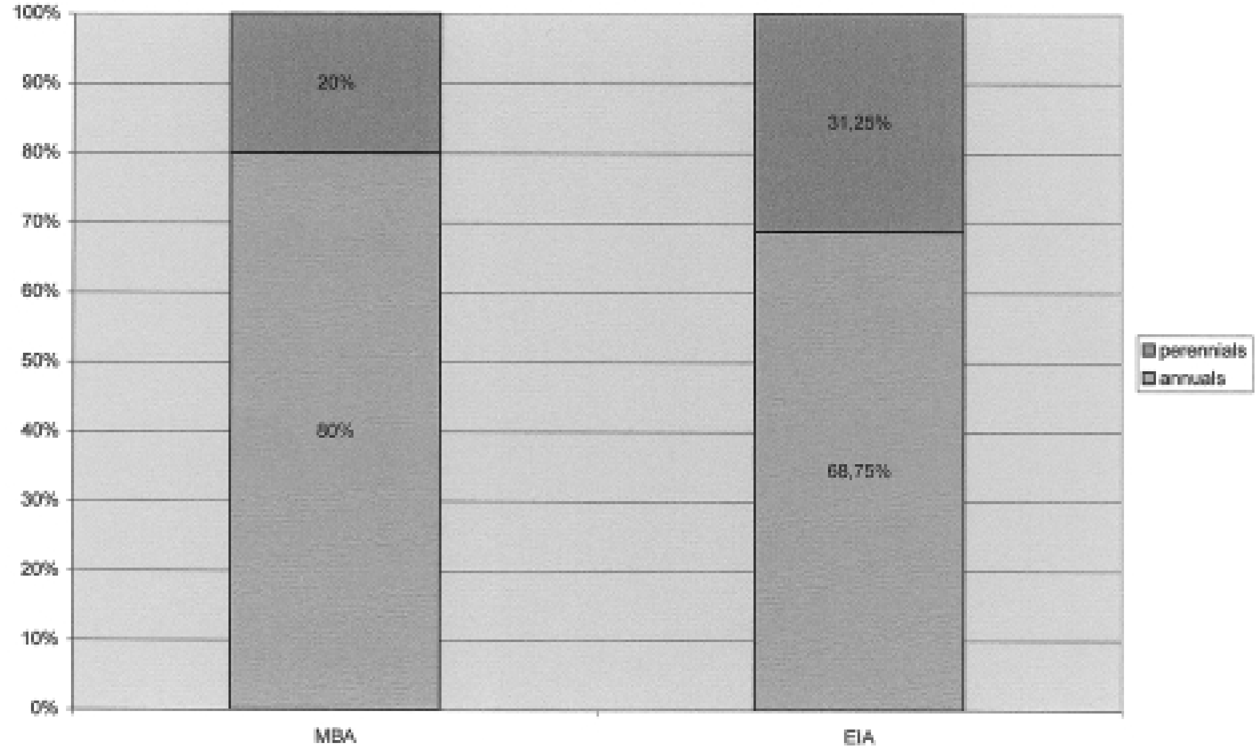


Fig. 9.12 MDS - region - ratio annuals/perennials (expressed in presence numbers)

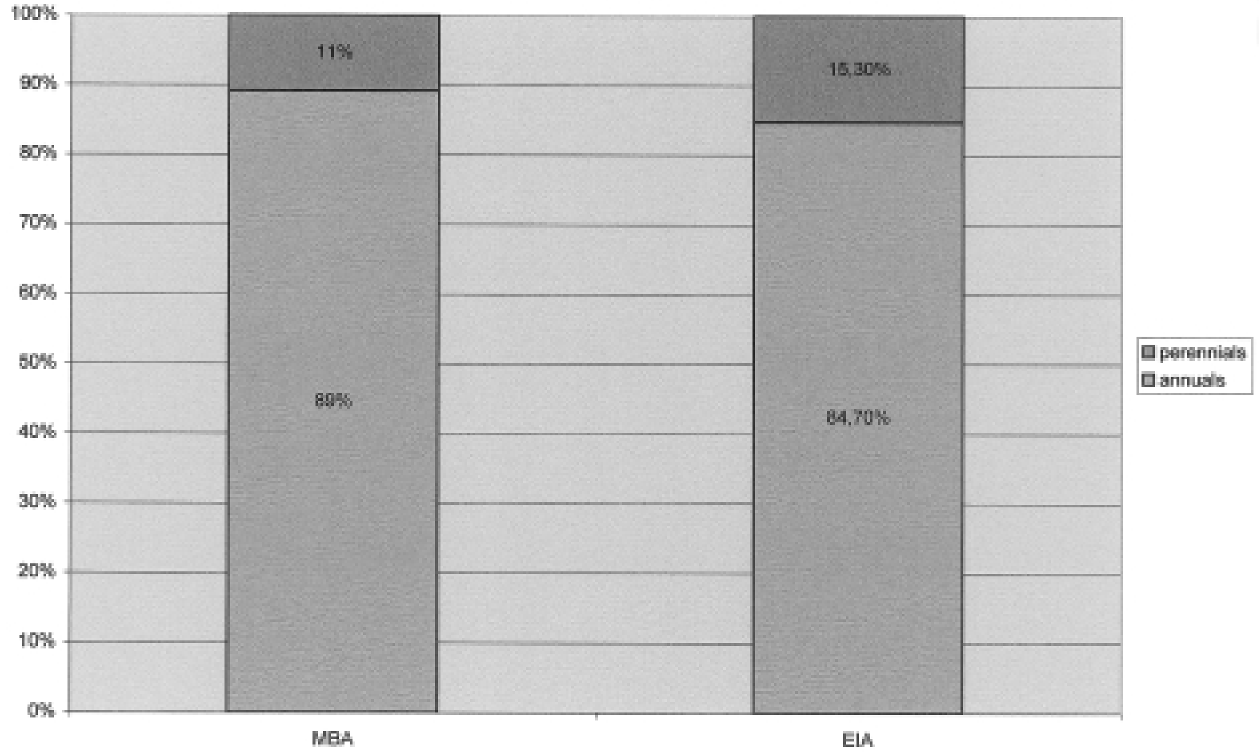


Fig. 9.13 MDS - region - ratio annuals/perennials (expressed in frequency numbers)

	Geldrop MBA	Son MBA	Boxmeer MBA	Boxmeer LBA	Someren EIA	Riethoven EIA	Neerharen EIA	Bladel MIA	Geldrop (M) IA	Son MIA	Runhaar
number of samples	22	1	1	1	12	10	2	18	9	9	
Oligotrophic species											
Carex demissa	-	-	-	-	-	1	-	-	-	-	P22 G22
Vicia sativa nigra	-	-	-	-	1	-	1	-	-	-	G43 G47 G63 G67
Ranunculus flammula	-	-	-	-	-	1	-	-	-	1	G22 G23 G27
Rumex acetosella	4	1	-	-	-	6	-	1	1	7	P61 P62 P67
Potentilla erecta	-	-	-	-	-	1	-	-	-	-	G21 G22 G41 G42
Veronica arvensis	-	-	-	-	-	1	-	-	-	-	G43 G63 G47 G67 P47 P67
Mentha aquatica/arvensis	-	-	-	1	-	1	-	-	-	5	G23 G27 R27 H27 V17 P47 G27 G47
Eutrophic species											
Galium aparine	2	-	-	-	5	2	1	-	-	-	H69 R48 H48
Chenopodium ficifolium	3	-	1	-	-	-	-	-	1	-	P48 P68
Echinochloa crus-galli	3	-	-	1	-	3	2	2	-	6	P48 P68
Persicaria maculosa	5	-	1	-	-	5	-	2	-	6	P48
Solanum nigrum	2	1	-	-	-	3	-	1	-	2	P48 P68
Chenopodium album	8	1	1	1	-	5	1	13	4	8	P48 P68
Persicaria lapathifolia	14	1	1	-	5	7	-	10	5	7	P48
frequency ratio											
Oligothrophic	9.8%	25%	0%	33%	9%	30.5%	20%	3.5%	9%	31%	
Eutrophic	90.2%	75%	100%	67%	91%	69.5%	80%	96.5%	91%	69%	

Table 9.6 MDS region - frequency of eutrophic and oligotrophic species and their ratios

on the fallow field (indirect manuring). *Plantago lanceolata* is also resistant to trampling and indicative of nutrient soils. However, this particular species is also resistant to the use of the ard. The same goes for *Rumex acetosella* which has a tough rootsystem, and expands when destroyed at ploughing. In general they are species resistant to (intensive) soil working, rather than indicators for long periods of fallow. The weed assemblages of the Middle Bronze Age samples indicate to some extent an intensive cultivation system.

This is an invitation to come back to the main aspects of land use patterns in the Middle Bronze Age in the MDS region (chapter 2). Roymans and Theuws described it as follows. In this period population density was relatively low. The availability of land does not yet seem to have been a critical factor in the reproduction of society. For this pre-Celtic fields phase, they imagine small dispersed field systems of plots of land (connected with individual farmsteads) which were extensively cultivated (Roymans/Theuws 1999). This view will be more elaborately argued in the final chapter of this book, but it should be noted that the (archaeological) model presented here is not consistent with the evidence from the analysis of the arable weed data sets.

The investigated arable weeds do not give any insight into the size of the fields that were in use for agriculture. We should note that little is known on Bronze Age (i.e. 2nd millennium) agricultural practices in general and especially on the spatial organisation of the arable fields in this era. This is a general problem also noted in other parts of Europe. It is only in the Late Bronze Age or Early Iron Age with the emergence of field systems like the Celtic fields that we seem to gain more insight in farming practices (Barrett 1989b, Brongers 1976).

Early Iron Age

As described in chapter 2, the Urnfield period should, according to some, be considered to be a phase of powerful demographical expansion. The increasing pressure on the land as a consequence must have had its impact on the territorial organisation. A continuous territorial reorganisation would have resulted in a reduction of the average size of the territories of local communities. It is within this framework that some authors understand the introduction of Celtic field agriculture (Roymans/Theuws 1999). According to Roymans and Kortlang (1999, 51) the Celtic fields complexes were characterised by a considerable level of collective regulation (co-operation) and organisation. The nature of the cultivation regime on these Celtic fields (intensive or extensive cultivation) remains rather unclear. Opinions differ on this matter.

Some believe that the further introduction of manure and the systematic use of the ard were part of an intensified agriculture. According to Brongers (1976, 60) the characteristic outlook of the Celtic fields, with their parcelling structure suggests that different types of crops were separately grown (which he called multiple-course rotation). He further suggests that the Celtic field agricultural system included the systematic use of the ard and the harrow and the transport of humus to the fields (which is interpreted by Fokkens as sod-manuring: 1991, 128). Separate parcels may have been reserved for special crops, perhaps horticultural ones. Brongers suggested that after several cropping stages, the fields had to lie fallow and were presumably used for grazing cattle (1976).

Others assumed that plots of the Celtic fields were extensively cultivated and that cultivation shifted every year or two. According to some, this was mainly due to the infertility of the poor sandy soils which made an intensive agricultural impossible (Roymans/Kortlang 1993). Behre (1998) also related Celtic fields to large scale “shifting cultivation” and explicitly not to permant land use.

The assemblages of the arable weed seeds from our MDS material suggest that the agriculture during the Early and Middle Iron Age remained rather intensive. Also in this era, the annual species still pre-dominate over the perennials, although not as convincingly as in the earlier periods. Almost 70% of the retrieved weed species are annuals (see table 9.5/figure 9.12). Expressed in frequency, the annuals are even more dominant (almost 85%) (table 9.5/figure 9.13). Apparently, the evidence for intensive soil working remains powerful. One exception may be the Early Iron Age site of Riethoven where we observe increasing indications of more extensively worked and poorer soils (see below).

In chapter 12, I will further elaborate upon this subject, but here it suffices to suggest that a certain part of the cultivation regime possibly became more extensive. An earlier suggestion (see chapter 2 above) was that the Early Iron Age inhabitants of the MDS region exploited a system comparable to an infield-outfield system, where intensive (small-scale and labour-intensive) horticultural-like agriculture and extensive (large-scale and labour-extensive) agriculture co-existed side by side. This hypothesis has to remain of a preliminary nature and will be discussed in chapter 12.

No explicit indications were found in the weed seed assemblages with respect to the size of the arable fields. Archaeological evidence leads to the conclusion that the plots on so-called Celtic field complexes or similar field-systems were in use. Botanical indications for the presence of hedges around the plots were absent.

Nutrient availability in the MDS complex

According to Roymans and Theuws (1999), the Pleistocene sandy landscapes of the Northwest European Plain — looked at from an agrarian perspective — have some structural constraints for habitation and subsistence resulting from the physical conditions of soil and climate. One of them would be that the coversands are characterised by oligothrophic soils; they are mineralogically poor. Fields cannot be permanently cultivated here without heavy additional manuring. A structural shortage of manure was the main limiting factor for plough agriculture until the introduction of artificial fertilizer in the 19th century (Roymans/Theuws 1999, 2). In their view, the prospects for intensifying (cereal) cultivation were very limited and therefore the sandy areas never belonged to the classic arable production landscapes such as the adjacent löss regions in the south (Roymans/Theuws 1999, 4; see also Roymans/Kortlang 1993). To these authors, the infertility of the soil (the shortage of nutrients available in and therefore the rapid depletion of the arable soils) is reason enough to assume that the inhabitants of the Bronze Age and Early Iron Age settlements shifted their arables every year or two (see chapter 2) and that complete settlements would be abandoned after a generation because of the shortage of arable land that was not yet exhausted (Roymans/Kortlang 1993).

In figure 9.14 are indicated the nutrient availability and moisture regime of the arable fields in use in this sub-region. For this purpose, all weed species which could be identified up to species level were subjected to the characterisation of the Runhaar-ecotope classification. The values for these two characteristics (nutrient availability and moisture regime) from the system of Runhaar et al. (1987) are used. The frequencies per arable weed species from Middle Bronze Age Geldrop, Son en Breugel and Boxmeer, Late Bronze Age Boxmeer and Early Iron Age Someren, Riethoven and Neerharen are established and presented in three-dimensional bar diagrams.

High numbers of the species present in the Middle Bronze Age assemblages could be attributed to ecotopes with moderate and high trophic values. The values P/G 48 and P/G 68 indicate humid and very fertile soils resp. dry and very fertile soils. As the diagrams illustrate, all Middle Bronze Age sites in the MDS region show relatively high values for these characteristics. Indicators of poor soils are relatively scarce or completely absent.

The Late Bronze Age is represented by only one sample which yielded arable weeds (Boxmeer). As the basis for analysis is obviously very narrow, this period is excluded from consideration. The botanical data from the MDS-Early Iron Age sites, by contrast, are well suitable for analysis. Here, the diagrams show a rather comparable picture of fertile, relatively dry arable fields.

The diagram referring to the Early Iron Age site of Riethoven however, differs considerably from the other two. Here as well, the high nutrient values dominate, but more arable weeds seem to be indicative of moisture and show lower values for nutrient availability. This is especially true for *Potentilla erecta*, *Rumex acetosella*, *Eleocharis palustris, Carex* spp. and *Ranunculus flammula*. Taken together, the arable soils here are of a more differentiated and moist nature, and appear to be indicative of a more extensive cultivation regime.

The Early Iron Age site of Riethoven consists of two contemporary houses dating from the Hallstatt C period (c 700 BC). The houses were probably occupied at the same time, which is quite exceptional during this period. The duration of settlement is supposed to have been no longer than a few decades (Slofstra 1991, 145). Through air photography, the location of a small part of a Celtic fields complex was established at 1 kilometre to the east of the settlement (Milikowski 1985) (see figure 2.12). We may assume, with a fairly high degree of certainty, that this complex represents the arable fields cultivated by the Early Iron Age inhabitants of Riethoven. The location of this field system would suggest that the arable plots by nature would be dry and sandy (the scanty capacity of sandy soils to retain moisture is notorious, see Vink 1980, 37). The arable weeds from the samples of Riethoven indicate more moisture on the one hand and a diverse availability of nutrients on the other. This could possibly point to the irregular addition of material onto the fields.

The outcome of the interpretation of the arable weeds from the MDS region is in sharp contrast to what archaeologists have suggested with respect to the nature of arable fields in this area. Weed species of dry, sandy and especially infertile soils are lacking or strongly under-represented in the botanical data sets in all chronological stages. To double-check the conclusion on the fertility of the arable fields on the sandy soils in North-Brabant, the ratio between indicators of fertile and infertile soils was established (see table 9.6).

In analogy of Behre (1991) and Brinkkemper (1991), I calculated the relative importance of eutrophic and oligotrophic plants for several sites in the MDS complex, dating from the Middle Bronze Age to the Middle Iron Age. The first author developed this method to find out what the importance of salt marsh plants versus freshwater plants was for several sites in the German coastal area and Brinkkemper succesfully applied this method to the Iron Age Voorne Putten region (1991, 102-6). He therefore selected sixteen halophytes and as many glycophytes and recorded absence and presence of these species on the site. The taxa were selected on the basis of their regular occurrence and a certain identification up to species level. Furthermore, he used the best indicators of salinity (grassland species), and excluded species that might have been transported from outside the area. Behre applied only qualitative ratios (1991). The large numbers preserved, related to different seed production per species led him to conclude that quantitative ratios based on numbers of seeds are not applicable (but see

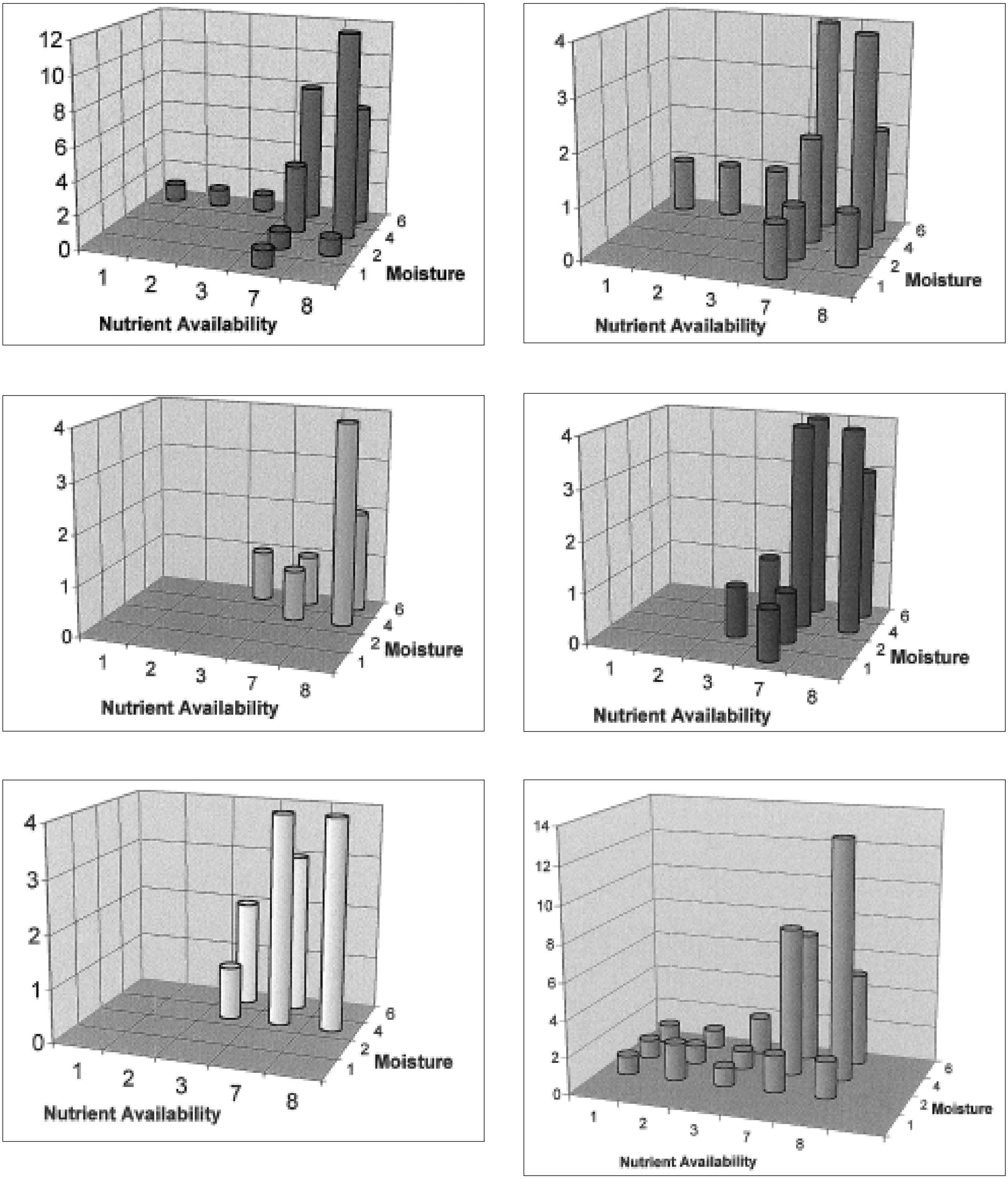


Fig. 9.14 MDS region - distribution of arable weeds according to nutrient availability and moisture regime values

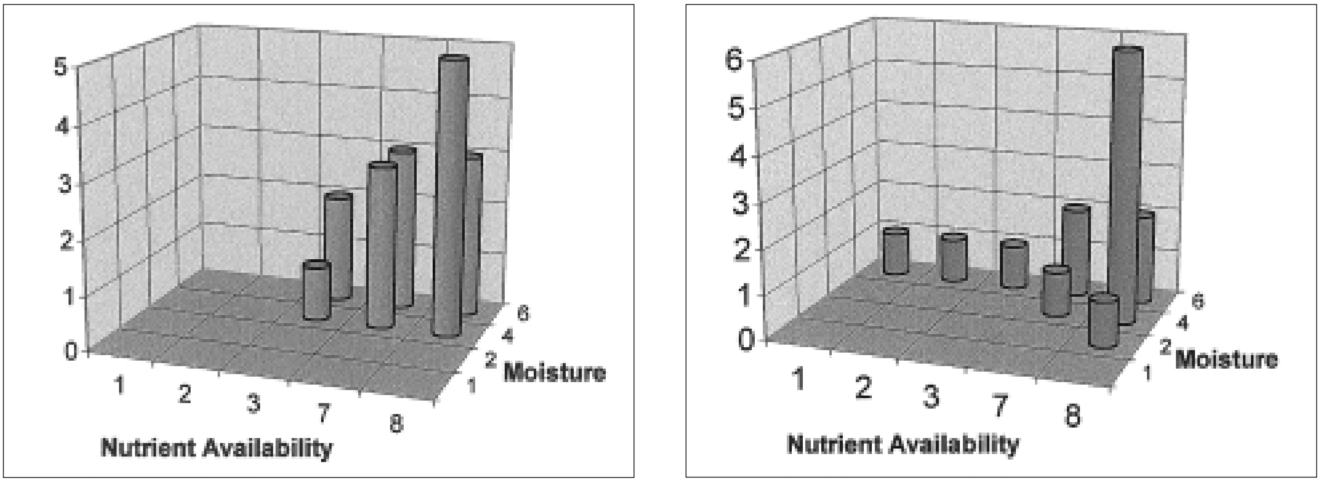


Fig. 9.14 continued

Brinkkemper 1991, 102).

I made a selection of oligotrophic and eutrophic species on the basis of the combined information from Runhaar et al. (1987), Bannink et al. (1974) and the various floras. This selection cannot be as straight forward as the selection of halophytes and glycophytes (see above) as there appears to be a large overlapping group of plants which, in theory, grow on infertile as on fertile soils as well. The species in the table are selected with regard to their presence in the botanical samples.

Like Brinkkemper, I use the frequency ratio to prevent the unique or rare presence of (small numbers of) seeds of eutrophic weed species having proportionally too great an influence on the ratio. The frequency equals the number of samples per site in which a species occurs divided by the total number of samples of the site concerned.

Table 9.6 demonstrates that the eutrophic species dominate in virtually all sites. The material from Geldrop (Middle Bronze Age), Riethoven (Early Iron Age), Bladel and Son (both Middle Iron Age) especially yielded sufficient data and therefore reliable results. Geldrop, Bladel and Son clearly demonstrate the dominance of euthrophic species. The site of Riethoven, already identified as representing a slight anomaly within the Early Iron Age group, again presents somewhat deviating results. The functional attributes to the weed flora of this site can probably be related to a more extensive cultivation, and perhaps the addition of moisture onto the arable fields. [12]

The previous results indicate either that the infertile sandy soils in the immediate surrounding of the sites were not used as fields, or that the nutrient availability of the sandy soils in the arable fields was (artificially) increased. If the prehistoric communities in the MDS complex have used the sandy soils as arables (e.g. the Celtic fields like the ones of the Riethoven complex, or their Bronze Age predecessors), they must have added manure to the soils if we judge by the present weed species.

If we look at the results on the arable weeds from the MDS region, we do not observe clear diachronical developments with regard to the nutrient availability or eutrophicness of the arable fields. From the Middle Bronze Age onwards, the human interference into the nature of the arable fields is evident. A more complete study of agriculture in the MDS region could probably strengthen this hypothesis (Karg in prep).

9.9 Conclusion

If we believe the outcome of the cultivation experiments presented by Lüning (1980, see above), the soils in the löss area of Lorraine and Luxemburg would enhance the possibility of a long-term permanent mono-cropping cultivation. Langohr (1990) however, argued that the soils of the Belgian löss belt some 7000 years ago were totally different from the present ones and in general presented a low to very low chemical and physical fertility. Further research should be carried out on detailed soilscape reconstruction in order to detect the possible importance of wet land soils in the löss area as Langohr mentions the fact that löss soils with a permanent groundwater table could have been of major importance for prehistoric agriculture (1990, 122). In that respect, the Moselle valley could have been an ideal environment for long-term agriculture. For the time being, the far-reaching conclusions on the excellent agricultural suitability of the löss area, made by many authors, should be of a more cautious nature.

The weed flora present in the samples from the Moselle region demonstrated a moderate to high degree of nutrient availability. There are some indications with regard to the addition of artificial fertilizers especially on the sites dating from around the beginning of the 1st millennium, but possibly less powerful than was the case for the MDS region. The general impression is that the qualities of the löss soils in the Moselle region did not invite the prehistoric farming communities to manure their arable fields on a large scale or in a systematic way. It is suggested that in the earlier periods (before the beginning of the 1st millennium BC), the cultivation regime was not highly place-permanent. This would explain the general low numbers of weed seeds and the relatively high numbers of perennials in the seed assemblages.

For the periods from the Bronze final onwards, it could be suggested that a cropping system was in use which included a more (labour-) extensive larger-scale cultivation on the one hand and a more intensive horticultural regime on the other. The possibility of the co-occurrence of different cropping systems in this stage of time is further elaborated in the next chapters.

With regard to the site of Geldrop (and indeed for the whole of the MDS area) it is usually assumed that arable fields were cultivated on an extensive scale. This would, according to the adherents of this extensive model, be determined by the natural infertility of the sandy soils (see chapter 2; Louwe Kooijmans 1995; Roymans/Kortlang 1993). The results of the analysis of the arable weeds should change our ideas with respect to this assumption. The weed flora from the North-Brabant sites does not present typical infertile sandy soils indicators. We can establish that there was a powerful human intervention into the nature of the arable fields, and that this was unmistakably so in the Bronze Age. Any indications for long fallow periods are absent. In contrast, the weeds seem to indicate short fallows, or rather the absence of fallow periods; there are no signs of a shifting cultivation system. The high nutrient values point to the (systematic) use of manure. Intensive working (expressed in the presence of weeds indicating soil disturbance) appears to have been an important part of the cultivation regime. The evidence (even though not based on high numbers of quantitative data) suggests a manuring regime and permanency of land use. We could probably relate it to the increasing habit of the stalling of cattle (either in longhouses or in separate stables) as well as to the collection of cattle dung. It contradicts fundamental ideas on the loose character of agriculture in this region in the Bronze Age by too much.

Late Bronze and Early Iron Age farming underwent minor changes in comparison to the previous period. Although the archaeological record demonstrates major shifts or transformations towards urnfields and Celtic fields, the botanical data on the land use suggest a rather strong continuity. An intensive cultivation of permanent plots of land, ploughing and manuring could, at least partially be attested. Possibly other plots of land were cultivated less intensively (see Riethoven), which could be related to the cultivation of different crops simultaneously on different parts of the agricultural land. For the Early Iron Age, we could presume a more varied system where extensive and intensive agriculture resp. horticultural agriculture co-occurred. In the next chapter, the range of food crops that were cultivated on these (different) plots will be presented.

A last comment should be made with regard to any possible distinctions between the agricultural systems of the two regions under study. Roymans suggested a powerful contrast between the sandy soils and the löss area with regard to the farming regimes in the Iron Age (1996). In his opinion, cattle must have played a dominant role in the subsistence economy of the MDS area because of the low fertility of the sandy soils and cereal growing must have been the principal agricultural activity in the Moselle region facilitated by the natural fertility of the löss soils which were possibly supplemented with manure (see also chapter 1). The assumption that all löss soils are very fertile by definition was sufficiently put into perspective by Langohr (1990; see above). The contrast between the agricultural regimes is not confirmed after the preceding analysis of the arable weeds. On the contrary, the reverse image can be reconstructed. The use of manure and a high frequency of cropping in general is very well demonstrated for the MDS region, but somewhat less convincing for the Moselle region.