Sowing the seed ? : human impact and plant subsistence in Dutch wetlands during the Late Mesolithic and Early and Middle Neolithic (5500-3400 cal BC)

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11. Evidence of human impact and plant subsistence from macroremains: crop plants and cultivation

11.1 Introduction

This chapter first discusses finds of crop plants and cultivation practices at the wetland sites of the Swifterbant culture and the Hazendonk group and other relevant sites. This discussion concerns finds of crop plants, the importance of crop plants, the evidence of use, preparation and consumption, possibilities for cultivation and the evidence of local cultivation. Afterwards, the results are compared with those from other macroregions. The chapter concludes with a discussion on the process of introduction into the study area. The chapter focuses on emmer wheat and naked barley since these are the main crop plants at the sites studied. A summary of the finds, the period of introduction and the discussion on local cultivation are also published elsewhere.[1]

11.2 Archaeobotanical remains of crop plants at the wetland sites

11.2.1 Finds of macroremains

The macroremains of crop plants represent the most direct indications of the presence of crop plants in the Dutch wetlands. Table 11.1 shows the identifications of macroremains of crop plants from Late Mesolithic and Early and Middle Neolithic Dutch wetland and dryland sites and from two comparable sites in Belgium and Germany. The finds of impressions are included in the table. Identified taxa are *Hordeum vulgare* var. *nudum* (*Hordeum hexastichum*, naked barley), *Triticum dicoccon* (emmer), *Triticum monococcum*-type (einkorn-type), *Triticum aestivum/durum* (bread wheat or macaroni wheat), *Papaver somniferum* ssp. *setigerum* (opium poppy) and *Pisum sativum* (pea). Thousands of remains of crop plants are known from the first phase of the Hazendonk and Swifterbant-S3, a few hundreds of remains were found at Ypenburg and Schipluiden, and approximately 100-125 remains were found at Brandwijk-Kerkhof, the third phase of the Hazendonk and Wateringen 4. The quantity of finds at other sites is small (see table 11.1).

Finds of naked barley are very common and generally include grains and internodia (single rachis fragments and in exceptional cases series of rachis fragments that were still attached to each other). Identifications are based on carbonised and waterlogged material, and on impressions. The internodia from the Hazendonk, Swifterbant, Schipluiden and Ypenburg indicate that it at least partly concerns six-rowed, pedicellate naked barley at these sites. The material of Barendrecht 20.126, Brandwijk-Kerkhof and Wateringen 4 also showed at least one of these characteristics. The material from the Hazendonk, Swifterbant and Schipluiden suggests the presence of the lax-eared type and the dense-eared type of naked barley, while an internodium found at Barendrecht is of the dense-eared type. At all these sites, however, it may concern lax-eared naked barley only, since this type produces internodes characteristic of both the dense-eared type and the lax-eared type internodes (Kubiak-Martens 2006a, 325). For other sites, the characteristics of barley are not precisely known. It is assumed that the available results are also representative of other sites and that all remains of naked barley found at Dutch wetland sites of the Swifterbant culture and Hazendonk group represent six-rowed, pedicellate, lax-eared naked barley and possibly dense-eared naked barley. Indeed, most Neolithic barley in Europe is six-rowed barley (Zohary and Hopf 2000). At Schipluiden and Ypenburg some grains were found that showed some similarity with hulled barley (Van Beurden 2008a, 316; Kubiak-Martens 2006a, 325). The grains from Schipluiden are interpreted as grains of naked barley that were harvested when almost but not completely ripened. Single grains enclosed by chaff that were found at Schokland-P14 and Urk-E4 were interpreted as not

1 Out 2008c. This chapter was completed later than the article and discusses some aspects in more detail.

site	date (yrs cal BC)	cultural group	Triticum dicoccon	Triticum dicoccon, spikelet forks/glume bases	Triticum dicoccon/monococcum	Triticum dicoccon/monococcum, spikelet forks	Triticum monococcum-type	Hordeum vulgare var. nudum	Hordeum vulgare var. nudum, internodia	Triticum aestivum/durum	Cerealia indet./ Triticum sp./Hordeum sp.	Papaver somniferum ssp. setigerum	Pisum sativum	preservation	quantity
Central river area															
Meerdonk	4030-3910	Sw	1	-	-	-	-	-	cf. 1	-	-	-	-	c	< 10
Rechthoeksdonk	4240-3980	Sw	1	-	-	-	-	1	-	-	-	-	-	c	< 10
Hazendonk (3)	3670-3610	Haz	+	+	-	-	-	+	-	-	-	-	-	c, w	c. 100
Hazendonk (1/2)	4020-3790	Sw	++	+	-	-	-	+	+	-	+	-	-	c, w	> 10.000
Brandwijk-Kerkhof (L50/L60)	4200-3800	Sw	++	+	-	-	-	+	+	-	+	+	-	c, w	c. 125
Brandwijk-Kerkhof (L30/L45)	4600-4400	Sw	-	-	-	-	-	-	-	-	-	-	-	-	-
De Bruin	5500-4450	Meso/Sw	-	-	-	-	-	-	-	-	-	-	-	-	-
Polderweg	5500-5000	Meso/Sw	-	-	-	-	-	-	-	-	-	-	-	-	-
Western river area															
Barendrecht 20.125	3660-3380	Haz	+	+	-	-	-	+	-	-	-	-	+	c	< 50
Barendrecht 20.126	4050-3790	Sw	1	+	-	-	1	+	+	-	-	-	-	c	< 50
Bergschenhoek	4340-4050	Sw	-	-	-	-	-	-	-	-	-	-	-	-	-
Randstadrail CS	5600-5400	Meso	-	-	-	-	-	-	-	-	-	-	-	-	-

Tabel 11.1 part 1.

site	date (yrs cal BC)	cultural group	Triticum dicoccon	Triticum dicoccon, spikelet forks/glume bases	Triticum dicoccon/monococcum	Triticum dicoccon/monococcum, spikelet forks	Triticum monococcum-type	Hordeum vulgare var. nudum	Hordeum vulgare var. nudum, internodia	Triticum aestivum/durum	Cerealia indet./ Triticum sp./Hordeum sp.	Papaver somniferum ssp. setigerum	Pisum sativum	preservation	quantity
Coastal region															
Rijswijk-A4		Haz	-	1	-	-	-	-	cf. 2	-	-	-	-	c	< 10
Sion	3640-3380	Haz	+	+	-	-	-	+	-	-	+	-	-	c	c. 50
Wateringen 4	3700-3400	Haz	+	+	-	-	-	++	+	-	+	-	-	c	c. 125
Schipluiden	3600-3400	Haz	+	+	-	-	-	+	+	-	+	-	-	c, w	c. 1500
Ypenburg	3850-3450	Haz	-	+	-	-	-	+	-	-	+	-	-	c	c. 750
Eem and Vecht regions															
Schokkerhaven-E170	3950-3700	Sw	+	+	-	-	-	+	-	-	+	-	-	c	< 10
Swifterbant-S3	4350-4050	Sw	+	+	-	-	-	++	+	(1)	-	-	-	c	c. 2000
Schokland-P14	4900-3600	Sw	+	+	-	-	-	++	-	-	-	-	-	c, i	< 25
Urk-E4	4200-3400	Sw	-	-	-	-	2	++	-	-	+	-	-	c	< 25
Urk-E4	7300-5000	Meso	-	-	-	-	-	-	-	-	-	-	-	-	-
Hoge Vaart-A27	6600-4150	Meso/Sw	-	-	-	-	-	-	-	-	-	-	-	-	-

Tabel 11.1 part 2.

site	date (yrs cal BC)	cultural group	Triticum dicoccon	Triticum dicoccon, spikelet forks/glume bases	Triticum dicoccon/monococcum	Triticum dicoccon/monococcum, spikelet forks	Triticum monococcum-type	Hordeum vulgare var. nudum	Hordeum vulgare var. nudum, internodia	Triticum aestivum/durum	Cerealia indet./ Triticum sp./Hordeum sp.	Papaver somniferum ssp. setigerum	Pisum sativum	preservation	quantity
Eastern Netherlands															
Nijmegen-Oosterhout	3770-3530	Haz	-	-	+	+	-	-	-	-	-	-	-	c	< 10
Winterswijk	4250-3700	Sw	-	+	-	-	-	cf. +	-	-	-	-	-	i	< 10
Scheldt valley (B)												-	-		
Doel Deurganckdok-sector B	4540-3960	Meso/Sw	-	-	-	-	-	-	-	1	-	-	-	c	< 10
NW Germany															
Hüde I	5000-3300	SW(?)/FB	-	-	-	-	+	+	-	-	-	+	-	i	< 10

Meso = Mesolithic
Sw = Swifterbant culture
Haz = Hazendonk group

FB = Funnel Beaker culture
B = Belgium
NW = Northwestern

+ = present
- = not present

c = carbonised
w = waterlogged
i = impression

Table 11.1 The sites of the Late Mesolithic, the Swifterbant culture and the Hazendonk group, crop plant macroremains. The internodia of *Hordeum vulgare* var. *nudum* found at Meerdonk and Rijswijk-A4 were only identified as *Hordeum vulgare*, but it is most likely that it consists of the naked variety, part 3.

completely ripened grains as well (Gehasse 1995, 60; Vernimmen 2001, 66).

Internodia of naked barley have been identified at all wetland sites studied where considerable quantities of cereal remains have been found, where preservation of organic material was good and for which the data can be considered as representative in view of the research methods. In contrast, internodia of naked barley appear to be absent at sites where the number of cereal remains is unlikely to be representative or where research methods were insufficient. For example, the absence of chaff remains of naked barley at sites that suffer from limited representativity, such as Schokland-P14 (late phases), Schokkerhaven-E170, Urk-E4 (late phase) and Ypenburg, is assumed to be related to the small number of finds of crop plants in general, to taphonomic processes and/or research methods such as the number of samples and the mesh width of the sieves (*cf.* Vernimmen 2001, 66). It is therefore assumed that internodia of naked barley have been present at all of the sites studied where any remains of cereals have been found.

Finds of emmer are very common and generally include grains, spikelet forks, glume bases and occasionally rachis fragments. Most finds were carbonised but waterlogged finds and imprints in pottery are also available.

Grains of *Triticum monococcum*-type, found in a carbonised state and identified from imprints, may represent *T. monococcum* but may also represent *T. dicoccon* since single grains sometimes develop in the top of ears of emmer wheat (Nesbitt and Samuel 1996, 56).[2] The finds at Brandwijk-Kerkhof, the Hazendonk and Ypenburg have been interpreted as emmer wheat for this reason (appendix III; Van Beurden 2008a; Out 2008a). The number of grains of *T. monococcum*-type at other sites (one or two grains) is too small to make firm conclusions on the identification. In the central river area and coastal region, the dominance of emmer compared with einkorn at many sites suggests it probably concerns emmer. If the finds indeed represent emmer wheat, the grains of *Triticum monococcum*-type in the refuse represent slender cereal grains that were sorted out during crop processing, *e.g.* during sieving or winnowing (Dennell 1974). The role of *T. monococcum* is however less clear for the northern group of the Swifterbant culture, since *T. monococcum*-type is the only wheat taxon identified at two sites in the north (Urk-E4 and Hüde I). The total number of cereal identifications at both sites was very small and the importance of einkorn may have been as limited as in the other regions.

Grains of *Triticum aestivum/durum* (bread wheat/macaroni wheat) have been mentioned for Swifterbant-S3 and Doel. The identifications could theoretically also represent the naked wheat *T. turgidum*. The single grain at S3 can be considered as a deformed grain of emmer since all other wheat grains at the site represented emmer wheat (*cf.* Braadbaart 2008). The single grain of Doel is difficult to interpret since this was the only wheat grain found at the site, and since the site is located in a region in Belgium from which no comparable data on crop plant species are available yet. At Schipluiden, a single grain, which morphology showed similarity with *Triticum aestivum*-type, has been interpreted as a grain of emmer wheat (Kubiak-Martens 2006a).

Waterlogged seeds of *Papaver somniferum* ssp. *setigerum* have been found at Brandwijk-Kerkhof (4220-3940 BC), Schokland-P14 (Neolithic; Gehasse 1995, 103), Vlaardingen (Late Neolithic; Van Beek 1990, 211) and western Flevoland (Late Neolithic, *c.* 4450 ± 40 BP: 3340-2930 BC, no known archaeological context, Gotjé 1997). Finds of opium poppy at sites of the Hazendonk group are not known yet. The finds at Brandwijk-Kerkhof represent the oldest finds since the finds at Schokland-P14 are not dated more precisely than Neolithic. The seeds might have been missed at sites where the analysis of botanical remains did not play an important role or where the smallest mesh width of the sieves was larger than 0.25 mm. The role of opium poppy as crop or weed is not precisely clear (see Bakels 1982) but the scarcity at the sites studied indicates that it functioned as an unusual crop plant, and that it was certainly not a common weed.

2 It is expected that single grains also develop at the base of ears of emmer wheat (pers. comm. Cappers 2009).

Peas are only known from Barendrecht 20.125 (Hazendonk group; Meirsman and Moree 2006). These finds are unique for the Netherlands since finds of peas younger than the Michelsberg culture (Bakels 2003) were until recently only known from the Iron Age (Buurman 1986). The apparent absence of peas at other (Early and) Middle Neolithic wetland sites may be related to the small chance of carbonisation during crop processing and food preparation, and small chances of preservation in a waterlogged state. These factors make it difficult to reconstruct the economic importance of the species.

A single grain of *cf. Avena* sp. has been found at Ypenburg, a site of the Hazendonk group (Van Haaster 2001). The find, representing *A. sativa* or *A. fatua*, is interpreted as the weed species *A. fatua* since Neolithic finds of cultivated oat are not known from the Netherlands. Van Haaster (2001) furthermore argues that the interpretation as a weed is supported by the association between finds of *A. fatua* and finds of emmer and barley in Dutch prehistory.

A taxon suggested to have functioned as a crop plant as well is *Bromus secalinus*-type (rye brome). Macroremains of this type have been found in a considerable frequency in the concentrations of carbonised cereal remains at the Hazendonk dating to phase 1, which is unique for the sites studied. It has been questioned whether the plant represents a more than tolerated weed or possibly a cultivated plant (Bakels 1981). High frequency-finds of *Bromus secalinus*-type that are similarly interpreted are also known from LBK and Rössen sites in Germany (Knörzer *et al.* 1999). At the Dutch wetland sites other than the Hazendonk, *Bromus secalinus*-type is however not found at many sites, in large quantities or in a high frequency at individual sites and it is therefore concluded that *Bromus secalinus*-type was not an important crop plant in the Swifterbant culture and Hazendonk group.

The crop assemblage seems to be fairly consistent in all regions, dominated by emmer and naked barley, except for the possible presence of *T. monococcum* in the north. Interestingly, the ratio of emmer and barley shows some variation between regions, although it cannot be detected for all regions and sites individually. In the central river area, emmer wheat is dominant to naked barley. In the Vecht region, naked barley is clearly dominant at Swifterbant-S3, for which a representative number of cereal finds is available. Barley is possibly also dominant at Schokland-P14 and Urk-E4, though the number of identifications at these sites is small. The data from the other sites in the Vecht region do not provide information. In the coastal region neither of the two crop plants is truly dominant to the other, and assemblages from separate sites in this region show subtle differences (further discussed in paragraph 11.6.10). The number of finds and samples from the other sites and regions presented in table 11.1 is too small to reconstruct the ratio of emmer and naked barley.

Nijmegen-Oosterhout ’t Klumke and Winterswijk in the eastern Netherlands (see table 11.1) are located in the middle of Pleistocene sand soils. Although the number of identifications from these sites is very small, the crop assemblage shows considerable correspondence with the wetland sites.[3] It is therefore hypothesised that emmer and naked barley were dominant at these sites as well. Some indirect evidence of the presence of crop plants at dryland sites can be derived from the presence of querns found at two Neolithic sites in the province of Noord-Brabant (discussed in Out in Ball and Van den Broeke 2007, 105).

11.2.2 Age of the macroremains

The data of the sites in the central river area demonstrate the presence of crop plants from 4220-3940 BC onwards, and the absence of crop plants certainly before 4450 BC and probably before 4370 BC. The dates on the latest absence and earliest introduction are based on the site Brandwijk-Kerkhof only, investigated on a small scale, and are supported by results from particularly Hardinxveld-Giessendam (Bakels *et al.* 2001; Out 2008a). The representativity of the results dating to the period between 4450 and 4370 BC can be improved by investigation of other dunes in the Alblasserwaard from this period (*e.g.* the Rommertsdonk).

3 See chapter 6.10 for further information on the identification of the impressions from Winterswijk.

The data of the sites in the Vecht region demonstrate that the introduction of crop plants occurred between 4300 and 4100 BC. The dates from Schokland-P14 allow introduction from 4400 BC onwards[4] but comparison with the other sites in the region suggests that the finds of crop plants from Schokland-P14 are not older than 4300 BC either. The absence of crop plants before 4300 BC is not demonstrated for this region since the investigations did not include sample programs that aimed to prove the absence of crop plants.

Interestingly, the data of Hoge Vaart strongly indicate the absence of crop plants, since the large excavation trench and numerous botanical samples did not reveal the presence of crop plants until and including the end of the last occupation phase, dated between 4350 and 4050 BC. This absence of crop plants is explained as a result of unavailability of crop plants in the Dutch wetlands during the first occupation phases at Hoge Vaart, and a result of environmental conditions and site function during the late phases, since the site was only used as a fishing camp during the last occupation phase (Visser *et al.* 2001). In view of the time range of that phase, it is also possible that even during that phase crop plants were not available yet in the Dutch wetlands either (see paragraph 5.10.3).

The oldest site in the coastal region dates from *c.* 3850 BC onwards, and is expected to date to the period after the introduction of crop plants, thus not giving any information on the precise moment of the introduction of crop plants there. The same is true for most sites in the western part of the river area (near Rotterdam). Bergschenhoek does not provide any information on the introduction of crop plants since the absence of crop plants is not significant (see appendix V). The apparent absence of crop plants at this site is generally assumed to be the result of site function as a small hunting camp. The range of the occupation period suggests that the general absence of crop plants in the Swifterbant culture may have played a role as well (see appendix V).

Combining data of the various regions, the age of the macroremains at Schokland-P14, Swifterbant, Urk-E4, Rechthoeksdonk, Brandwijk-Kerkhof and Doel strongly indicates that crop plants were introduced after (4400/)4300 BC and before 4100 BC.

11.2.3 Finds of microremains

Pollen grains of crop plants also form evidence of the presence of crop plants, although these identifications are generally more often the subject of debate (*cf.* Behre 2007). There are no identifications of pollen of pea and opium poppy. Pollen grains of Cerealia-type have been found at Brandwijk-Kerkhof (late phase; Out 2008a), the Hazendonk (appendix III), Bergambacht, Bergschenhoek, Ypenburg (Van Beurden 2008b), Schipluiden (Bakels 2006), Urk-E4 (Van Smeerdijk 2001), Schokland-P14 (Gehasse 1995), Schokkerhaven-E170 (Gehasse 1995), and near Lelystad and Tollebeek in the Vecht region (De Roever 2004, see chapter 4). The Cerealia-type pollen identifications of Bergambacht, Bergschenhoek, Lelystad and Tollebeek are doubtful since there are no finds of cereal macroremains at these sites until now. The identifications of cereals mostly concern Cerealia-type, while it sometimes concerns *Hordeum*-type or *Triticum*-type. At Urk (Swifterbant culture), a single pollen grain of *Avena*-type was identified as well (Van Smeerdijk 2001), but *Avena* sp. is not considered as a crop plant, as discussed above. At Schipluiden, phytolith analysis additionally demonstrated the presence of phytoliths of the *Hordeum*-type (Van Gijn and Houkes 2006, 180). Various authors admit that Cerealia-type pollen may represent wild grasses. Scarce identifications from Cerealia-type (Bergschenhoek) and *Hordeum*-type (Hardinxveld-Giessendam Polderweg) and large grass pollen from chronologically Mesolithic or (apparent) non-agricultural sites or occupation phases are generally not interpreted as cereal pollen (*cf.* Behre 2007, 208). In absence of other characteristics of Cerealia-type pollen, identifications of pollen grains of Poaceae > 37/40/45 μm are not interpreted as cereal pollen either.

4 The age of the cereal finds of Schokland-P14 is discussed in chapter 4 and in Out 2008c.

11.3 Evidence of use and consumption

Crop plants may have been used for various purposes, such as food for people, food for animals, temper, alcoholic drinks and symbolic/ritual uses (Dineley 2006; Verhart 2000). This paragraph investigates the evidence of use with focus on consumption (see also the discussion on the role of crop plants below). The evidence of use and consumption of crop plants has been analysed in the same way as indications of the consumption of wild plants, focussing on finds of carbonised macroremains, the frequency of finds, finds in hearths, evidence from anthropogenic concentrations, evidence from food crusts, coprolites and use-wear analysis (see chapter 9).

Cereal remains are found at a relatively large number of sites. Cereals are usually found in a carbonised state, which supports handling by people and which is probably related to fire involved in the crop and food processing and/or with the burning of refuse. Of all the plant macroremains, remains of emmer and naked barley are most frequently found in a carbonised state, except for the remains of *Corylus avellana* (see chapter 9). The samples that contain carbonised cereal remains moreover frequently contain taxa that are probable food plants (see paragraph 10.3.2). The frequent presence of food plants in these samples supports that samples are related to food, implying that the cereals present in these samples were consumed. Concentrations of carbonised remains of crop plants are known from the Hazendonk (see appendix III), containing emmer and naked barley (and rye brome). In addition, considerable numbers of carbonised chaff remains of emmer were found in some samples at Schipluiden and Ypenburg. Finds of cereals from hearths are known from Doel (*T. aestivum/durum*), Urk-E4 (wheat), Schipluiden (emmer and naked barley) and Ypenburg (emmer). At Schipluiden, there is evidence of the processing of coarsely crushed grains of emmer embedded in an organic matrix, possibly representing porridge (Kubiak-Martens 2006b). Interestingly, phytolith analysis of querns of the same site suggests the crushing of cereals as well (Van Gijn and Houkes 2006, 180). The analysis of food crusts from Ypenburg also demonstrated the preparation of emmer wheat (Kubiak-Martens 2008). There is little explicit evidence of the intentional and regular use of cereals in ways other than as food. The presence of cereal remains inside some fragments of pottery from Schokland-P14 was interpreted as intentional use of cereal remains as temper (Gehasse 1995, 59). There is no knowledge of other evidence of the intentional use of cereal remains as temper or decoration (pers. comm. Raemaekers). Residual analysis that can indicate preparation of especially naked barley by mashing and sparging (malting) (Dineley 2006) is not commonly applied at Dutch wetland sites yet, but there is no evidence of sprouted grains that could indicate the use of cereals for brewing.

In conclusion, there are various indications of the handling, processing and the consumption of cereals. However, the evidence is surprisingly restricted when considering that cereals are cultivated plants, although this may be partly related to research methods. Therefore, the restricted evidence of consumption puts the evidence of handling and consumption of non-cultivated plant taxa into perspective (see chapter 9). The indications of consumption of certain of these non-cultivated taxa is actually relatively large compared with the evidence of the consumption of crop plants, even though the range of non-cultivated use plants is presumably much larger than can be detected.

Information on the social aspects of consumption is very scarce. Only the spatial distribution at Schipluiden indicates that crop processing may have occurred at each yard (household) separately at this site (Kubiak-Martens 2006a, 329). It is therefore tentatively assumed that the daily final stage of crop processing was also done at a similar scale at other sites of the Swifterbant culture and Hazendonk group.

The peas at Barendrecht were found in a carbonised state, which supports handling by people, but other indications of handling or consumption are not available (the site of Barendrecht was however not excavated). There are few indications of the consumption of opium poppy since there are no carbonised finds and since the seeds were not found in a context that indicates consumption. The chances to find carbonised macroremains of both taxa are however small compared with cereals due to differential preparation processes, and in the case of opium poppy also due to restricted chances of preservation in a carbonised state (*cf.* Willerding 1971).

11.4 The role and importance of crop plants

One of the aspects of the neolithisation process is the social and economic role of crop plants. The function and importance of crop plants probably changed through time, from being a very exceptional new aspect in life to something that was part of the daily and seasonal routines. Also the social and symbolic function may have changed through time in relation to the introduction of crop plants (Fairbairn 2000), although this is difficult to grasp. The role and economic importance of crop plants will be investigated by discussion of aspects such as the context of finds, the character of the finds, the frequency of finds. Quantitative analyses of crop plants will not be taken into consideration since the numbers of finds are strongly influenced by use (including consumption), crop processing and food preparation, deposition, preservation and taphonomy (Jacomet *et al.* 1989; Rowley-Conwy 2004).

Firstly, the common presence of cereals supports that emmer wheat and naked barley were of importance in the subsistence of the Swifterbant culture and Hazendonk group. Remains of emmer wheat and naked barley have been found at all sites dating after the introduction of these crop plants where they can be expected in view of site function and methodology of the archaeobotanical research. The consistent common presence of the taxa indicates that the crops were probably part of the standard agricultural subsistence strategy for people of the Swifterbant culture and Hazendonk group after the introduction of crop plants (independent of quantities of calories they provided, see discussion below). The similarity of the finds from the dryland sites to the finds from wetland sites supports the dominance of emmer wheat and naked barley there.

Secondly, the role of emmer wheat and naked barley in the subsistence of the Swifterbant culture and Hazendonk group is supported by the evidence of consumption, although the restricted amount of evidence may suggest restricted importance compared with other food sources (discussed in paragraph 11.3).

Thirdly, the finds of cereal remains from the Early and Middle Neolithic Dutch wetland sites from which context data are known were mainly collected from refuse layers, and additionally from hearths, refuse pits and unlined wells. Material collected from refuse layers is generally interpreted as the result of general practices that accumulated over a long period of time, resulting from regularly occurring activities. There are no indications that macroremains samples were collected from possible ritual or symbolic contexts. The contexts of cereal macroremains finds therefore indicate that the cereals were used in daily life during domestic activities, which are in this case primarily interpreted as activities related to food processing, preparation and consumption (*cf.* Fuller *et al.* in press; Jones and Rowley-Conwy 2007; Stevens 2003). If cereals had a more special function, such as a symbolic meaning or a ritual function, it is expected that finds were primarily known from specific contexts such as deposition pits as observed at Hardinxveld-Giessendam De Bruin, and possibly in higher densities per sample.

An aspect related to the importance of crop plants is the absence of evidence of the storage of crop plants at Dutch wetland sites. Subterraneous storage of plant food at the wetland sites was probably not possible because of the high ground water level and the humid climate. Storage in aboveground structures or within houses should however have been possible, but such structures were not attested except for two possible granaries at Ypenburg (Houkes and Bruning 2008, 83). The absence of storage structures does not demonstrate that crop plants were not stored, neither that they were not incorporated in the subsistence, since chances of carbonisation of stocks play an important role (see Jones and Rowley-Conwy 2007, 401). One could on the one hand argue that absence of storage finds indicates limited occurrence of stocks of cereals, suggesting that cereals only occurred in small quantities (*cf.* Stevens 2007, 383), and on the other hand that the high importance of cereals resulted in stocks not being lost by accidents or forgotten.

The presented arguments on the importance of crop plants indicate that emmer and naked barley were incorporated in the common domestic subsistence practices of the Swifterbant culture and Hazendonk group and were consumed on a regular basis, at least during the period for which data are available.[5] It must however also be questioned how important crop plants were in comparison to other food sources that were part of the subsistence. In the first place, the economy of the Swifterbant culture and Hazendonk group was a broad-spectrum economy, based on a large variety of food sources, both before and after the introduction of domestic animals and crop plants (Louwe Kooijmans 1993a, b; Zeiler 1997). It may be assumed that the importance of single food sources including crop plants in the broad-spectrum economy was only moderate, since people did not primarily depend on a single source, and since other resources could be drawn on in case of shortages. On the other hand, it may be argued that each of the many food sources had its own function in the subsistence, and that each of them was considerably important as a result, for example by serving specific dietary needs in specific seasons. The importance of crop plants *versus* gathered plants cannot be reconstructed since quantitative analysis of the ratio of crop plants and gathered plants is hampered by differential representation and differential recovery (discussed above). The data nevertheless show continuity in the assemblage of gathered plants that probably functioned as food plants, suggesting that crop plants did not replace gathered food plants immediately (see chapter 9).

The fact that crops were cultivated locally at the wetlands or not (see paragraph 11.6) does not strongly influence the importance of the crop plants in the subsistence, since it is the presence and use of crop plants that is relevant. The role of cereals at sites that imported their crops from elsewhere, possibly after exchange with other communities, may have been as important as at sites that cultivated their own crops.

11.5 Environmental possibilities and restraints for crop cultivation

The following paragraphs discuss the conditions favourable for the cultivation of emmer and naked barley, followed by discussion of the conditions at the Dutch wetland sites. Wheat can best be cultivated in a climate with a relatively high mean winter temperature and moderate rainfall, well distributed through the season (Renfrew 1973). Optimal conditions for cultivation of wheat are loamy, rich and damp soils rich in humus, while unfavourable conditions are loose sandy or peaty soils and wet clays (Renfrew 1973). Barley prefers a temperate climate with moderate rainfall and a long and cool ripening season, and fertile, well-drained, deep loamy soils. It tolerates the most extreme conditions of all cereals, especially concerning salinity and alkalinity (Körber-Grohne 1987; Renfrew 1973). If grown on sandy soils, the yields will be low, while the crop will tend to lodge when grown on nitrogen-rich soils (Renfrew 1973). It should be realised that there consist many local varieties of both crops that are sometimes well adapted to local conditions.

The climate in the Netherlands during the Early and Middle Neolithic, being some degrees warmer than today, was no restriction for crop cultivation. The discussion will focus on three major factors that possibly influence the suitability of dryland patches in the wetland regions for crop cultivation: fertility, sediment and hydrology.

Fertility is assumed to have been not restrictive for arable farming at the dryland patches. Soil formation had started at dryland patches, but had not resulted in podsolisation yet (Berendsen 1997a; Hommel *et al.* 2002), which made most dry terrain probably suitable for arable farming. Possible factors that resulted in fertilisation are flooding resulting in the deposition of clay and organic material, and the presence of wild and domestic animals that left excrements. Both factors have an optimal effect as long as the field or crop is not destroyed. Flooding by (slightly) brackish water probably resulted in an influx of nutrients as well, for example in the

5 The observed role of crop plants in the Swifterbant culture may be related to the possible absence of information on the earliest introduction of crop plants in the culture/regions in the data set studied, during which crop plants may have had another function.

coastal region and in the northern estuary. This would not have been a problem as long as the influx of salinity was restricted, especially during the growing season (Van Zeist *et al.* 1976, 137).

The sediment of the wetlands surrounding the sites studied (peat, detritus, clay and gyttja) was definitely not suitable for crop cultivation due to the high water table. Only dry patches may have been suitable for crop cultivation. Types of dry terrain present in the studied wetland regions were dunes, natural levees, channel belts, crevasse splays, outcrops of glacial till, isolated coastal dunes in the former beach plain, the high salt marsh and relatively dry parts of the beach plain in the coastal region, mainly consisting of sand and/or clay.

Hydrology was probably a major factor in view of crop cultivation at dryland patches. Firstly, flooding during the growing season reduced the possibilities of crop cultivation at relatively low dryland patches. Secondly, the ground water table influenced the possibilities and restraints for crop cultivation. In case of relatively low water tables, the presence of humic soils and vegetation may have been essential for the availability of moisture in the soil at and around arable plots, since these factors influence the availability of capillary water. The gradual rise of the ground water level may have increased the possibilities for crop cultivation at the dry terrain in the wetland regions through the Atlantic and Sub-Boreal, but in the end restricted the extent of the area suitable for crop cultivation in the studied regions to a few scarce patches. The continuation of the gradual rise of the ground water level finally resulted in the submerging of most of the studied sites and in their complete unsuitability for crop cultivation. The role of the ground water level is of course different for those sandy dryland regions where the ground water level did not reach the surface.

The overall suitability of dry terrain in the wetlands probably depended on the scale of arable farming. Large-scale crop cultivation, based on fields of several hectares, would have resulted in large-scale deforestation, disturbance of the hydrology, disturbance of the nutrient cycles and finally into the reduction of the possibilities for permanent crop cultivation, if cultivated over a period of several thousands of years. Small-scale crop cultivation, based on plots of several square metres up to a few hundred square metres, would have resulted in less problematic implications for the environment and enhanced possibilities for crop cultivation.

11.6 Local crop cultivation at Dutch Early and Middle Neolithic wetland sites?

Local cereal cultivation at the Dutch Early and Middle Neolithic wetland sites has been the subject of debate in the Netherlands for *c.* thirty years. Opinions on cultivation shifted considerably through time, especially concerning Swifterbant-S3 and the Hazendonk that played a key role in the discussion (Bakels 1981, 1986; Casparie *et al.* 1977; Louwe Kooijmans 1976, 1993b; Van Zeist and Palfenier-Vegter 1981). Initially, finds of pollen and macroremains of cereals were interpreted as evidence of local crop cultivation in the direct vicinity of the sites, without the consideration of alternatives. Indeed, if the same remains were found at sites located in the middle of dry terrain, local crop cultivation would not have been the subject of debate at all. Soon people presumed potential problems concerning crop cultivation at the wetland sites, and started to doubt and finally reject local crop cultivation, assuming the import of crop plants from other regions instead. Renewal of the discussion has resulted in refinement of the arguments and conclusions, and local crop cultivation now gains support again (Cappers and Raemaekers 2008; Out 2008a, Out 2008c; see the discussion below). The discussion concerns primarily sites where macroremains have been found or where they are expected based on chronology, and does not concern 'Mesolithic farming'.

The central aspects of the discussion are the apparent contradiction between the botanical finds at the wetland sites and the expectations on crop cultivation. On the one hand, archaeobotanical finds as presented above indicate at least the consumption of crop plants, and possibly even local cultivation at the dryland patches where the sites are located or in the exploitation area of the sites. According to some scholars, an important argument in favour of local crop cultivation concerns the finds of heavy chaff remains (rachis internodes) of naked barley. In this view, the internodia exclude long-distance transport and thus demonstrate local crop cultivation, assuming that the relatively heavy chaff remains of free-threshing cereals primarily represent a by-product of initial stages of crop processing that would have been removed from the crop product before transport in view of volume reduction (Cappers and Raemaekers 2008; Casparie *et al.* 1977; Kubiak-Martens 2006a; Van Zeist and Palfenier-Vegter 1981). This assumption is based on ethnographic models from regions outside Northwestern Europe (*e.g.* Hillman 1981, 1984; Jones 1984).

On the other hand, our present view on arable farming, which does not necessarily correspond with the view of the Neolithic people, results in the tendency to reject crop cultivation at the wetland sites for three main reasons. Firstly, environmental conditions may be considered as far from optimal for crop cultivation compared with conditions at modern-day fields. The small occupied dryland patches were surrounded by wetlands where flooding must have occurred on a regular basis. Most sites were located on partly sloping terrain, where deforestation could have caused a considerable risk of erosion. Other aspects of discussion are the ground water table and the fertility of the soils (see paragraph 11.5). Secondly, it was indirectly or directly presumed, and sometimes still is, that crop cultivation was practised on a considerable scale, comparable with the fully agricultural LBK and Late Neolithic cultures. This expectation has resulted in calculations of *e.g.* minimal amounts of surface of dry terrain needed to feed complete households for a year (*e.g.* Bakels 1986). The extent of the dry terrain that is available at the wetland sites then becomes a major restricting factor for local crop cultivation. The amount of dry surface in the wetland regions was limited and moreover decreased through time due to the gradual rise of the ground water level. It can however be questioned whether crops were indeed cultivated on such a scale as supposed, or that large plots were not necessary for cultivation, since crop cultivation possibly played a less important role at the Dutch wetland sites with an extended broad-spectrum economy than in fully agricultural societies (see paragraph 11.4). Crops may alternatively have been cultivated at dryland patches within the wetland regions other than the occupied ones where sites are being excavated. Thirdly, interpretations of subsistence, site function and mobility patterns in combination with expectations on crop cultivation play a role in the discussion on crop cultivation at the wetland sites. Could people that were not fully sedentary have cultivated crops? Do fields need to be guarded during the whole growing season? Could crops have been cultivated at sites where hunting played a major role in the site function? These aspects are clearly related to expectations on the scale and importance of crop cultivation in the subsistence and society. They are very difficult to reconstruct for the case of the Early and Middle Neolithic Dutch wetlands for which precise ethnographic parallels do not exist.

An alternative for local crop cultivation is that crops were brought in from Pleistocene sandy dryland regions. For the central river area this would concern in the first place the province of Noord-Brabant, and alternatively Zuid-Holland and Utrecht. For the Vecht region this would concern dryland in the Flevopolder, Gelderland and Overijssel and/or Drenthe. Import from other regions cannot be excluded either. The hypothesis on the import of crop plants is not confirmed or rejected by information on crop plants in the dryland regions since there is hardly any information on settlement or subsistence available from these regions (see paragraph 11.2). The restricted knowledge about the cultural identity and mobility of the people living on the sandy soils and the relationship between the communities in the drylands and wetlands enables the presumption of a variety of interaction models that may have resulted in import of crop products at the Dutch wetland sites.

The paragraphs below aim to discuss the various arguments that play a role in the discussion on local crop cultivation at the Early and Middle Neolithic Dutch wetland sites and to investigate the evidence from the sites studied related to these arguments. The discussion deals with evidence from non-botanical archaeology such as artefacts and features, and archaeobotanical evidence based on pollen diagrams, potential arable weeds, and the composition of samples with crop plants. The results are summarised in table 11.2.

site (phase)	date (yrs cal BC)/cultural group	crop plant macroremains (impressions included)	Cerealia-type pollen	internodia of naked barley	querns	sickle gloss	tillage marks (fields)	micromorphological analysis	seeds of potential arable weeds	pollen: deforestation	coprophilous fungi and/or parasites	interpretation publication	new interpretation
Central river area													
Hazendonk (3)	3670-3610	+	+	-	+	+?	-	-	+	+	-	var.	-?
Hazendonk (1/2)	4020-3790	+	+	+	?	+?	-	-	+	+	-	var.	-?
Meerdonk	4030-3910	+	ni	cf. 1	ni	ni	ni	ni	+	ni	ni	n.r.	-?
Rechthoeksdonk	4240-3980	+	ni	ni	ni	ni	ni	ni	+	ni	ni	n.r.	-?
Brandwijk-Kerkhof (L50/L60)	4200-3800	+	+	+	?	-	-	-	+	+	-	?	-?
Brandwijk-Kerkhof (L30/L45)	4600-4400	-	-	-	?	-	-	-	+	-	-	-	-
Zijdeweg	5220-5100	-	ni	ni	ni	ni	ni	ni	-	ni	ni	n.r.	-
De Bruin	5500-4450	-	-	-	-	-	-	-	+	±	+	-	-
Polderweg	5500-5000	-	+	-	-	-	-	-	+	±	-	-	-
Western river area													
Barendrecht 20-125	3660-3380	+	ni	-	ni	ni	-	ni	+	ni	ni	?/n.r.	?
Barendrecht 20.126	4050-3790	+	ni	+	ni	ni	-	ni	+	ni	ni	+	?
Bergschenhoek	4300-4100	-	+	-	ni	ni	-	ni	+	+	-	-	-
Randstadrail CS	5600-5400	-	-	-	ni	ni	-	ni	+	+	-	n.r.	-

Table 11.2 part 1.

site (phase)	date (yrs cal BC)/cultural group	crop plant macroremains (impressions included)	Cerealia-type pollen	internodia of naked barley	querns	sickle gloss	tillage marks (fields)	micromorphological analysis	seeds of potential arable weeds	pollen: deforestation	coprophilous fungi and/or parasites	interpretation publication	new interpretation
Coastal region													
Rijswijk-A4	Haz	+	ni	+	ni	ni	ni	ni	+	ni	ni	n.r.	+?
Sion	3640-3380	+	-	-	-	-	-	ni	+	-	+	?	+?
Wateringen 4	3700-3400	+	-	+	+	-	-	ni	+	-	-	+	+
Schipluiden	3600-3400	+	+	+	+	+	-	ni	+	-	-	+	+
Ypenburg	3850-3450	+	+	-	+	+	-	+	+	-	+	+	+
Eem and Vecht regions													
Schokkerhaven-E170	3950-3700	+	+	-	ni	ni	ni	ni	+	-	-	+?/n.r.	+?
Swifterbant-S3	4350-4050	+	-	+	+	-	+?*	+?*	+	-	-	var.	+?
Urk-E4	4200-3500	+	+	-	-	ni	+?	+	+	+?	+	+	+?
Urk-E4	7300-5000	ni	ni	-	-	ni	-	ni	+	ni	ni	-	-
Schokland-P14	4400-3600	+	+	-	+	ni	-	ni	+	-	-	+	+?
Hoge Vaart	6600-4150	-	-	-	-	-	-	-	+	±	+	-	-

Table 11.2 part 2.

site (phase)	date (yrs cal BC)/cultural group	crop plant macroremains (impressions included)	Cerealia-type pollen	internodia of naked barley	querns	sickle gloss	tillage marks (fields)	micromorphological analysis	seeds of potential arable weeds	pollen: deforestation	coprophilous fungi and/or parasites	interpretation publication	new interpretation
Eastern Netherlands													
Winterswijk	4250-3700	+	ni	-	ni	ni	ni	ni	ni	ni	ni	n.r.	+?
Nijmegen-Oosterhout	3770-3530?	+	ni	-	+	ni	-	ni	+	ni	ni	n.r.	?
Scheldt valley (B)													
Doel Deurganckdok-sector B	4540-3960	+	-	-	ni	ni	ni	ni	+	-	+	-	?

B = Belgium
Haz = Hazendonk group

indications of local cultivation:
ni = no information available, not investigated or not published
+ = present
+? = presumably present
± = evidence of moderate strength
- = not present
? = present but not assigned to a single phase
* = evidence of marks available for another location

interpretation:
+ = local cultivation at or near the site
- = no local cultivation
? = not clear
+?/-? = further research can give more detailed results
var. = publications present various interepretations
n.r. = not relevant (no publication, not investigated or not possible to investigate)

Table 11.2 The sites of the Late Mesolithic, the Swifterbant culture and the Hazendonk group, evidence of local crop cultivation. "Interpretation" concerns the interpretation on local crop cultivation at or nearby the site, part 3.

11.6.1 Querns

Querns used for the grinding of cereals support the local processing and consumption of cereals. The presence of querns cannot be used as an argument supporting local crop cultivation, while the absence of querns can tentatively be used as an argument against consumption and thus cultivation of cereals at the site. A problem remains to distinguish stones used for the grinding of plants in general from stones used for the grinding cereals.

Grinding stones and querns have been found at Polderweg, De Bruin, Brandwijk-Kerkhof, the Hazendonk, Schipluiden, Wateringen 4 and Schokland-P14. Detailed use-wear and phytolith analysis has however been performed and/or published for a small number of sites only. Use-wear analysis of the querns of Polderweg and De Bruin did not indicate the processing of cereals (Van Gijn and Houkes 2001), in agreement with the absence of cereals at these sites. The stone assemblage at Hoge Vaart did not contain querns or grinding stones, and use-wear analysis or phytolith analysis was not performed. The absence of querns at this site corresponds with the absence of crop plants, although the absence of stones used for grinding other plant material is remarkable. Use-wear analysis of a fragment of a quern found at Brandwijk-Kerkhof could not demonstrate or reject cereal processing (pers. comm. Verbaas 2006). Phytolith analysis of querns of Schipluiden has indicated the presence of phytoliths of cereals (Van Gijn and Houkes 2006, 180).

11.6.2 Sickles and sickle gloss

Flint sickles and sickle gloss that is related to cereal cutting are considered as being indicative of local crop cultivation since these finds implies harvesting, although it cannot be excluded that the sickles are brought in together with crop plants (for example when people were on their way through). A wooden artefact interpreted as a possible haft of a sickle is only known from Ypenburg (made of oak; Kooistra 2008b). The absence of sickles at other sites does not necessarily indicate that crops were not cultivated locally since crops may have been harvested in other ways than with sickles, or since sickles may have been deposited at off-site locations. In the absence of more artefacts, sickle gloss on flint forms the best alternative to demonstrate cereal harvesting. The general term sickle gloss may refer to cutting grasses, sedges and rushes rich in silica, splitting and peeling of plants, as well as sod-cutting (Anderson 1992, 182-183). In this paragraph it concerns only gloss in a longitudinal direction indicative of cutting cereals.

Bienenfeld (1986) demonstrated the presence of use-wear indicative of soft plant working on flint artefacts of Swifterbant, the Hazendonk and the dryland site Gassel (province of Noord-Brabant), but she was not able to distinguish between the working of cereals and other plants (especially wild grasses). The results are therefore not informative and cannot be used as an argument in favour of local crop cultivation (*contra* Cappers and Raemaekers 2008).

At De Bruin, Polderweg, Hoge Vaart, Urk-E4 and Wateringen 4 there are indications of the working of plants including siliceous plants that may theoretically represent cereals, but cereal working was not positively demonstrated (Van Gijn, Beugnier and Lammers-Keijsers 2001; Van Gijn, Lammers-Keijsers and Houkes 2001; Peeters, Schreurs and Verneau 2001; Raemaekers *et al.* 1997).[6] The results from these sites therefore do not support local crop cultivation. The analysis of flint from Swifterbant has not resulted in positive identification of sickle gloss (pers. comm. Van Gijn 2004[7]). The presence of sickle gloss indicative of cereal working is rejected for Brandwijk-Kerkhof (pers. comm. Van Gijn 2006). Convincing evidence of cereal gloss in a longitudinal direction indicative of cutting cereals has been found at Ypenburg and Schipluiden (Van Gijn *et al.* 2006, 154; see also note 20). Some flint artefacts from the Hazendonk (Hazendonk phases 2 and 3) showed considerable similarity with this material, but the results were not as convincing as the material from the coastal region (pers. comm. Van Gijn 2008).

6 See also paragraph 3.7.6.

7 Results from the recent excavations are not included (*cf.* Out 2008c).

The discussion above indicates that sickles are rarely found at wetland sites of the Swifterbant culture (except for possible finds at the Hazendonk), although evidence of absence is not demonstrated for all sites. In contrast, they are better known from especially the coastal sites from the Hazendonk group. The meaning of this find pattern remains to be investigated. It may be questioned whether local crop cultivation was practised at sites of the Hazendonk group only, or that the two closely connected cultural groups applied different harvesting techniques or possibly treated and deposited their harvesting tools differently (see also Van Gijn 2008, 198). Data from contemporaneous sites from the Swifterbant culture and Hazendonk group on the sandy soils are scarce and cannot function as a reference.

11.6.3 Arable plots

The presence of arable plots at wetland sites would be a strong argument in favour of local cultivation. Their presence is difficult to prove or reject since the characteristics of the fields and tillage techniques applied at the sites studied are hardly known, nor the resulting features. The oldest ard marks in the Netherlands are found at Zandwerven, Bornwird and Groningen, probably dating to the Vlaardingen group, Funnel Beaker culture and the Single Grave culture (Fokkens 1982; Van Iterson Scholten 1988; Kortekaas 1987). Similar straightforward features are not known from the Swifterbant culture and Hazendonk group. Features interpreted as tillage marks are known from Urk-E4 and Swifterbant-S4 that date to the middle phase of the Swifterbant culture (Huisman and Raemaekers 2008; Peters and Peeters 2001). The features of Urk are discussed in chapter 4. There is not enough information to confirm or reject the interpretation of the relevant features as the oldest ard marks or tillage marks of the Netherlands. The results of the investigation of the features at Swifterbant-S4 were not published in detail yet at the time of writing this text. At both sites, the results from micromorphological analyses support the interpretation of the features as resulting from tillage. Micromorphological analysis of a layer at Ypenburg points to the same direction (Kooistra *et al.* 2002). The problem that arises from the available micromorphological data is, however, that it is difficult to distinguish tilling of the soil from other kinds of disturbance.

Tillage marks are not known from any of the other studied wetland sites. This does not demonstrate the absence of fields since they may have been located on parts of dryland patches that became eroded or at dryland patches that were not investigated. Tillage marks may alternatively have been washed out when they were uncovered for a considerable period (Thrane 1989). In addition to scarcity of features indicative of the presence of arable plots, there are no finds of artefacts that can be related to the preparation or working of arable plots.[8]

11.6.4 Indications of human impact in pollen diagrams

Indications of human impact in pollen diagrams, and especially deforestation, play a role in the discussion on local cultivation. Positive indications of deforestation indicate that cultivation may have been practised, and the scale of deforestation may provide information on the scale of cultivation. It should however be realised that indications of human impact in pollen diagrams can also be explained by other factors than cultivation, such as grazing. The absence of indications of deforestation has been used as an argument against (large-scale) local crop cultivation (*e.g.* Bakels 1986; Van Regteren Altena *et al.* 1963a). Detection of deforestation however depends on *e.g.* the sampling location, sample interval and the openness of the natural vegetation. The absence of indications of deforestation in pollen diagrams can therefore only be applied as an argument against local crop cultivation when a large amount of data on the development of the vegetation enables the detection of small-scale changes in the vegetation at the dry terrain that surrounded the relevant site.

Distinct deforestation phases that are possibly related to crop cultivation are visible in the pollen diagrams of the semi-agricultural sites Brandwijk-Kerkhof (late phases; Out 2008a) and the Hazendonk in the

8 For one artefact from Schokland-P14 a relation with tillage was proposed (Gehasse 1995, 60-61, see also paragraph 4.3.3.3).

central river area. The results indicate that it concerns human impact on a small scale (see chapters 2 and 8). The evidence of disturbance appears to be stronger than at non-agricultural sites in the region. Indications of deforestation at these sites can be used as a supportive argument in favour of local crop cultivation, but do not demonstrate local cultivation since vegetation may have been disturbed for other reasons.

Information on the development of the vegetation and the scale of human impact in the Vecht region is restricted (see chapter 8). Arable farming on any scale cannot be excluded. Only at Urk the pollen samples from the presumed tillage features explicitly indicate very open vegetation that may be related to cultivation, but this open vegetation could also have resulted from the submerging of the site (see paragraph 4.5.6). In the coastal region, the vegetation was very open naturally, and information on deforestation is restricted (see paragraph 3.10.2). As a result, it is not possible for this region to use the openness of the vegetation to investigate the probability of local cultivation.

11.6.5 Presence of Cerealia-type pollen

Paragraph 11.2.3 presents the finds of cereal pollen. The macroremains indicate that this pollen probably represents emmer or naked barley. Emmer and naked barley both are autogamous (self-fertilising) plants (Zohary and Hopf 2000). Most of the pollen is therefore not released during flowering but instead during threshing, in case of free-threshing cereals, or during dehusking, in case of hulled cereals (Behre 1981; Bottema 1992; Robinson and Hubbard 1977; Willerding 1986). Experiments of Bottema (1992) indicated that considerable quantities of pollen of naked barley are still present in the ear after harvesting. As a result, pollen of Cerealia-type found at the Dutch wetland sites does not necessarily indicate local crop cultivation, but may represent crop processing instead. Even the pollen of *Hordeum*-type cannot be interpreted as being indicative of local crop cultivation since it is not known whether they were transported in chaff (see discussion below).

The possibilities to detect arable plots are restricted. Experiments at Jalès, France indicate that the percentage of wild and modern wheat pollen grains in an arable field is *c.* 10% of the total number of pollen and spores, 2-4% at 10 metres distance and 1-2% at 50 metres distance (Diot 1992). Pollen analysis of the ard marks and from the vegetation horizon of a Funnel Beaker field in Groningen demonstrated the presence of only a single pollen grain of Cerealia-type (Mook-Kamps and Van Zeist 1987). Pollen analysis at ten metres distance of a Bronze Age field near Haarlem hardly demonstrated the presence of the field either (Bakels 2000a).[9] These results indicate that absence of pollen of Cerealia-type does not necessarily demonstrate the absence of arable fields, and that it is difficult to distinguish the pollen signal of a field from a pollen signal of a site where crops were processed. This distinction is especially problematic in the case of sampling of general contexts such as refuse layers, in contrast to sampling of more specific features such as tillage marks.

11.6.6 Dung indicators

The presence of coprophilous fungi and intestinal parasites (*e.g. Trichuris* sp.) in pollen diagrams or pollen samples can be used as an indication of the presence of dung. When assuming that the deposition of dung was the result of intentional manuring, this may support local cultivation. Even in the case that relevant information is obtained from tillage features, it can be questioned whether a small number of relevant micro-organisms demonstrates manuring as a planned practice that was applied to the arable plot only, or that it resulted from free-roaming cattle, domestic pigs or wild animals. The relationship between dung-indicators and the presence of crop cultivation is even more problematic when the identifications are not collected from tillage features. Diagrams showing changes in the curves of dung-indicators that can be related to the start or end of cultivation, independent of enrichment due to occupation in general, can give a new form of evidence of local cultivation at the sites studied in the future (*cf.* the methods of Innes and Blackford 2003; Innes *et al.* 2006).

9 See also the discussion in Brinkkemper 1993, 24 on the subject of detection of arable fields by pollen analysis.

11.6.7 Arable weeds

The presence of potential arable weeds (as defined in chapter 10), attested at practically all sites, does not indicate local crop cultivation for several reasons. Firstly, it is often unclear whether the potential arable weeds are indeed related to the crop product or whether they represent local disturbance indicators. Even taxa that are known as anthropochoures in other Neolithic cultures in Northwestern Europe are not necessarily related to crops at the sites studied (see paragraph 2.8.4.3). Secondly, the presence of arable fields results in the presence of weeds, but the import of crop products can result in presence of weeds as well.

Potential arable weeds that are with certainty associated with the crop product and that with certainty represent the regional vegetation would indicate local crop cultivation. The fact that most samples subjected to macroremains analysis represent refuse layers, made up by a combination of deposition processes, prevents the detection of associations between crop plants and other taxa (see chapter 10). It is furthermore very difficult to exclude that weed taxa may have grown in another region. For the coastal region a clear association between crop products and salt marsh taxa is not demonstrated (see chapter 3). Nevertheless, the unique presence of *Hordeum marinum* and *Malva neglecta*/*Malva* sp. that are likely to represent arable weeds in the coastal region supports local cultivation there, since these taxa are not known from other wetland regions (see chapter 10).

Alternatively, taxa that are associated with the crop product and that with certainty do not represent the local and regional vegetation indicate the import of cereals from another macroregion. An exceptional example in this respect is the presence of large numbers of *Bromus secalinus*-type in the cereal concentrations at the Hazendonk. The importance of *B. secalinus*-type there forms a contrast to apparent absence of this taxon in later assemblages from the same site as well as other sites in the region, indicating that crops were brought to the site from elsewhere (see appendix III). Comparable large numbers of *Bromus* sp. are moreover not reported for any of the other Early and Middle Neolithic Dutch wetland sites.

11.6.8 Poor development of emmer wheat

The presence of grains of *Triticum monococcum*-type interpreted as emmer grains could indicate cultivation under less suitable conditions, implying local cultivation at the wetland sites that would result to poor development of the crop (see Van Zeist and Palfenier-Vegter 1981, 143 and paragraph III.4.5). This argument is however not valid since it implies that the wetland sites were less suitable for cultivation than dryland sites, an assumption that should not be used since it is based on our view on the cultivation practices instead of data. The validity of the argument can be tested by comparison of the wheat found at wetland sites and wheat found at dryland sites of the Swifterbant culture and Hazendonk group when finds from dryland sites would become available.

11.6.9 Internodia of naked barley

At certain Dutch wetland sites, finds of internodia of naked barley have been used as an argument indicative of local crop cultivation. This argument is primarily based on the ethnographic work of *e.g.* Hillman (1981, 1984) indicating that free-threshing cereals are generally not transported in the ear, and that grains of naked barley are usually separated from chaff remains including internodia in an early stage of crop processing (after harvest and before transport). This would be especially beneficial in view of the economic costs of transport of chaff and straw (volume and weight) and the ease to remove the chaff remains.

The argumentation that internodia of naked chaff indicate local cultivation has been applied to Schipluiden (Kubiak-Martens 2006a), Swifterbant-S3 (Cappers and Raemaekers 2008; Casparie *et al.* 1977; Van Zeist and Palfenier-Vegter 1981) and Barendrecht 20.126 (Brinkkemper in Moree 2006, 25). In contrast, this argument is not applied for internodia found at the Hazendonk in those interpretations that assume import (Bakels and Zeiler 2005, 317, 318; Louwe Kooijmans 1993b). The internodia found at Brandwijk-Kerkhof are included in the discussion on local cultivation, but do not lead to a final conclusion (Out 2008a). This means that the argument is not applied consequently to all sites. Importantly, it has been argued above that the absence of internodia of naked barley is the result of poor representativity, implying that internodia of naked barley were probably present at all sites (paragraph 11.2.1). The presumed common presence of naked barley raises two questions: how to explain this find pattern, and can the internodia still be used to conclude local cultivation?

A first hypothesis that corresponds with existing interpretations on the internodia is that it may be assumed that naked barley was locally cultivated at all sites, and emmer wheat as well. This hypothesis corresponds with the model of small-scale cultivation at the wetland sites as part of the risk-spreading extended broad-spectrum economy (Cappers and Raemaekers 2008; Louwe Kooijmans 1993b). However, the indications of cereal import at the Hazendonk (phase Hazendonk 1; see appendix III) form an argument against this interpretation, at least for that site and this specific phase.

A second hypothesis is that naked barley was transported into the sites studied and that the crop product still contained some internodia despite earlier threshing (*cf.* Gehasse 1995, 223). Especially these heavy chaff remains tend to be overrepresented in the final crop product, whereas final processing of the crop product at the sites studied would have resulted in discarding of this waste (Hillman 1981, 135, 1984; Stevens 2003, 66). This explanation can possibly explain the find assemblages of most sites (with possible exception of Schipluiden and Ypenburg). This hypothesis, however, makes it difficult to distinguish between quantities of internodia resulting from threshing and quantities of internodia resulting from final cleaning of a threshed crop product.

A third hypothesis is that naked barley was transported to the wetland regions as unthreshed ears, which has been concluded for the Hazendonk as well as for the Late Neolithic wetland site Hekelingen III of the Vlaardingen group (*cf.* Bakels 1988, 161, 2000b, 105; Louwe Kooijmans 1993a, 133). Indeed, the transport of ears of both emmer and naked barley can be considered to be supported by the finds of ears and indications of import in the material of phase 1 at the Hazendonk (see appendix III). The transport of naked barley over kilometres distance is usually rejected because of the ethnographic models assuming that naked cereals were threshed in an early stage of crop processing, and because of the transport costs that can be reduced by threshing before transport. There are however three reasons why this hypothesis would be economically worthy after all. Firstly, naked barley may have been transported in the chaff because of use of the chaff, *e.g.* for winter fodder for domestic animals. Secondly, the transport of naked barley in the ear, with part of the stems still attached, may have been economic because of optimal after-ripening of the crop and/or protection against moisture and fungi (Cappers 2006, 435-436; Cappers *et al.* 2004; Maier 1999, 93).[10] Losses of grain during transport of naked barley, being a free-threshing cereal, would have been restricted when the crop was transported before it was fully ripened (*cf.* Maier 1999, 92). The few indications of harvesting of naked barley before complete ripening are presented above (paragraph 11.2.1). Finds from the Single Grave site Mortens Sande 2 in Denmark also point to harvesting of not completely ripe naked barley (Robinson and Kempfner 1987, 126). A third reason for transport of naked barley in the ear (or possibly with the stems still attached) could be the restricted availability of labour forces for crop processing at the location where the crop was grown (Fuller *et al.* in press; Stevens 2003). If there are not enough people in the producing community to thresh the harvest, naked barley may be transported and stored at the consumers households in unthreshed state. This may apply to the extended broad-spectrum economy of the Swifterbant culture and Hazendonk group since the combination of hunting, collection of gathered plants and agricultural practices may have resulted in an accumulation of activities during late summer and autumn.

10 According to the ethnographic model of Cappers (2006) based on observations in Egypt, the argument of harvesting not completely ripe naked barley for optimal after-ripening implies transport of not only ears of naked barley, but also of complete stems that were still attached to the ears. However, Maier (1999, 92) has suggested for the Middle Neolithic site Hornstaad Hörnle IA that storage of naked barley in the ear without complete stems was applied, based on indications of cutting the barley high on the culm, while the ears were presumably still after-ripening during storage. It remains an open question which scenario is most relevant for the Dutch Neolithic harvesting processes. Ears with large parts of the culm attached were not found at the sites studied but this may be related to the poor preservation of these soft plant parts rather than processing and transport practices.

The arguments that explain the presence of internodia of naked barley without local cultivation presented above indicate that the ethnographic models are too simplistic to use the finds of internodia as a decisive argument for local crop cultivation without consideration of other arguments. Indeed, Hillman (1981, 131, 138) has emphasised that the storage products are highly variable between regions, depending on the climate. It was furthermore explained that cleaning with sieves is undertaken in small batches in wet climates (referring to sieving after threshing of free-threshing cereals amongst others) (Hillman 1981, 155). Interestingly, there are both historical and archaeobotanical examples that demonstrate that crop processing was not always in concordance with the model that is central in the theory that is applied to cereal finds at Dutch wetland sites. Historical examples of the storage of sheaves in the ear at consumer sites are known from Scandinavia (Hillman 1984, 8) and Great Britain (Tusser 1580 cited in Fuller *et al.* in press and Stevens 2003). Archaeobotanical examples from storage of free-threshing cereals in the ear are known from the Swiss Middle Neolithic site Hornstaad Hörnle IA (various cereals including naked wheat and naked barley stored in houses; Maier 1999) and Neolithic sites in Switzerland and southern Germany (naked wheat; Jacomet and Schlichterlee 1984)**.**

A final important question is whether the internodia of naked barley are still informative in the discussion on local cultivation at wetland sites of the Swifterbant culture and Hazendonk group. For the moment, it can only be concluded that the presence of internodia cannot be used as an argument in favour of local cultivation, while only high-quality indications of the absence of internodia of naked barley, not affected by preservation, number of finds or research methods, can give an argument against local cultivation. New approaches to argue in favour of local cultivation could concern quantities of internodia and the ratio of internodia and grains of naked barley but these numbers will always partially be influenced by factors other than local cultivation.

The presence of spikelet forks and glume bases of emmer is not relevant for the discussion on local crop cultivation since emmer is a hulled wheat. In contrast to free-threshing cereals, transport of hulled cereals as semi-threshed product is no subject of debate (Hillman 1981, 1984).

11.6.10 Ratio of emmer and naked barley

A new argument in the discussion on local crop cultivation is the ratio of naked barley and emmer. The cereal finds at the sites studied are dominated by carbonised material. Comparison of the quantities of carbonised finds of emmer and naked barley does not necessarily give a representative view on the importance of the taxa at single sites since differences in preparation and use may result in more frequent carbonisation of remains of especially hulled emmer wheat (though see Meurers-Balke and Lüning 1992). It can however be assumed that preparation and use was approximately similar at the different sites, and that ratios of emmer and naked barley can be compared between sites and between regions.

Paragraph 11.2.1 discusses the main trends in the ratio of emmer and naked barley. Naked barley is clearly dominant at Swifterbant-S3, and at Schipluiden during the early phases. Both these sites are located in regions where minor to moderate marine conditions occurred (minor in case of Swifterbant), as indicated by identifications of pollen, macroremains and diatoms (see chapters 3 and 4). Experimental crop cultivation at high salt marshes has demonstrated that naked barley tolerates marine conditions better than emmer wheat (Bottema *et al.* 1982, 139). The dominance of naked barley at sites with marine conditions therefore may be explained by crop cultivation at the sites or in the exploitation area of the sites. The shift of dominance from naked barley to emmer wheat at Schipluiden can then be related to decreasing marine conditions. Similarly, it has been suggested that the dominance of naked barley at the Late Neolithic site Aartswoud is related to crop cultivation on high salt marshes (Gehasse 1985).

The crop assemblages from the other sites in the coastal region do not support or reject the hypothesis of local cultivation. At Ypenburg, emmer appears to be the dominant crop plant, but the difference between the numbers of grains of both cereals is restricted, a large number of cereal grains could not be identified up to genus level and it is not possible to analyse changes through time that could show more subtle patterns (see Van Beurden 2008a). The ratio at Wateringen 4 is approximately equal, which corresponds with the very restricted marine influence at this site. This ratio therefore may support local cultivation but does not reject cultivation at more inland locations.

The crop assemblages from the central river area (Brandwijk-Kerkhof and the Hazendonk) may support the hypothesis on the relationship between the presence of marine influence and the dominance of naked barley. The assemblages show dominance of emmer, which corresponds with the absence of marine influence. However, the ratio of cereals does not give information on the location of crop cultivation for this region, except that the crops were not imported from the coastal region. The cereal assemblages from sites other than those discussed above, including other sites in the Vecht region, comprise too small numbers of cereals to discuss the ratio of the two crops.

11.6.11 Site function

Site function is a final argument relevant for the discussion on crop cultivation. Local cultivation has been considered as less likely for sites with a specific (seasonal) function related to hunting, fishing or fowling, such as Bergschenhoek and Hoge Vaart (last phase), and may be rejected for Brandwijk-Kerkhof and the Hazendonk (see paragraph 2.8.1). Local crop cultivation has instead been proposed for sites that represent a year-round occupied settlement or that could have had such a function during certain occupation phases (sites in the coastal region and the Vecht region other than the Swifterbant sites). In addition to year-round occupation, intermittent summer occupation at seasonal base camps enables local cultivation when spring sowing is assumed, for example in the case of Swifterbant-S3 and possibly the Hazendonk.

11.6.12 Conclusion on the types of evidence

Analysis of the available evidence gives some clear results on the value of some arguments. Several types of evidence should not play a decisive role in the discussion on local cultivation, which are the presence of pollen and grains of cereals, the presence of internodia of naked barley, the presence of potential arable weeds, the presence of parasites and potential dung indicators, the presence of querns, indications of the presence of 'sickles' based on outdated research methods, the apparent absence of indications of deforestation, the absence of sickles and the absence of features indicative of soil tillage. The positive types of evidence from this list indicate consumption only and are expected at sites in the case of import as well, while the negative types of evidence do not demonstrate that cultivation was not practised (see discussions above).

Types of evidence that remain are indications of human impact in pollen diagrams, weed assemblages pointing to import, the presence of sickles and sickle gloss (as defined above), and the presence of tillage marks. Indications of human impact from pollen diagrams reject large-scale cultivation for many sites except those in the coastal region and the Vecht region. Information from the weed assemblage pointing to import is only known from phase 1 of the Hazendonk. Such a conclusion is only possible when weed assemblages from comparable sites in the region are known and when these are sufficiently representative. The presence of flint artefacts with sickle gloss in a longitudinal direction resulting from the working of cereals strongly supports local crop cultivation. The analysis and the criteria for the distinction of tillage marks at sites of the Swifterbant culture and Hazendonk group seem to be still under development, since it remains to be defined how to distinguish tillage marks from other features indicative of disturbance convincingly by using a variety of research strategies (see paragraph 11.5.3). The presence of tillage marks may appear to be a highly useful supportive argument in the future discussion on local crop cultivation, after more research with attention to sampling (and control sampling), dating and refutation of alternative interpretations.

The discussion on the different arguments makes clear that the discussion has gone into such a detailed level that it is difficult to prove or reject local crop cultivation at Dutch Neolithic wetland sites. A profound conclusion should be based on a combination of both archaeobotanical and archaeological arguments.

11.6.13 Conclusion on local crop cultivation at the sites

Table 11.2 shows an overview of the available evidence on local cultivation from the sites studied of the Late Mesolithic, the Swifterbant culture and Hazendonk group. The evidence of individual cultural phases of sites is presented separately when relevant and/or possible. It should be realised that a discussion of the data on the level of occupation phases, for which sufficient information is generally lacking, would be more nuanced.[11] No information on evidence (ni) is reported when the data set, research or excavation did not enable the discovery of relevant finds, while absence (-) is reported when the data set could possibly have included the relevant evidence in view of the research methods and the quality of the data set. True absence of finds is however not always demonstrated since research methods, preservation and taphonomy are highly relevant as well.

The absence of finds of crop plants is taken as a very good indication against the cultivation of crops, although evidence of the absence of cereals is not always available. The absence of cultivation is argued for Hardinxveld-Giessendam Polderweg, Hardinxveld-Giessendam De Bruin, Zijdeweg, Randstadrail CS, Hoge Vaart, and probably Bergschenhoek. Cultivation was probably not practised during the early phases at Schokland-P14 and Urk-E4 (before 4400 BC) either.

It is hardly possible to make a final conclusion on local crop cultivation at or near Rechthoeksdonk, Meerdonk, Barendrecht 20.126, Barendrecht 20.125, Rijswijk-A4, Sion, Schokkerhaven-E170, Winterswijk, Nijmegen Oosterhout ’t Klumke, Doel and Hüde I, since the sites are investigated on a small scale or by coring only, since the results of the excavation are not completely published, since the preservation of organic remains was poor, since the number of carbonised cereal grains was small and/or since the sites appear to form individual cases in their geographical region and time period.

For the sites Brandwijk-Kerkhof and the Hazendonk in the central river area, the data do not demonstrate or reject local cultivation in a straightforward way. The pollen diagrams at least clearly indicate that large-scale cultivation did not occur, and that the discussion concerns small-scale cultivation at the sites only. The flint assemblages of phases Haz 2 and 3 of the Hazendonk contain artefacts that show similarity with the artefacts interpreted as sickles from the coastal region, but they are not convincing enough to conclude local cultivation. The function of these sites during the major phases is not sufficiently understood to incorporate in the discussion. One could argue that the option of year-round occupation at the Hazendonk would support local cultivation during certain phases, but the importance of hunting and fishing at both Brandwijk and the Hazendonk is more in support of a special site function than a base camp and can be considered as an argument against local cultivation. The strongest argument in the discussion comes from the weed assemblage of earliest phase at the Hazendonk, which indicates the import of cereals from another region. This is supported by the finds of opium poppy recovered at Brandwijk-Kerkhof that are unique for the central river area[12] and the finds of peas at Barendrecht 20.125 in the western river area. Indeed, crops could easily have been brought in by canoe trips.

For the sites in the coastal region, there are various arguments in favour of local crop cultivation near the sites or at a distance of a few kilometres: at least some of the sites were occupied and functioned as permanent settlements, there are indications of disturbed soil interpreted as arable fields, the dominance of naked barley seems to be related to marine conditions, and there are finds of flint artefacts with gloss in a longitudinal direction indicative of cereal cutting. The absence of indications of deforestation does not reject cultivation since the absence is related to the open character of the natural vegetation and its low pollen production (see chapter 3). However, due to the absence of information on deforestation, there is no information on the scale of the arable plots.

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11 It is furthermore assumed that the complete crop assemblage from a site was either cultivated locally or imported. The consideration of individual crops instead of crop assemblages could also result in a more nuanced view.

12 The finds of opium poppy at Brandwijk-Kerkhof possibly represent an even more unique find since the other finds of opium poppy possibly all date to the Late Neolithic, and could all be younger than the finds from Brandwijk-Kerkhof.

For most sites in the Vecht region there is not enough information to conclude whether crop cultivation was practised at the sites and/or in the exploitation areas since there is little relevant information on these sites. The number of cereal finds from sites other than Swifterbant-3 is too small to make conclusions on the ratio of crop plants, detailed pollen analyses are hardly available (except for Schokland-P14), and modern-day use-wear analysis and phytolith analysis is not available for most sites (except for Swifterbant). The argument of site function is difficult to apply due to the long-term occupation and mixed assemblages at Schokland-P14 and Urk-E4. For Swifterbant, temporary summer occupation is not in contradiction with local cultivation, but seasonality and site function data are only available for a few of the large number of sites from the cluster. A few arguments in favour of cultivation at or near the sites in the Vecht region are nevertheless available. Firstly, two sites in this region showed features that may represent soil tillage features. Furthermore, the indications of open vegetation and identifications of cereal pollen from samples collected from the presumed tillage features at Urk-E4 tentatively support local cultivation. Finally, the dominance of naked barley at Swifterbant-S3 can be explained by local cultivation, at least in the region. The absence of flint artefacts from S3 showing relevant sickle gloss seems to be in contrast to the indications of local cultivation, but is not relevant when it is assumed that the crops were harvested in another way. In conclusion, the available evidence of local cultivation in the Vecht region is best for Swifterbant and Urk-E4, although it needs further confirmation, while the data from Schokland-P14 and Schokkerhaven-E170 do not enable to make a final conclusion. Although relevant data are hardly available from Emmeloord, local cultivation at that site can be considered as unlikely since the (excavated) site is primarily a fishing site in the middle of a water course and since the indications of the presence of dryland vegetation are very scarce . The fragmentary information on vegetation, crop plants, weeds, sickle gloss and the information from potential tillage marks indicates that the available evidence from the northern estuary would benefit from more detailed research. There is however no reason to reject crop cultivation in that region.

11.7 Cultivation practices

This paragraph investigates various cultivation practices. It must be kept in mind that different races of emmer wheat and naked barley may have been adapted to different practices, but that it is not known what kind of races were available at the sites studied. Some aspects of the discussions on cultivation practices below are based on the analysis of potential arable weeds. The weed analysis indicates that the spectrum of potential arable weeds of the Vecht region differed slightly from the river area region and the coastal region, which could imply regional differences in crop cultivation practices (see chapter 10).

11.7.1 Cultivation methods

Four major models on cultivation put forward for the Early Neolithic in Central Europe by Bogaard (2004) are shifting cultivation, extensive ard cultivation, floodplain cultivation and intensive garden cultivation. The practice of shifting cultivation at the sites of the Swifterbant culture and the Hazendonk group is rejected by the analysis of potential arable weeds that indicates that most probable weeds are annuals, suggesting that the arable plots were continuously located on the same spot (see chapter 10 for discussion and references). It can be argued that the use of fixed plots corresponds with the limited indications of human impact at the wetland sites, since shifting cultivation would have resulted in deforestation on a larger scale (at more locations). It is not excluded that the restricted evidence of limited human impact is related to the absence of local cultivation (see below).

The practice of extensive ard cultivation (cultivation requiring little human labour per unit area and enabling cultivation of large plots, without the practice of manuring) at the sites studied has not been investigated by the same methods as Bogaard (2004). The tillage marks at Urk were interpreted as ard marks, but the features are not indisputably similar to ard marks known from later periods. Moreover, ards are not known yet from this time in Northwestern Europe (Louwe Kooijmans 2006a).

The remaining alternatives are floodplain cultivation and intensive garden cultivation. Cappers and Raemaekers (2008) suggested floodplain cultivation for the wetland sites of the Swifterbant culture because of the location in the river area (especially the Vecht region), resulting in the natural supply of nutrients and the need of spring sowing in order to avoid winter floods. Such cultivation is supported by the evidence from weeds that indicates spring sowing (discussed in paragraph 10.4.2 and below), as well as by the environmental conditions of the wetland sites, since the sites studied are all located in the delta of the Rhine, Meuse and IJssel. In the coastal region however it would primarily concern flooding by water from the sea and the estuary instead of flooding by river water alone. The features at the levee site Swifterbant-S4 that are interpreted as traces of soil tillage (Huisman and Raemaekers 2008) confirm such practices as well. Various models present floodplain cultivation as an extensive way of cultivation, whereby only restricted human labour is necessary (Bogaard 2004, 36). This would fit with many scenarios of mobility applied to (groups of) the Swifterbant culture and Hazendonk group. There are however arguments against the practice of flood plain cultivation as defined by Bogaard at the Dutch wetland sites (see the comments by Bogaard in Cappers and Raemaekers 2008).

Some (parts) of the sites studied that were situated on a relatively high location were probably less strongly influenced by floods during certain occupation phases (*e.g.* glacial till outcrops, dunes with lime woodland on top and possibly some coastal dunes). At these sites garden cultivation without natural enrichment by flooding may have been practised. The practice of intensive garden cultivation implies high inputs of human labour per unit area by *e.g.* specific sowing techniques, manuring, weeding, watering, close integration of crop cultivation and animal husbandry, and also implies small-scale cultivation because of the high inputs (Bogaard 2004, 41). This implies that cultivation played a considerable role in labour organisation, and that some people were probably sedentary during those months that the crops were grown. The data from the sites studied do not give clear evidence that supports or rejects this kind of cultivation. The model can be rejected for those sites where there is strong evidence of seasonal activity that cannot be combined with arable farming, but not for those sites that were occupied during considerable parts of the year, or year-round, or for which the seasonality and site function is unclear.

In conclusion, the botanical data of the sites studied reject shifting cultivation while there is no substantial evidence of extensive ard cultivation, leaving floodplain cultivation and intensive garden cultivation as alternatives. The botanical data from the sites studied do not allow distinction between the two methods, whether only one or both were practised, whether different cultivation practices were applied to separate crops, *etc.* Knowledge about the intensity of cultivation, possibly to be obtained by the FIBS method (Functional Interpretation of Botanical Surveys; Charles *et al.* 1997), as well as more knowledge about the location of arable plots of the Swifterbant culture could possibly give more detailed insight.

11.7.2 Separate or mixed cultivation?

One aspect of crop cultivation is whether people cultivated emmer and naked barley as maslin crop (together in the same fields) or separately. Based on ethnographic models, one would expect that the two crops would not be cultivated together as a single crop since it concerns a hulled cereal and a naked cereal species, which are processed in different ways (*cf.* Cappers and Raemaekers 2008; Juel Jensen 1994, 110). The composition of samples containing cereal remains was investigated in order to answer the question.

Pollen data from the sites studied are generally not suitable to investigate separate or mixed cropping since cereal pollen is not identified up to genus or species level, and since the time-range of individual samples is often too large due to sampling of refuse layers. Only the pollen data from presumed ard marks at Urk-E4, identified up to species level (Van Smeerdijk 2001), suggest separate cultivation of emmer since pollen grains of barley were not found. However, the validity of the results would have been stronger if the number of samples was larger.

More data on the composition of crops can theoretically be found in the macroremains assemblage since these can be identified up to species level. Table 11.3 shows the composition of macroremains samples at the sites studied where crop plants were found. Firstly, the table shows that there is evidence at various sites of samples that contain both crops. This may indicate anything, since the two crops may have been combined in any stage of cultivation, crop processing, food preparation and waste discarding. The presence of samples containing both crops therefore does not prove mixed cultivation. Alternatively, the data do not enable the exclusion of the cultivation of a maslin crop either.

Secondly, some samples contain remains of a single crop only, especially emmer wheat. It concerns not only samples from refuse layers but also some (scarce) samples from concentrations that contained emmer only (see paragraph 10.3.1). The presence of these unmixed samples suggests separate cultivation of emmer. The evidence is available for a few sites only (in particular the Hazendonk phase 1, Ypenburg and Schipluiden). It remains a question for further research whether the relevant samples and data are representative of arable farming at these sites and at the Early and Middle Neolithic Dutch wetlands in general.

11.7.3 Harvesting methods

Potential harvesting methods could be the burning of the harvest[13], picking or stripping of ears by hand, beating of ears, using reaping knives and *mesorias* to pull off or cut off ears, reaping the ears and part of the culm with a sickle and uprooting (Anderson 1992; Hillman and Davies 1992). Beating of ears is no likely option since it is not suitable for domestic cereals (particularly hulled cereals), needs repetitive harvesting moments and results in relatively high losses (Anderson 1992, 182-183; Hillman and Davies 1992). Picking of seed heads by hand and collection of the grains after crop burning are highly time-consuming, but time-consuming methods could especially have been applied to small arable plots (Zapata Peña 2007, 200), which may apply to the wetland sites studied. Uprooting could have been applied at sandy soils at the sites studied but is less suitable for crops cultivated on clayey soils that dry out in summer (Hillman and Davies 1992, 128).

Various authors (Van Beurden 2008a, 316; Gehasse 1995, 60; Kubiak-Martens 2006a, 325; Vernimmen 2001, 66) have suggested for the Swifterbant culture and the Hazendonk group that naked barley was harvested prior to the final stage of ripening, preventing losses by the harvesting activities themselves that would have caused the scattering of ripe grains, and that the harvesting was followed by after-ripening before food preparation. This harvesting method implies the harvesting of (part of) the stems of naked barley in order to optimise the after-ripening process (*cf.* Cappers 2006), or harvesting with sickles (Cappers and Raemaekers 2008, 387).

The evidence of sickle gloss at the sites studied is discussed in paragraph 11.6.2 and has been demonstrated with certainty for sites in the coastal region only. The botanical finds may also give indications on harvesting methods since different methods result in the harvesting of different products, although with some variation. The finds of small quantities grains of naked barley that are still hulled in chaff or that showed some similarity with hulled barley indicate that harvesting resulted in the collection of grains that represent various stages of ripening. This implies the gathering of ears and not loose grains, thus rejecting beating and hand-stripping of ears for the collection of separate ripe grains (hand-plucking of complete ears is not excluded). The finds of emmer wheat and naked barley in combination with collars at the Hazendonk (phase 1, Swifterbant culture) also supports the collection of whole ears and tentatively rejects the collection of ears by stripping (see appendix III). The weed analysis of all sites studied indicates that the crops were mainly harvested at the middle or upper part of the culm. In the coastal region, two taxa additionally suggest harvesting on a relatively low height (see chapter 10). These results all support the model presented above that cereals were harvested prior

13 Burning of the harvest involves burning the crop in the field, followed by gathering of grains from the ground (Hillman and Davies 1992, 129).

site	cultural group	mixed samples	pure emmer finds	pure naked barley finds	representativity
Central river area					
Meerdonk	Sw	+	-	-	?
Rechthoeksdonk	Sw	+	-	-	?
Hazendonk (3)	Haz	+	+	-	?
Hazendonk (1/2)	Sw	++	++	-	ok
Brandwijk-Kerkhof (L50/L60)	Sw	+	+	+	?
Western river area					
Barendrecht 20.125	Haz	+	-	-	?
Barendrecht 20.126	Sw	+	+	-	?
Coastal region					
Rijswijk-A4	Haz	-	+	+	?
Sion	Haz	+	-	-	?
Wateringen 4	Haz	+	+	+	ok
Schipluiden	Haz	+	+	+	ok
Ypenburg	Haz	++	++	+	ok
Vecht region		-	-	-	
Schokkerhaven-E170	Sw	+	+	-	?
Swifterbant-S3	Sw	+	+	+	?
Schokland-P14	Sw	-	+	+	?
Urk-E4	Sw	+	+	+	?
Eastern Netherlands					
Nijmegen-Oosterhout	Haz	-	+	-	?
Winterswijk	Sw	+	-	-	?

Sw = Swifterbant culture
Haz = Hazendonk group

+ = present
++ = frequent
- = not present

ok = sufficient
? = questionable

Table 11.3 The sites of the Swifterbant culture and the Hazendonk group with crop plants, composition of the cereal macroremains samples. The representativity is based on the number of cereal finds, and the number of samples that contained cereals and of which the composition has been published for individual samples.

to the final stage of ripening. The finds of sickle gloss in the coastal region moreover support harvesting with sickles. It remains a subject for further research how harvesting was practised in other regions, and whether emmer wheat and naked barley were harvested in the same way or not. For example, the stripping of ears with reaping knives and *mesorias* is especially effective for hulled cereals and less suitable for free-threshing cereals (pers. comm. Anderson 2007; Mery *et al.* 2007, 1110; Zapata Peña 2007).

11.7.4 Autumn-sown crops or spring-sown crops

T. dicoccon can be cultivated as autumn-sown crops and spring-sown crops (see Brinkkemper 1993, chapter 6 for a more extensive discussion of the relevant literature). *Hordeum vulgare* is mainly cultivated as an autumn-sown crop (Körber-Grohne 1987). The environment of the Dutch wetlands, with high risk of flooding during autumn and winter, was probably more suited for spring-sowed crops than autumn-sown crops. Various authors assume spring sowing because of this environmental argument (*e.g.* Cappers and Raemaekers 2008; Gehasse 1995, 67; Kubiak-Martens 2006a; Peters and Peeters 2001, 121), but the assumption is not always discussed or tested by data. The analysis of potential arable weeds from the sites studied has been analysed in order to investigate the validity of the assumption. The group of probable arable weeds is indeed dominated by summer-annuals, supporting spring sowing. However, winter-annuals are also present among the weeds of the sites studied. In addition, indicators for spring sowing may be overrepresented in waste products since the dimensions of their seeds and fruits tend not to be similar to those of cereal grains, in contrast to autumn sowing indicators (Bogaard *et al.* 2005). This may also apply to the data of the Dutch wetland sites since the data set of the Dutch wetland sites in the first place represents waste products instead of storage finds.

11.7.5 Manuring

Fertility of the soil is one of the factors influencing the suitability of sites and regions for arable farming. Some evidence of manuring practices in Europe is available at least from the Late Neolithic onwards (Bakels 1997). For the Swifterbant culture and the Hazendonk group, it can be questioned whether manuring was necessary, and what the available evidence is. In the case of floodplain cultivation, it is expected that people did not need to practise active manuring at the wetland sites since the landscape was probably manured naturally (see paragraph 11.7.1).

The practice of manuring with dung started in the Netherlands presumably in the Middle Bronze Age, when stables for domestic animals were present (Fokkens 2005, 464; De Hingh 2000, chapter 9). The explanation is that housing allows the efficient collection of dung on a considerable scale. For the Swifterbant culture and Hazendonk group, there are no indications of the presence of stables or structures used for the housing of domestic animals. This suggests that dung was not easily collected on a considerable scale. It can nevertheless not be excluded that dung was collected incidentally for dispersion on arable plots, or that domestic animals roamed through the fields when these were not in use. The archaeological data do not provide further details on the activity areas of domestic animals and the protection of fields that would influence natural fertilisation by animals.

Investigation of Urk-E4, Swifterbant, Ypenburg and Sion indicates that vegetation was probably burned, both at sites and at possibly unoccupied dryland patches (see chapters 3 and 4). This may indicate the clearance of vegetation by burning, which would result in open patches and, in cases of mixing of the ashes in the soil, improved fertility of the soil. Such burning practices may have been performed in relation to cultivation. Evidence of the burning of vegetation however does not demonstrate the use of the location as an arable plot. The burning of vegetation could also have been applied to create open space for other purposes, while ash layers could also have resulted from a long history of daily activities.

An alternative method of fertilisation would be the distribution of mud and/or decomposed plant remains (peat) from the surrounding wetlands on the fields (see references in De Hingh 2000, 159). This would have been a fertiliser that was easily available at all sites. Such fertilisation remains highly hypothetical since there is no evidence of need or practice of it. At the sites studied, this practice would probably not be recognisable in the botanical data set since it concerns enrichment with taxa from the natural vegetation whose presence could have resulted from natural flooding as well, depending on the height of the arable plots and the distance to open water. At sites of the Swifterbant culture located on dryland soils, manuring with mud and peat may be recognised easier, since wetland vegetation and water plants are a less important component of the natural vegetation in those regions (*cf.* Bakels 1997).

11.8 Comparison with other cultures and regions

This paragraph compares the data from the wetland sites of the Swifterbant culture and the Hazendonk group with other Northwestern European Neolithic cultures. The other cultural groups represent on the one hand Early and Middle Neolithic groups that may have influenced the neolithisation process in the Dutch wetlands, and on the other hand later Neolithic groups from the Netherlands and other parts of Northwestern Europe. The first group comprises the LBK, the Großgartach culture, the la Hoguette group, the Limburg group, the Blicquy group, the Rössen culture and the Michelsberg culture. The second group comprises the Vlaardingen group, the Ertebølle culture, the Funnel Beaker culture and the Early and Middle Neolithic cultural groups in Great Britain and Ireland. Discussed subjects are the crop assemblage, the period of introduction, the importance of crop plants in relation to local cultivation, and cultivation practices. The comparison aims to identify differences and similarities between various different cultures and regions and the sites studied to improve our understanding of the cultivation practices and the introduction of crop plants.

11.8.1 Crop plant assemblages from other Neolithic cultures

The following paragraph aims to give an overview of the crop plants from Neolithic cultural groups that are comparable with the Swifterbant culture and Hazendonk group in chronological and geographic respect. Table 11.4 shows an overview of the relevant crop plant assemblages, based on data from sites in Northwestern Europe (Arora and Zerl 2004; Bakels 1999, 2003; Bakels and Rouselle 1985; Bakels and Zeiler 2005; Behre and Kučan 1994; Campbell and Robinson 2007; Heim and Hauzeur 2002; Hopf 1982; Knörzer 1991, 1997; Knörzer *et al.* 1999; Kroll 1981; Modderman *et al.* 1976; Päffgen and Zerl 20005; Robinson 2007; Van Zeist 1970). The data of the wetland sites Swifterbant culture and Hazendonk group are added for comparison. For some relevant cultural groups representative data are not available (la Hoguette, Limburg, and dryland sites of the Swifterbant culture and Hazendonk group), while data from the Blicquy group are scarce (Bakels 1990, 86).

Comparison of the rather uniform crop assemblage of the Swifterbant culture and the Hazendonk group with earlier and contemporaneous Neolithic cultural groups in Northwestern Europe shows that the assemblage from the sites studied is relatively narrow. Naked wheat (*Triticum aestivum* or *Triticum durum*) is present in the Blicquy group, Rössen culture, Bischheim group and Michelsberg culture, but not in the Swifterbant culture and Hazendonk group. *Triticum monococcum*, *Lens culinaris*, *Linum usitatissimum*, *Papaver somniferum* ssp. *setigerum* and *Pisum sativum* are not present at most of the wetland sites studied, while these are present in several of the other earlier and contemporaneous Neolithic cultural groups. The difference between the crop assemblages of early and contemporaneous Neolithic groups on the one hand and the Swifterbant culture and Hazendonk group on the other hand indicates that a strong selection of crop plant species occurred during the introduction of crops into the Swifterbant culture. The reasons for this selection process are unclear, though may be related to the change from cultivation in the loess regions to cultivation in sandy regions outside the loess region, and the (possible) shift of arable plots from the sandy regions to the wetlands regions afterwards.

cultural group/region \ taxon	Triticum dicoccon	Triticum monococcum	Triticum aestivum	Triticum durum/turgidum	Triticum aestivum/durum/turgidum	Hordeum vulgare var. vulgare	Hordeum vulgare var. nudum	Pisum sativum	Lens culinaris	Papaver somniferum ssp. setigerum	Linum usitatissimum	Avena sp.	Panicum miliaceum
Great Britain	+	+			+	+	+			+	+		
Funnel Beaker culture (Denmark and NW Germany)	+	+	+			+	+				(+)	(+)	(+)
Funnel Beaker culture (NL)	+	+					+	+			+		
Vlaardingen group	+		+			(+)	+			+	+		
Hazendonk group	+						+	+					
Swifterbant culture	+	+?					+			+			
Michelsberg culture	+	+		++			+	+		+	+		
Bischheim group	+	++	+	+	+		+	+	+	+			
Rössen culture	+	+	++			+	++						
Blicquy group	+	+	+					cf. +		+			
Großgartach culture	+	+											
LBK culture	++	++				-	(+)	+	+	+	+		

NW = Northwestern
NL = the Netherlands

+ = present
++ = frequent

(+) = present though of restricted importance
+? = presence unclear

Table 11.4 Neolithic cultures and regions in the Lower Rhine Basin, Northwestern Europe, main crops based on macroremains and their impressions (see paragraph 11.8.1 for sources).

Possible relevant factors varying between the different regions are environmental conditions at the arable fields such as availability of nutrients and minerals in the soil and climate, or cultivation practices and cultural preferences. The selection process remains poorly understood since there are hardly any data available on crop plants from the sandy dryland regions in between the loess soils and the wetland regions in the Lower Rhine Basin for the relevant period before 4100 BC (see paragraph 11.2.1).

Comparison of the crop assemblages of the Swifterbant culture with earlier and contemporaneous cultures provides information on the introduction process. Naked barley hardly plays a role in the subsistence of the LBK in the Rhineland; it became an important crop plant in that region only in the Rössen culture under influence of a southern connection (Bakels 1990). This makes it less probable that the LBK communities in the Rhineland played a key role in the introduction process of crop plants at wetland sites of the Swifterbant culture. However, finds of naked barley are known from more western regions inhabited by the LBK (Aisne valley, the Kleine Gete area and the upper Dendre area; Bakels 1992b, 5, 1999, pers. comm. Bakels 2008[14]). The results on the assemblage of the Blicquy group are not representative enough to make conclusions on the comparison of crop assemblages. The crop assemblages of both the Rössen culture and the Michelsberg culture show considerable similarities with the assemblage of the Swifterbant culture, except for the presence of naked wheat which is not commonly present at sites of the Swifterbant culture and Hazendonk group.

11.8.2 Period of introduction

People of the LBK introduced crop plants in the loess region in the very southern parts of the Netherlands (south Limburg) and surrounding regions in Belgium and Germany at *c.* 5300 BC. The sites Maastricht-Randwijck of the Rössen culture and Maastricht-Vogelzang of the Michelsberg culture confirm the consumption and cultivation of crop plants in this southern region in the subsequent cultural stages (Bakels 2008; Bakels *et al.* 1993). Crop plants thus were more or less continuously present from 5300 BC onwards at less than 200 km south/southeast of the wetland sites.

There is little knowledge about the absence, presence and introduction of crop plants on the sandy soils that bordered the Dutch wetlands in the Neolithic due to the poor preservation of organic material on these sandy soils. Some indications of the presence of crop plants at dryland regions occupied by Swifterbant communities come from the pollen-analytical study of Bakker (2003). There are indications of the presence of cereals in (northern) coastal regions from at least 4050 BC onwards and the presence of cereals in the province of Drenthe from *c.* 3500 BC onwards (Bakker 2003).

In Denmark and northern Germany, the evidence from macroremains indicates that cereals were present from 4100 BC onwards, corresponding with the presence of the Early Neolithic stages of the Funnel Beaker culture (Hartz *et al.* 2007, 587; see also the relevant references of table 11.4). Incidental pollen evidence suggests that cereals may have been present at the time of the Ertebølle culture, perhaps as the result of exchange, and cereal presence is (tentatively) suggested particularly from 4300/4200 BC onwards (Fischer 2002; Hartz *et al.* 2002; Kalis and Meurers-Balke 1988, Wiethold 1998, 268; see paragraph 8.3). The early pollen identifications are however not confirmed by indisputable finds of macroremains (discussed in Behre 2007).

For Great Britain and Ireland, early arrival of cereals before 4000 BC has been suggested based on pollen evidence, especially in Ireland. Evidence based on macroremains however indicates the presence of cereals only from 4000 BC onwards (see Behre 2007 and Brown 2007 for a summary of the discussion). In conclusion, comparison of the period of crop introduction between Swifterbant culture and more or less contemporaneous cultural groups in Northwestern Europe indicates that the process started slightly earlier in the Dutch delta (before 4100 BC). The specific subsistence in the wetland regions does not exclude that the process may have started even earlier in the Pleistocene sand regions in the Netherlands occupied by the Swifterbant people.

14 See also Crombé and Vanmontfort (2007) for the locations of the two latter regions.

11.8.3 The location of arable plots

The discussion on local cultivation at Dutch wetland sites during the Early and Middle Neolithic may also be relevant for other cultural groups and regions in Northwestern Europe other than those presented in this study. The subject is however rarely discussed for such sites and regions. A major exception is the Late Neolithic Vlaardingen group in the Netherlands, for which the location of arable plots has been discussed as well. The discussion and the arguments are highly comparable with the sites studied, especially for the Hazendonk, Vlaardingen and Hekelingen III. The similarity of the arguments is related to the similarity of the environmental conditions and in particular to the fact that the discussion on cultivation at the sites of the Swifterbant culture and Hazendonk group was partly based on the interpretation of sites of the Vlaardingen group. The interpretation of local cultivation at these sites follows the development of the discussion. For example, pollen finds of Cerealia-type at Vlaardingen were interpreted as being indicative of local cultivation in the early sixties (Groenman-van Waateringe 1969; Van Regteren Altena *et al.* 1963a, 54, 1963b, note 57). Later on, some authors rejected local cultivation on a considerable scale at all three sites (Bakels and Zeiler 2005, 327). Other sites of the Vlaardingen group are located on dunes and beach barriers. The landscape at these sites is comparable with the sites of the Hazendonk group in the coastal region, but there the extent of the dunes was larger and the vegetation had developed into woodland vegetation. Similar to dryland sites, local cultivation is no subject of debate for these sites. A very supportive argument in favour of local cultivation at these sites is that the excavation at Zandwerven revealed distinct ard marks (Van Iterson Scholten 1988).

Local cultivation has however hardly been a subject of debate for the scarce contemporaneous Dutch and Belgian dryland sites of the Swifterbant culture, Hazendonk group and Michelsberg culture. This can be related to the general absence of evidence of crop plants at dryland sites, to the less problematic expectations on the suitability of the landscape for cultivation around dryland sites, and to the absence of data on aspects such as seasonality, subsistence and mobility (*cf.* Schreurs 2005, 317). An exception is the site Oudenaarde Donk from which pollen data and a single macroremains sample are available (De Ceunynck *et al.* 1985). Based on these results, Vanmontfort (2004, 152) concluded: "That cereal pollen is present indicates that cereals were at least processed at the site and might have been cultivated nearby. …Remains of ruderal weeds are scarce and cereals [cereal macroremains] were not found. It can therefore be concluded that cereals were known and used by the Middle Neolithic occupiers, but that their importance in the diet was limited and that they were probably not grown in the immediate vicinity." It can however be argued that the single macroremains sample analysed does not offer representative results on local cultivation and the importance of crop plants.

The British discussion on the importance of crops generally does not touch the subject of local crop cultivation, as shown by the following example: "... the evidence from charred cereals suggests cultivation ..." (Brown 2007, 1048). Only Richmond (1999, 33, 34) discussed finds of cereal pollen, chaff remains, tillage tools and tillage marks to conclude that "the growing of cereals perhaps took place far from where the grains have been found. It is even possible that some of the cereals used in the Neolithic, were imported from abroad." This discussion is however strongly related to the view that cereals only had a non-economical role in society (Richmond 1999, 40, see also the next paragraph). The botanical finds can however be explained in completely opposite way (discussed below) while it should be stressed that the absence of evidence of cultivation does not demonstrate evidence of the absence of cultivation practices.

The practice of local cultivation before 4100 BC in Denmark and northern Germany is a subject of debate due to the lack of finds of macroremains (see paragraph 11.8.2); this discussion mainly concerns the interpretation of pollen evidence. The practice of cultivation in the Funnel Beaker culture in Denmark and northern Germany appears to be not much of a subject of debate among archaeobotanists during the recent years. Ard marks give clear evidence of cultivation practices, particularly in Denmark (from *c.* 3500 BC onwards; Fisher 2002; Thrane 1989). An exception comes from the Early Neolithic Funnel Beaker kitchen midden at Visborg, Denmark (Robinson 2007, 370): "A total of 4½ charred cereal grains were recovered … Whether the cereals were grown by the users of the midden is open to question. However no cereal processing waste was found, prompting the logical conclusion that the cereals were grown and processed elsewhere." Further discussion may be given in the expected archaeobotanical report about the site.

11.8.4 The importance of crop plants

There is little discussion on the importance of crop plants at the scarce dryland sites of the Swifterbant culture, Hazendonk group and Michelsberg culture, which can be explained in the same way as the scarcity of discussion on the location of fields (see the previous paragraph). There are some exceptions, such as the discussion on the importance of cereals at Oudenaarde Donk presented in the previous paragraph.

The palynological study on the province of Drenthe (Bakker 2003) hardly discusses evidence on the scale or importance of crop cultivation practised by people of the Swifterbant culture in this dryland region, which can be partly explained by the available data set, and his discussion of subsistence focuses on leaf-foddering instead. Small-scale cultivation is put forward, and is presumably based on the indications of human impact and the scarce and irregular presence of cereal pollen and ruderals including *Rumex acetosella* in the studied pollen diagrams (*ibid*., 273, table 25). It was additionally concluded that the economy was "adaptive to the environment, resulting in only minor interference with nature; it was a system that required a dispersed and mobile society" (*ibid*., 268). This seems to be more a conclusion based on general information and hypotheses on the Swifterbant culture and restricted visibility of the people on the sandy soils than a conclusion based on archaeobotanical data.

For Great Britain and Ireland the discussion on early cultivation in the Neolithic has strongly focussed on the assumed limited importance of crop plants (cereals) in mobile societies and their possible symbolic role, supposedly supported by the scarcity of tools and features that demonstrate cultivation (Richmond 1999, 34; Thomas 1999, 23-32; Whittle 2003, 157; see also references in Bogaard and Jones 2007; Jones and Rowley-Conwy 2007; Rowley-Conwy 2004; Stevens 2007). In contrast however, economic importance of cereal cultivation during the British Neolithic has been put forward based on the archaeobotanical evidence and discussion of relevant processes influencing the attested find assemblages (Jones 2000; Jones and Rowley-Conwy 2007; Rowley-Conwy 2004; Stevens 2007). Stevens (2007, 382) interestingly suggests that cereals were part of a broad spectrum of food sources in Neolithic Britain, a hypothesis that implies that the role of cereals in Britain would have been comparable with that in the Dutch wetlands. Recent hypotheses have suggested a change in the importance of cereals in Britain after 3800/3700 BC, corresponding with other aspects of neolithisation (Bradley 2008; Brown 2007).

The option of an introduction and as a result the importance of crop plants as early as in the Late Ertebølle culture in Denmark and northern Germany is the subject of debate, and the conclusions are differentiated for coastal and inland regions (Hartz *et al.* 2007; Larsson 2007). Ertebølle people had contact with early farming communities in southern areas for more than 1000 years (Hartz *et al.* 2007, 587; Klassen 2002, 315), which allows various scenarios of import, exchange and cultivation. Domestic animals and cereals were incorporated in the subsistence from *c.* 4100 BC onwards (Hartz *et al.* 2002, 2007, 587; Noe-Nygaard *et al.* 2005;Scheu *et al.* 2008). Pollen evidence indicates that an earlier presence of cereals cannot be excluded, but this has until now not been confirmed by indisputable finds of macroremains or impressions in pottery (see also paragraph 11.8.2). As a result, the discussion focuses more on the presence and introduction of crop plants than the local cultivation of crop plants.

The importance of cereals in the Danish and northern German Funnel Beaker culture after 4100 BC appears to be not much of a subject of debate among archaeobotanists during the recent years. The importance of crop plants is accepted at least for the Middle Neolithic in view of the finds of ard marks and the Neolithic (agricultural) character of the culture. Robinson (2007, 367) nevertheless has stated that "…the extent, nature and effect of settlement, cultivation and animal husbandry varied from region to region." The analysis of flint artefacts of the Funnel Beaker culture in relation to sickle gloss indicative of cereal harvesting has furthermore resulted in the suggestion that arable farming may initially have been of minor importance after introduction of crop plants, and that the importance of crop plants gradually increased during the Neolithic, although changes in harvesting and crop processing methods could also play a role (Juel Jensen 1994, 150, 156). Comparison of the discussions on the role of crop plants in other regions and cultures indicates that the questions on importance are comparable for all studies on the Early Neolithic in Northwestern Europe, although the emphasis on this aspect varies.

11.8.5 Crop practices in other Neolithic cultures

The crop cultivation methods of the LBK are reconstructed in detail by various authors, based on the analysis of botanical remains of a large number of sites. Einkorn and emmer were probably cultivated as a mixed crop in small, partly shaded fields (Bakels 1978, 62). Analyses by various authors using different methods give various results on sowing time (*e.g.* Bogaard 2004, 114; Bogaard *et al.* 2005, 508; Kreuz *et al.* 2005). The plots were probably permanently located at the same patch and shifting cultivation was probably not practised (*e.g.* Bogaard 2004, 154). Weed analysis indicates that cereals were reaped at the middle or upper half of the culm (Bakels and Rouselle 1985; Colledge *et al.* 2005, 148, though see also Kreuz *et al.* 2005). There is clear evidence of the use of sickles for harvesting, and the importance of sickles probably increased during the spread of the LBK through Western Europe (Kreuz *et al.* 2005).

The agricultural practices of the Michelsberg culture are less well known than those of the LBK, especially when considering the local groups of the Michelsberg culture bordering the Netherlands. An important difference with the LBK is that flint artefacts showing sickle gloss that resulted from cereal cutting are very scarce in the regions south of the wetland sites (Schreurs 2005, 308). Traces of use-wear indicative of the use of siliceous plants are known from Maastricht-Klinkers and Thieusies, Belgium (Schreurs 1992 and references there). The use-wear traces from Maastricht-Klinkers may be the result of cereal processing but this was not proved. The scarcity of sickle gloss resulting from cereal processing suggests that crops may have been harvested without sickles. The harvesting methods without sickles applied in the Michelsberg culture may also have been applied in the Swifterbant culture, which would explain the scarcity of sickles in this cultural group.

Bakker (2003) does not discuss cultivation practices for the communities of the Swifterbant culture living in the Northern Dutch Pleistocene sandy regions, which can partly be related to the absence of macroremains finds that are an important source of relevant information.

For Britain shifting cultivation as well as the working of small permanent plots with digging sticks has been suggested (see Rowley-Conwy 2004). The weed assemblages suggest the use of permanent plots (Bogaard and Jones 2007). The earliest ard marks from Great Britain date to *c.* 3500 BC (Ashbee *et al.* 1979). Chaff remains are relatively scarce compared with central Europe and suggest specific crop processing activities, storage conditions and/or functions of chaff in Britain (Bogaard and Jones 2007).

It is traditionally presumed that the cultivation practices of the Funnel Beaker culture in Denmark consisted of small plots that were cleared in a system of shifting cultivation (Iversen 1941; Juel Jensen 1994; Robinson 2007). Shifting cultivation is however tentatively rejected for the Funnel Beaker sites at Flögeln (Behre and Kučan 1994, 149), while it is unclear for the northern part of the Netherlands (Bakker 2003, 270). In Denmark, the oldest ard marks date to *c.* 3500 BC (Fisher 2002; Thrane 1989). There is evidence from Denmark for the use of sickles for the harvesting and cutting of the culm at such a height that relatively low-growing weeds were collected (Juel Jensen 1994, 137). Sickles are initially scarce, to become more common after *c.* 3300 BC, which is suggested to be related to the increasing importance of crop plants and/or with changes in the crop assemblage or in the crop processing activities (Juel Jensen 1994, 149). Data from the Netherlands confirm the use of sickles in the Funnel Beaker culture (Van Gijn and Bakker 2005, 286).

Comparison of the information on cultivation practices from different cultures and regions indicates that the evidence on arable plots and tools used for tillage is rather fragmentary for many parts of Northwestern Europe, similar to the Swifterbant culture and Hazendonk group. The presence of fixed plots seems probable for many regions.

11.9 Neolithisation process: dispersal of crop plants

There are several hypotheses on the introduction of crop plants into the Dutch wetlands area. Gehasse (1995, 195-198) proposed that introduction of domestic animals and crop plants into the northern part of the Dutch wetlands area occurred at *c.* 4900 BC resulting from the interaction with people of the Rössen culture. This hypothesis is based on the similarity of the material cultures and the presumed presence of domesticates from that period onwards at Schokland-P14 (see chapter 4). She suggested that there might have been earlier contact with the LBK as well.

Brinkkemper *et al.* (1999, 82) concluded that "the diffusion of crop plants to the Rhine Meuse delta may have taken place somewhere during the period 4600-4550 and 4250-4000 BC, that is during a late phase of the Rössen culture". This statement suggests the involvement of the Rössen culture in the spread of crop plants to the Dutch wetlands, especially since the LBK and Rössen culture are mentioned in the paper while the Michelsberg culture is not.

Raemaekers (1999, 191) stated that "During the third phase of the Central European Neolithic (the Michelsberg culture), crop cultivation was included in the residential mobility strategy of the Swifterbant culture from at least 4100 BC onwards." He furthermore added that "the development of new agricultural techniques by people of the Michelsberg culture (and Bischheim group) enabled the people of the Swifterbant culture to incorporate crop cultivation into their subsistence base". The Michelsberg culture plays a central role in the spread of crop cultivation according to this hypothesis. A comparable conclusion is put forward by Louwe Kooijmans (2007, 299): "So the introduction of cereal cultivation seems for the time being to be fixed at *c.* 4100-4000 BC by the presence of charred cereal remains and chaff at Swifterbant-S3 and in the lowest Hazendonk level, in combination with the pollen evidence of Gietse veentje."

Bakker (2003) concluded that "the Rössen culture seems to be responsible for the people of the Ertebølle and Swifterbant cultures first encountering agriculture. But it was only in the period of the Michelsberg culture, which extended its habitation area between 4100 and 4000 BC from the loess soils to nearby sandy soils, that agriculture gained considerably in importance in the Ertebølle and Swifterbant communities, to become an inextricable part of it." This conclusion is clearly based on comparison with northern Germany (Kalis and Meurers-Balke 1998), and furthermore strongly based on palynological data.

The section on the age of macroremains from the sites studied (paragraph 11.2.2) shows that there are no indications of the presence crop plants before (4400/)4300 BC, supported by indications of the absence of crop plants before that time in the central river area and at Hoge Vaart. This chronology indicates that there are no indications of the exchange of crop plants with the LBK, Blicquy group, Rössen culture and Bischheim group (further discussed below). The hypotheses that people of the Rössen culture played a key role in the introduction of crop plants into the wetland sites of the Swifterbant culture must therefore be rejected, except for the Vecht region where the evidence of the absence of crop plants before 4300 BC is lacking. Nevertheless, the available data suggest the introduction of crop plants after the time horizon of the Rössen culture for that region as well.

The age of the macroremains strongly indicates that crop plants were introduced after (4400/)4300 BC and before 4100 BC. This chronology indicates that the Michelsberg culture played a key role in the neolithisation process during the Swifterbant culture (as reflected in the wetlands) in view of crop plants.[15] Such a role of the Michelsberg culture in the introduction of crop plants at the wetland sites corresponds with a continuation of the (botanically visible) southern connection as proposed by Bakels (1990), with the indications of contact with the south at sites in the coastal region and central river area (Louwe Kooijmans 2007), and with the unusual presence of opium poppy and pea in the river area that may indicate active exchange processes and a developed state of neolithisation. Alternatively, the unusual presence of opium poppy and pea may be related to the intensity of research activities in the river area. The hypothesis on the influence of the Michelsberg culture furthermore corresponds with the good similarity in the assemblage of crop plants between the Swifterbant culture, Hazendonk group and Michelsberg culture (discussed above). Reconsidering the hypotheses presented above, the hypothesis of Gehasse can be rejected, while the other can be refined in a cultural or chronological sense.

It has been argued in paragraph 11.4 that the relatively common presence of cereals from 4300/4200 BC onwards suggests that they were probably part of the standard agricultural subsistence strategy in the Swifterbant culture and Hazendonk group, and played a role in the subsistence as such. Furthermore, there are no finds that can be interpreted with certainty as the earliest finds of crop plants in the Swifterbant culture, representing the first import or exchange of crop plants that may have started the introduction process. It is however not possible to exclude such exceptional exchange in an early phase of the neolithisation process, possibly with other cultural groups than the Michelsberg culture such as the Bischheim group, since this is very difficult to trace. If such exchange processes would have occurred, this could be recognised by unique finds of crop plants for which no contemporaneous finds are known in the same cultural region.[16] Therefore, the available data on the earliest presence of crop plants do not necessarily represent the earliest introduction of crop plants. Information on the first stage of the introduction process is almost by definition absent. This lack of knowledge about the details of the import and exchange processes in the initial stage of neolithisation has also been observed for other periods and regions in the Lower Rhine Basin (Amkreutz *et al.* 2008). The limited information on the introduction of crop plants is especially related to the absence of data on neolithisation from the Pleistocene sandy soils (Crombé and Vanmontfort 2007; Louwe Kooijmans 2007; Vanmontfort 2007, see also chapter 1).

The reconstructed period indicates that the introduction of crop plants took place slightly earlier than in Great Britain, Denmark and northern Germany along the Baltic. Indications of the influence of the Michelsberg culture in Denmark and northern Germany (*e.g.* Hartz *et al.* 2002, 2007, 588; Klassen 2004) support an important role of these communities in the neolithisation including the spread of crop cultivation through Northwestern Europe, although other cultural groups played a role as well (Hartz *et al.* 2002, 321). The restricted role of the Rössen culture in the introduction of crop plants in Swifterbant culture and the slightly later introduction of cereals in Great Britain indicates that the Rössen farming system was probably not "ancestral to the early farming system in Great Britain" (*contra* Coward *et al.* 2008, 54). A more prominent role of the Michelsberg culture can be put forward here.

15 It should be noticed that it may concern a local group of the Michelsberg culture since the Michelsberg culture in Belgium is labelled as the Belgian Michelsberg culture and since there is little knowledge about the cultural characteristics of the people and cultures present in the sandy regions that bordered the wetland sites during the Middle Neolithic.

16 An example of such find in the Late Neolithic in the Netherlands could be the grains of *Triticum aestivum* at Vlaardingen, which are unique for the Vlaardingen group.

11.10 Suggestions for future research

Subjects for future research are the presence and importance of einkorn, pea and opium poppy at the studied sites, improving knowledge about the Vecht region and the sandy dryland regions as much as possible by the systematic analysis of macroremains but also tubers, food crusts, phytoliths and use-wear, refining the information on the moment of introduction of crop plants and the rate of this process, refining knowledge about the initial introduction process, application of the FIBS method (Functional Interpretation of Botanical Surveys; Charles *et al.* 1997) to reconstruct agricultural practices, the application of comparative quantitative analysis of densities of crop remains per sample to reconstruct aspects of crop processing activities, and the development of the research on tillage marks.