Handbook of

PLANT PALAEOECOLOGY
Handbook of

PLANT PALAEOECOLOGY

R.T.J. Cappers
Groningen Institute of Archaeology
University of Groningen

R. Neef
Deutsches Archäologisches Institut
Berlin

Barkhuis
Groningen University Library
Groningen 2012
Contents

Preface 9

1 General Introduction 13

1.1 Plant taxonomy 13
  1.1.1 Taxonomic ranks 13
  1.1.2 Abbreviations 14
  1.1.3 Synonyms and type identifications 15
  1.1.4 Naming of cultivated plants 15
  1.1.5 Plant names in written sources 16
  1.1.6 Vernacular names of common crops 20
  1.1.7 Genetic research 22

1.2 Plant ecology 26
  1.2.1 Seed production and seed predation 26
  1.2.2 Seed dispersal 28
  1.2.3 Environmental conditions 34
  1.2.4 Water stress 37
  1.2.5 Agricultural practices 47

1.3 Flora and vegetation 93
  1.3.1 Landscape, flora, and vegetation 93
  1.3.2 Flora 94
  1.3.3 Vegetation 97

1.4 Subfossil plant remains 128
  1.4.1 Biomolecules 128
  1.4.2 Phytoliths 130
  1.4.3 Spores and pollen 131
  1.4.4 Seeds and fruits 135

2 Palynology 143

2.1 The archaeobotanical archive 143
  2.1.1 Dispersal of spores and pollen 143
  2.1.2 Pollen precipitation 144
  2.1.3 Peat Formation 146
  2.1.4 Sampling and microscopic analysis 151

2.2 Vegetation reconstruction 153
  2.2.1 Pollen diagram 153
  2.2.2 Anthropogenic pollen indicators 157
  2.2.3 Pollen precipitation and vegetation 159

2.3 Pollen morphology 159
  2.3.1 Anatomy and morphology of pollen and spores 159
  2.3.2 Glossary of terms 163
  2.3.3 Atlas of spores, pollen, and algae 165
3 Non-woody macro-remains

3.1 The archaeobotanical archive
   3.1.1 Origin and taphonomy
   3.1.2 Sampling

3.2 Morphology of fruits and seeds
   3.2.1 Morphology of fruits
   3.2.2 Fruit types
   3.2.3 Morphology of seeds
   3.2.4 Subfossil seeds, fruits, and threshing remains
   3.2.5 Cereals
   3.2.6 Pulses
   3.2.7 Oil and fibre crops
   3.2.8 Seed atlas

4 Vegetation history of the Netherlands

4.1 The Late Glacial
   4.1.1 General overview
   4.1.2 The Older Dryas
   4.1.3 The Allerød
   4.1.4 The Younger Dryas

4.2 The Holocene
   4.2.1 General overview
   4.2.2 The Preboreal (10 300–8800 BP)
   4.2.3 The Boreal (8800–7500 BP)
   4.2.4 The Atlanticum (7500–5000 BP)
   4.2.5 The Subboreal (5000–2800 BP)
   4.2.6 The Subatlanticum (2800 BP to present)
   4.2.7 Case study

5 Food economy

5.1 Transition to farming
   5.1.1 Modelling the dawn of farming
   5.1.2 Domestication

5.2 Reconstruction of the diet
   5.2.1 The food spectrum
   5.2.2 Cereals
   5.2.3 Pulses
   5.2.4 Oil crops
   5.2.5 Vegetables and fruits
   5.2.6 Case studies

6 Fuel

6.1 Woody plants
6.2 Non-woody plants

7 Appendixes

7.1 Chronology of the Near East
7.2 Chronology of ancient Egypt
8 Literature
  8.1 Taxonomy
  8.2 Ecology
  8.3 Flora and vegetation
  8.4 Identification
  8.5 Spores and pollen
  8.6 Fruits, seeds, and mosses
  8.7 Vegetation history
  8.8 Food economy
  8.9 Fuel
  8.10 Additional references cited

9 Indices
  9.1 Taxonomic and syntaxonomic index
  9.2 Subject index
Burning of kitchen trash outside the camp area (Berenike excavation, Egypt; 2000–2001 season).
Preface

Plant palaeoecologists use data from plant fossils and plant subfossils to reconstruct ecosystems of the past. This book deals with the study of subfossil plant material retrieved from archaeological excavations and cores dated to the Late Glacial and Holocene.

Subfossil plant remains offer us great opportunities for the reconstruction of former landscapes and the ways in which humans exploited and even transformed vegetations. However, to improve our knowledge of the past, we need to employ sampling procedures that will provide us with samples that contain the relevant kinds of plant material. This, in turn, means we need to have solid knowledge of all processes that act upon plant material. By modelling the transport of plant material from outside the settlement towards the settlement and its final destination in specific archaeological contexts, we can design an optimal sampling strategy to be used during the excavation.

Most archaeological contexts contain plant remains that originate from more than one source and that entered that context by more than one pathway. Recognizing these pathways — which is a real challenge — may facilitate the identification of the different depositional origins within the archaeological context. It also may help to improve the typology of archaeological contexts. Fortunately, nowadays archaeobotanical research focuses much more than it did in the past on a clear link between archaeology, taphonomy, and biology.

One of the main objectives of this book is to describe the processes that underlie the formation of the archaeobotanical archive and the ultimate composition of the archaeobotanical records, being the data that are sampled and identified from this immense archive. Our understanding of these processes benefits from a knowledge of plant ecology and traditional agricultural practices and food processing. This handbook summarizes the basic ecological principles that relate to the reconstruction of former vegetations and of agricultural practices in particular. Ethnoarchaeobotanical research offers the opportunity to document processes that assist us in interpreting subfossil records. We were fortunate to have many opportunities to observe traditional agricultural practices during our research stays in the Near East, the cradle of agriculture—especially in Turkey, Syria, and Egypt. Although there, too, globalization is resulting in the modernization of agriculture, some small-scale, traditional agriculture still exists. This offered us the possibility to research methods of crop growing, crop processing and storage, and food processing that in other parts of the world have long since been lost because of the transformation to large-scale modern agriculture. Although we recognize that, as with any ethnographic analogy, agricultural practices and food processing will have differed in the past because they were adapted to local conditions and traditions, our observations are nevertheless a valuable source of information that can be used to interpret
subfossil records. We grew up and were educated in the Netherlands, so because of this background, we have provided information on wild and crop plant ecology and history — and on vegetation ecology and history in general — from the Netherlands as well, as a means of verifying of our work in the Near East. Of course in the Netherlands, traditional agriculture has disappeared, and the definition of what is waste and garbage has changed enormously in an era of combine harvesters and waste disposal services.

Botanical evidence relating to the past is extensive and includes both written sources and subfossil records. Our ability to interpret and use earlier written sources and identifications is, however, hampered by the ongoing changes in taxonomy, which recently have become tightly linked with genetic research. Because of these changes, the same plant can be presented under different names — which is especially true for crop plants. To facilitate the consultation of these sources, this handbook presents the valid scientific plant names together with their most important synonyms. In addition, we link the most commonly used plant names in classical Latin and Greek texts with modern plant taxonomy. A substantial part of this book gives a more detailed view of plant taxonomy and morphology, especially of the main crop plants in Europe, western Asia, and northern Africa.

We hope this book will help palaeobotanists, environmental archaeologists, and colleagues from related disciplines optimize inferences based on what we could term “old-style” archaeobotany. And we hope that our observations will serve as an eye-opener and improve future research, not only as it is practised in our laboratories, but also as it is practised in the field.

We would like to thank all those who supported our research and studies. In the first place, we want to express our gratitude to the people (too many to name) of the countries where we documented traditional agriculture — especially in Turkey, Syria, and Egypt — for their hospitality and sincerity. We also extend many thanks to the archaeologists (again, too many to name individually) with whom we collaborated, and of course to the institutions that have supported our work, the Groningen Institute of Archaeology (GIA) of the Rijksuniversiteit Groningen and the Deutsches Archäologisches Institut (DAI) in Berlin. We thank Suzanne Needs-Howarth (copy editor), Nynke Tiekstra (designer and typesetter), and Roelf Barkhuis (publisher) for giving a “face” to the book. We are grateful to Renée Bekker, Susanne Jahns, Benjamin Kilian, and Jan Frits Veldkamp for their critical remarks on some of the chapters. We thank our former professor Willem van Zeist, who introduced us to the field of palaeobotany. And, finally, we would like to express our gratitude to the late professor Sytze Bottema (1937–2005), who influenced both of us a lot by the way he incorporated field observations into his research.

René Cappers and Reinder Neef
Groningen and Berlin, February 2012
1.1.7 Genetic research

Until recently, the classification of plants was mainly based on morphological and anatomical features. Over the past 20 years, much research has been done on the genetics of plants, resulting in a better understanding of phylogenetic trees and in major shifts of plants between genera and even families. However, this work is still in progress and current floras only present a status quo of our increasing insight into phylogenetic relationships. For example, based on available genetic research, the traditional classification of the Brassicaceae family turns out to be rather artificial, and a revision may be expected.

Genetic research is applied on two levels: the size of the genome and the nucleotide sequences of genes. The genome is the entire number of genes present in each cell of a particular plant taxon. A gene is a functional unit bearing the code for a specific feature of the organism. Genes are linked together in long molecules, called deoxyribonucleic acid (DNA). In organism with a large number of genes, the DNA is split up into several parts, each of which is called a chromosome. In comparison with mammals, the amount of DNA in the flowering plants varies tremendously. This is partly related to the presence of multiple copies of the chromosome set (see below). For example, the total genome of *Arabidopsis thaliana* contains 157,000,000 base pairs (157 megabases; Mb) representing 25,498 genes, which are subdivided over five chromosomes. Because of its relatively small genome size, *Arabidopsis thaliana* is one of the model plants for genetic research (fig. 2). Genes are concentrated in ‘gene islands’, and more than 80 percent of the genome consists of repetitive elements (e.g. retrotransposons).

Figure 2: Its small plant size, short life cycle, and small genome make *Arabidopsis thaliana* one of the model organisms for genetic research.
Most flowering plants are classified as diploid, which means that the genome is present as a double set of chromosomes in the nucleus of each cell. Only the gametes (pollen and ovules) of the plants have a single copy in their nucleus, being the result of a special cell division called meiosis. The division of the genome into a unique set of the genome makes it possible that each fusion of a pollen grain and an ovule results in a diploid cell. In this way, the size of the genome remains the same for a particular plant species.

The number of the unique (haploid) chromosome number is designated with the letter n (1 x n = n). Diploid organisms have two homologous chromosomes in each cell nucleus, which is designated ‘2n’. A homologous set of chromosomes contains the same genes in a fixed sequence, although the expression of both genes may differ. Arabidopsis thaliana has five different chromosomes. The genome of this diploid plant species can thus be designated as n = 5 or 2n = 10. The genome is designated with a capital letter. This is of special interest for illustrating the composition and origin of the genomes of plant species in which changes of chromosome numbers occur (viz. polyploids; see below).

Aberrant numbers of chromosomes may be present in organisms. Humans have 23 different chromosomes (n = 23), but abnormalities occur due to the absence of, for example, one of the sex chromosomes (genome is 2n − 1) or the presence of an extra copy of chromosome number 21 (genome is 2n + 1). In both cases, the aberrant number of chromosomes results in an abnormal human phenotype. The former leads to Turner syndrome and the latter to Down syndrome. Because the aberrant chromosome number results in a combination of specific, clinically recognizable features, the term syndrome is used.

In plant species aberrant numbers of chromosomes also occur. This phenomenon is of special interest with respect to the process of plant domestication. The term domestication syndrome has been introduced to describe the spectrum of traits that characterize domesticated plants. A disadvantage of this term is that it is based on a clinical perspective rather than on an ecological framework. See section 5.1.2 for a further discussion on the use of this term.

Variations in chromosome numbers can be achieved by reducing or increasing the number of chromosomes. The reduction of the number of chromosomes is largely restricted to diploid plant species, resulting in double haploid plants (monoploids) in which every nucleus has just a single copy of each chromosome. In fact, the genome of a monoploid, which in essentially is a diploid organism, is similar to that of a haploid gamete (pollen and ovules). Monoploids can be artificially produced by special tissue cultures in which, for example, plants are grown from pollen or unfertilized ovules. The use of pollen is preferred because they are more easily obtained in large quantities. Because genes can still be represented by several copies in the haploid genome, the phenotypic expression is only predictable when dealing with major genes. This kind of crop manipulation has been successfully applied to, for example, Soybean (Glycine max) and Common tobacco (Nicotiana tabacum). Once such monoploids have been cultivated, the chromosome number is doubled again by treating the cells with chemicals. In this way, double haploids are created having similar (homozygotous) chromosomes.
We are dealing with polyploids if more than two copies of the chromosome set are present. The genome of a triploid plant consists of three copies of the unique chromosome set (3n), that of a tetraploid has four copies (4n), that of a pentaploid has five copies (5n), that of a hexaploid has six copies (6n), and so forth. Each pair of chromosomes is designated with a capital letter. For example, the genome of the hexaploid Bread wheat (*Triticum aestivum* ssp. *aestivum*) is BBAADD, and can be written as 6n. This wheat species has 21 different chromosomes (7B, 7A and 7D), the total number of chromosomes being $6 \times 7 = 42$. Preferably, the genome is written as $2n = 6x = 42$, in which n is the sum of a single set of chromosomes. This means that it behaves as a diploid plant (viz. the number of chromosomes of BAD = $3 \times 7$) and x is the number of one unique set of chromosomes ($= 7$). This description can be reduced to $2n = 42$, in which the total number of chromosomes is mentioned but the polyploidy level remains obscure.

The sequence of the genome designation in genomic formulas is determined by the taxon providing the cytoplasm (ovule); thus female parent x male parent. The BA genome of *Triticum turgidum* indicates that the B genome has been donated from a female *Aegilops* plant (present in the ovule) and the A genome stems from a male *Triticum* plant (present in the pollen grain). The hybrid offspring receives the organelles, residing in the cytoplasm, from the female parent. In plant cells, organelle genes are present in mitochondria (producing energy-rich ATP molecules) and chloroplasts (conducting photosynthesis). Recombination of mitochondrial DNA (mtDNA) and chloroplast DNA (cpDNA) does not occur during sexual reproduction, but changes in the DNA structure (viz. the sequence of the bases) result from rapid mutations. For this reason, studying the organelle genes is of much interest for understanding the evolutionary relationships of plants.

The presence of more than two copies of the chromosome set is rather common in the plant kingdom. About one-third of all flowering plants are polyploids, and the proportion is even higher in economic plants. Because the number of chromosomes is large in polyploids, the nucleus and cell are often larger as well, resulting in plants that are more flexible and can adapt to different conditions and habitats. Polyploidy can be the result of chromosome duplication within a species, which is called autopolyploidy, but it can also be the result of a crossing between two different species (hybridization), which is called allopolyploidy.

Autopolyploids have been cultivated because of the increase in flowers and fruits in particular. Fruits of Grape (*Vitis vinifera*) may serve as an example. The fruits of the diploid species (genome: $2n = 38$) are normalized, whereas those of the tetraploid cultivars (genome: $4n = 76$) have fruits that are almost twice as large.

Allopolyploidy has played an important role in the cultivation history of several crops, including Wheat (*Triticum*), Banana (*Musa*), Sugarcane (*Saccharum*), Potato (*Solanum*), and Sweet potato (*Ipomoea*). *Triticum urartu* and *T. monococcum* are both diploid, having two sets of seven chromosomes, but their genome is distinct, and the related chromosomes show little affinity, as a result of which hybridization is rare (Table 7). A superscript letter designates the different character of both genomes: A<sup>a</sup> and A<sup>m</sup>. These letters are not fixed, and different combinations are used in publications. The two tetraploid wheat species, *T. timopheevii* and *T. turgidum*, both have the A genome, which is donated by *Triticum urartu*. The domestication of wheat also
includes hybridization with Aegilops species. Recent research shows that the B and G genomes were probably donated by Ae. speltoides and the D genome by Ae. tauschii, although the origin of the B genome is still a matter of debate. The domestication history of wheat most probably included two independent hybridizations of Ae. speltoides with T. urartu. The first hybridization could have taken place some 300,000 years ago, by which the B genome was donated. During a second, more recent, hybridization between the species about 90,000 years ago, the G genome was donated. Due to the long time span since these hybridizations, the genome of the outcrossing Ae. speltoides has evolved, and identical alleles are only found in the G genome; hence it gets its own designation with the letter S. Most probably, specimens of Ae. speltoides having a genome that is almost identical with the B and G genomes cannot be found anymore (Kilian et al., 2009; Kilian et al., 2011; Wang et al., 2011).

Table 7: Genotype designation of Aegilops and Triticum species. The two Aegilops species have donated their genome by hybridization.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Genome</th>
<th>A</th>
<th>B</th>
<th>G</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegilops speltoides</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>Aegilops tauschii</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum urartu</td>
<td>A&lt;sup&gt;u&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum monococcum</td>
<td>A&lt;sup&gt;o&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum timopheevii</td>
<td>G</td>
<td>A&lt;sup&gt;u&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum turgidum</td>
<td>B</td>
<td>A&lt;sup&gt;u&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum aestivum</td>
<td>B</td>
<td>A&lt;sup&gt;v&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triticum zhukovskyi</td>
<td>G</td>
<td>A&lt;sup&gt;u&lt;/sup&gt; A&lt;sup&gt;o&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recently, artificial hybridization has resulted in new crops, such as Triticale (x Triticosecale) and several Cabbages (Brassica). Triticale is a hybrid of Wheat (Triticum) and Rye (Secale cereale), combining the high yield and protein content of wheat with rye’s the adaptation to more harsh environments and its high lysine content, one of the essential amino acids. Several hybrids exist in which genomes of different wheat species have been used. No valid names on a species level are available yet. Although the first crossings were made in the late 1890s, it only became a commercial crop in the 1970s. This commercially produced hexaploid Triticale (genome AABBRR) is a hybrid of the tetraploid Hard wheat (Triticum turgidum ssp. durum; genome BBAA) and the diploid Rye (genome RR). The octaploid Triticale (genome BBAADDRR), resulting from a cross between the hexaploid Bread wheat (Triticum aestivum; genome BBAADD) and Rye, has less favourable traits and is therefore not cultivated on a commercial basis.

Within the genus Brassica, three diploid species are considered to be basic species: B. nigra (2n = 2x = 16), B. oleracea (2n = 2x = 18), and B. rapa (2n = 2x = 20). Hybridization between B. nigra and B. oleracea resulted in the tetraploid B. carinata (2n = 4x = 34), hybridization between B. nigra and B. rapa in the tetraploid B. juncea (2n = 4x = 36), and hybridization of B. oleracea and B. rapa in the tetraploid B. napus (2n = 4x = 38). Each of these tetraploids is represented by several varieties, demonstrating the large phenotypic potential within this genus.
The classification of plants has recently been improved by the analysis of DNA sequences. This kind of research focuses on the specific gene sequences, such as that of the gene *rbcL* (ribulose biphosphate carboxylase, large subunit). This gene is present in the chloroplast DNA and has the genetic code for the production of an enzyme that triggers an essential process in photosynthesis. Because of this essential trait, this gene is present in all angiosperms and is suitable for this kind of research. The phylogenetic relationship between plants is inferred by specific dissimilarities in the base sequences of the gene. The conserved regions of this gene are of special interest when comparing the same gene in different species, because they accumulate mutations over time. Assuming a rather constant rate of mutations, the dissimilarities in base sequences can be interpreted on a time scale and used for the reconstruction of phylogenetic trees. This kind of reconstruction is, however, hampered by specific events that can lead to a higher rate of mutations. The Angiosperm Phylogeny Group (AGP), which has published three overviews so far, governs this research (viz. APG 1 in 1998, APG 2 in 2003, and APG 3 in 2009).

1.2 Plant ecology

1.2.1 Seed production and seed predation

Subfossil plant remains can be used to reconstruct the former vegetation and the past food economy. Ideally, archaeobotanical data records should consist of the scientific plant name; the plant part; the number of plant remains; the preservation condition; and the presence of specific features dealing with fragmentation, predation, and processing. The number of seeds or fruits, being part of most archaeobotanical records, can be indicative of the relative contribution of each plant to the former vegetation or food diet. This does not imply, however, that the observed differences in numbers coincide with the original representation in the vegetation or diet. Several variables have to be taken into account for a more reliable interpretation. For the reconstruction of the former vegetation in a particular landscape, these include seed production, seed dispersal, and the taphonomic processes that act on seeds after deposition over time. A complicating factor for the reconstruction of vegetation is that descriptions of vegetation are based on the surface area coverage of the individual species, whereas archaeobotanical records predominantly consist of seed counts. A possible pathway to link the archaeobotanical data record to the syntaxonomy will be discussed in section 1.3.3. Variables that determine the presence in the archaeobotanical data record of edible plants deal with crop processing and food preparation in particular. A meaningful conversion of seed counts to energy levels will be discussed in section 5.2.5.

Seed production is the primary variable that determines the number of seeds recovered from an archaeological sample. Differences in seed production are, however, not mirrored in the archaeobotanical archive. Seed dispersal and all kinds of taphonomic processes are responsible for a shift in the proportions between plants.

The potential seed production is primarily determined by the number of ovules present in the lower part of the pistil. Actual seed production is primarily determined by the degree of fertilization. This, in turn, depends
During the entire growing season, and close to harvesting time in particular, crops are vulnerable to predation. Agricultural experiments in salt marshes have, for example, shown that crops can be damaged by insects, cattle, and birds (figs. 63 and 64). The fencing of fields proved to be necessary to prevent such a loss of yield. Birds need trees in the vicinity of the fields to use as shelter; in the absence of trees, depredation by birds is no longer a serious threat.

1.2.5.6 **Threshing, winnowing, and sieving**

Threshing is the first process after harvesting. It is aimed at separating the edible parts from the non-edible parts. Threshing can be followed by winnowing and sieving, during which the edible parts are cleaned to a higher degree. While threshing, if practised, takes place only once, winnowing and sieving can be applied several times before the grains are used for food preparation. Crop processing following harvesting can be rather complicated and is determined by the kind of crop, its use, the harvesting method, and the cultural traditions, which may be partly related to environmental conditions.

Hulled and naked (or free-threshing and hull-less) cereals are threshed using different methods. In hulled cereals, the grain kernels are tightly enclosed by the chaff, whereas naked cereals have loose chaff. The threshing of hulled cereals is aimed at separating the spikelets from the rachis, whereas the threshing of naked cereals is aimed at separating the grain kernels from the ear. The threshing of naked cereals can be completed in one go. The grains are easily separated from the chaff on the threshing floor—hence its alternative adjective, free-threshing. The threshing remains of naked cereals consist of culm fragments; chaff (namely, glumes, lemmas, and paleae); and diaspores of field weeds (fig. 65). The lighter fragments can be removed by winnowing. The difference in husk tightness determines both the use that the threshing remains can be put to and the archaeological contexts that should be sampled.
Hulled cereals need two stages of threshing. The first threshing results in the fragmentation of the culms and spikes. Subsequent winnowing and sieving separate the spikelets from the threshing remains. Threshing remains from hulled cereals consist of culm fragments (the number depends on the reaping height) and diaspores of field weeds (fig. 66). A second threshing is necessary for dehusking the grain kernels. This can be done by pounding and grinding. To facilitate the removal of the chaff, spikelets can be slightly roasted.

Figure 65: Threshing remains from Bread wheat (*Triticum aestivum*) produced by a modern threshing machine. These remains are fragmented to a high degree and are relatively poor in diaspores from associated field weeds (Tunis, Egypt; September 2002).

Figure 66: Threshing remains from hulled 6-row Barley (*Hordeum vulgare* ssp. *vulgare*) produced by a modern threshing machine. These remains contain a large number of diaspores from associated field weeds. Barley is only represented by some smaller sterile spikelets (Calabria, Italy; July 2007).
The degree of fragmentation of the threshing remains depends on the implements used. The use of a flail or roller will bruise the crop. The same is true if animals, such as horses or oxen, are used for trampling the grain out of the crop (fig. 67). More advanced implements, such as the threshing sledge, having stones or metal on its underside, combine separating with fragmenting. Flailing and eventually rolling can be done inside, whereas trampling and sledging need more space and are done on a threshing floor that is located outside. Threshing may be delayed because of the pressure of work during the summer period. In that case, the unthreshed harvest is stored and threshing is done during the winter period at regular intervals.

When hulled cereals are ear-harvested, threshing is not necessary if the grain is to be used as fodder or for making beer, especially in the case of 2-row Barley. If used as fodder, the whole yield can be fed to the animals. There are several advantages to this. The spikes can be fragmented into their individual spikelets, and they can also be separated from the culm fragments. Fragmentation of the harvested crop also reduces the amount of space that is needed for storage. The spikelets have a higher nutritional value. And finally, spikelets are larger and are more easily chewed than the grain kernels themselves.

For beer making, spikelets are isolated from the yield, but separating the grain kernels from the chaff (dehusking) is not necessary. Grain kernels are allowed to germinate, and this occurs naturally within the chaff. Only when grain is to be used for human consumption should an effort be made eventually to separate the grain kernels from the chaff.

Threshing can be done off-site or on-site. In the latter case, the yield can be stored and threshing can be done in periods when less labour is required on the fields. Threshing is preferably done on a threshing floor that is clean, flat, and solid (fig. 68). The size and quality requirements for the floor also depend on the implements used for threshing. Cato (On Agriculture, 91) and Varro (On Agriculture, 11), for example, describe the requirements for a threshing floor. To facilitate the drainage of rainwater, the central part should be somewhat elevated, and the solid and well-packed floor may be coated with amurca, being the last liquid that is produced during olive pressing. This black water has antiseptic properties and protects against weedy plants, insects, and moles.
Some crops, such as Sesame, can be threshed without special tools. When the uprooted plants have become sufficiently dry, they can be turned upside down, and the seeds can then be shaken from the fruits (fig. 69). The threshing of many crops is, however, done by animals or with special tools. By walking over the harvested crop, animals can tread the spikelets from the ears and the seeds from the fruits with their feet. Traditional tools used for threshing are flails, threshing sledges, and rollers (fig. 70). A flail is made from two rods of uneven length, connected to each other with a short chain or other strong, flexible material, such as the dried skin of an eel, which is extremely durable. The threshing sledge was used until recently around the Mediterranean and in the Near East. The most common type consists of a
wooden board with many small holes on the bottom, in which sharp stones or metal blades have been inserted (fig. 71). The use of sledge flints illustrates that even in modern times implements could be still partly made of stone. In Egypt, a different type of threshing sledge evolved: the *nurag*. This sledge consists of a frame that is furnished with metal or wooden rollers. Each roller carries several large metal disks (fig. 72).

Figure 69: Seeds of Sesame (*Sesamum indicum*) are shaken from the fruits (Tunis, Egypt; October 2003).

Figure 70: Threshing fruits of Chickpea (*Cicer arietinum*) using a roller. Picking the fruits from the plants and crushing the fruits is done on the roof (Murtazaköy, Turkey; August 2010).
3.2.5.4.4 Subfossil remains
Charred grain kernels of Broomcorn millet are mostly preserved without chaff. The scutellum is large and the embryo may be exposed or broken off. In the latter case, the shape of the grain kernel is characterized by a hollow base (fig. 81).

![Charred grain kernels of Panicum miliaceum from Tanais (Russia), dating to the Roman period.]

3.2.5.5 Setaria (Bristle grasses)

3.2.5.5.1 Classification

<table>
<thead>
<tr>
<th>Wild</th>
<th>Domesticated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setaria italica (L.) P. Beauv. ssp. viridis (L.) Thell.</td>
<td>Setaria italica (L.) P. Beauv. ssp. italica</td>
</tr>
</tbody>
</table>

Note: Panicum italica L. is a synonym of Setaria italica ssp. italica.

The progenitor of Foxtail millet (Setaria italica) is Green bristle grass (S. italica ssp. viridis). Although the wild ancestry is well defined, many floras still use the name Setaria viridis (L.) P. Beauv. for the wild progenitor. One of the synonyms of domesticated Foxtail millet is Panicum italica L.

3.2.5.5.2 Ecology

Setaria italica ssp. viridis
Green foxtail millet is native to Europe, the temperate part of Asia, the Indian subcontinent, and northern Africa. It is a weed that grows on both cultivated and waste ground and is thus a potential seed contaminant. Green foxtail millet propagates by means of shattering spikelets.

Setaria italica ssp. italica
Foxtail millet is propagated by sowing florets and by tillering. It grows in areas with a temperate climate and is adapted to poor soils, being less exacting than Panicum miliaceum. Soils should not be too dry or waterlogged. Foxtail millet can be harvested 2.5–3 months after sowing. If soils are not too poor, Foxtail millet produces higher yields than P. miliaceum. Mixed cropping with P. miliaceum is also practised.
3.2.5.5.3 Morphology

The infructescence is a dense, spike-like panicle. Spikelets of *Setaria* differ from those of *Panicum* by the presence of a large number of long scabrid bristles at the base of each spikelet, giving the infructescence a bristly appearance (fig. 82). The dispersal unit of the wild subspecies (ssp. *viridis*) is a spikelet (consisting of glumes and sterile and fertile floret), whereas that of the domesticated subspecies (ssp. *italica*) is the fertile floret (grain kernel enclosed by the lemma and palea) (figs. 83 and 84). In both subspecies, the bristles remain attached to the axis. The spikelet of Foxtail millet has a similar structure to that of Broomcorn millet (*Panicum miliaceum*). One of the main differences is the presence of small papillae on both lemma and palea, which are more or less arranged in short wavy lines on the lemma (thus being transversely rugose). The papillae on the palea are limited to the central area and are sharply bordered by smooth fringes (fig. 85). As in Broomcorn millet, the colour of the hardened lemma and palea of the fertile floret varies.

![Figure 82: Infructescences (spikes) of Setaria italica ssp. viridis (left) and S. italica ssp. italica (right). In the wild subspecies (viridis), part of the florets has been shattered, whereas all florets are still present in the spike of the domesticated subspecies (italica).](image1)

![Figure 83: Spikelets and florets, the latter with dark flecks, of Setaria italica ssp. viridis.](image2)
Figure 84: Spikelets and florets of Setaria italica ssp. italica.

Figure 85: Ventral view of fertile florets of Setaria italica ssp. viridis (left), Setaria italica ssp. italica (middle), and Panicum miliaceum (right). Fringes of the lemma cover those of the palea and are thus visible in a ventral view. Papillae are present on the lemma and the central part of the palea of both subspecies of Setaria italica. The palea of Panicum miliaceum is characterized by three nerves.

Figure 86: Charred grain kernels of Setaria italica ssp. viridis from Lebehn (Germany), dating to the Late Bronze Age.
Most of the literature is organized in sections and also includes relevant references that are not cited in the text. Although there is some overlap among the sections because publications may cover several themes, we feel that this presentation facilitates the search for relevant literature on a certain topic. The last section concerns references from the text that are not directly related to any of the named sections.

8.1 Taxonomy


8.2 Ecology


8.3 Flora and vegetation


8.4 Identification


[http://www.plantenatlas.eu]


8.5 Spores and pollen


8.6 Fruits, seeds, and mosses


8.7 Vegetation history


8.8 Food economy


8. 9 Fuel


8. 10 Additional references cited


Stripping Date palm (*Phoenix dactylifera*) leaves (Marazig, Egypt; February 2010).
9 Indices

9.1 Taxonomic and syntaxonomic index

Accepted names are in roman face. Synonyms, invalid names and names mentioned in classical texts are in italics. Bold face signifies syntaxon names.

Abelmoschus esculentus, 425
Abies, 166
Acacia, 61
A. nilotica, 180
A. tortilis, 30-31, 42, 46, 89, 103, 423
Acer, 161, 361, 366
A. pseudoplatanus, 164, 168, 243
Ador, 19
Adoreum, 19
Adoxaceae, 348
Aegilops, 24, 91, 252, 320, 322, 396
Ae. bicornis, 286, 321
Ae. biuncialis, 286
Ae. caudata, 286, 321
Ae. columnaris, 286
Ae. comosa var. somosa, 286
Ae. comosa var. subventricosa, 286
Ae. crassa, 286
Ae. cylindrica, 285-288, 290, 321
Ae. geniculata, 286
Ae. juvenalis, 286
Ae. kotschyi, 286
Ae. longissima, 286, 321
Ae. neglecta, 286
Ae. peregrina var. brachyathera, 286
Ae. peregrina var. peregrina, 286
Ae. searsii, 286, 321
Ae. sharonensis, 286, 321
Ae. speltoides, 25, 285-289, 321
Ae. speltoides var. ligustica, 286-288, 321
Ae. squarrosa, 285-286
Ae. tauschii, 25, 285-287, 289-291
Ae. triuncialis, 286

Ae. triuncialis var. persica, 286
Ae. triuncialis var. triuncialis, 286
Ae. umbellulata, 286
Ae. uniaristata, 286
Ae. vavilovi, 286
Ae. ventricosa, 286
Aegopodium podagraria, 35
Aerva javanica, 46, 103
Agrostemma githago, 88, 92, 115, 246, 341
Aizoon canariense, 45-46, 102
Alhagi graecorum, 90, 116, 429, 432-433
Alica, 19
Alisma, 217-218
A. plantago-aquatica, 339
Alismataceae, 339
Allium cepa, 50, 114, 184
Alnetea glutinosae, 99
Alnus, 160, 359-360, 364
A. glutinosa, 164, 168, 345, 361
Alopecurus aequalis, 110
A. myosuroides, 115
A. pratensis, 138, 340
Alstroemeria, 133
Amaranthus graecizans, 103-104
Ammi majus, 211
Ammophila arenaria, 340
Ammophiletea, 99
Anagallis, 245, 347
A. arvensis, 207-208, 210, 346
A. arvensis ssp. arvensis, 346
Ananas comosus, 39
Anchusa arvensis, 14
A. officinalis, 14
Andromeda polifolia, 187
Angelica sylvestris, 106-107
Angiosperms, 26, 96, 132, 135, 166, 240
Anisantha sterilis, 95
A. tectorum, 95
Anthemis, 126
Antirrhinum, 96, 245
Apera spica-venti, 115
Aperion spicae-venti, 114
Aphaka, 19
Apiaceae, 14, 27, 159, 170, 208, 243-244, 347-348
Apium, 14
Aquifoliaceae, 169-170
Arabidopsis thaliana, 22-23, 115
Arabis, 20
Arachis hypogaea, 187, 246
Araliaceae, 170
Areca, 14
Arecaceae, 14
Argania spinosa, 187, 246
Araliaeae, 170
Areia, 14
Artemisia, 356, 365, 376
A. vulgaris, 111
Artemisiae, 170
A. barbata, 257-260
A. brevis, 21, 257-258, 264
A. byzantina, 257
A. diffusa var. segetalis, 257
A. diffusa var. vogelensis, 257
A. fatua, 118, 208, 210, 250, 257-258, 260-261, 267, 320
A. fatua var. glabra, 260
A. ludoviciana, 257
A. nuda, 21, 257-259, 262-263, 267
A. nudibrachis, 257
A. orientalis, 257
A. sativa, 18, 21, 114, 209, 257-259, 264-268, 320, 383
A. sterilis, 209, 250, 257-258, 261-262, 267, 320
A. strigosa, 21, 257-258, 263-264, 320
Balanites aegyptiacus, 31, 194, 196, 423
Bellis perennis, 108
Beta vulgaris, 53-54, 80, 114, 117-118, 209-210, 217, 225
B. vulgaris ssp. vulgaris, 133
Betula, 164, 244, 356, 358, 365-366, 372
B. nana, 352-354
B. pendula, 29, 168, 353, 359
B. pubescens, 164, 168, 353, 363
Betulaceae, 168, 345
Bidens tripartita, 110, 349
Bidentetea tripartitae, 99, 107, 110
Bolboschoenus maritimus, 339
Boraginaeae, 244, 346
Borago officinalis, 346
Brassica, 14, 191, 225
B. carinata, 25
B. juncea, 25
B. napus, 25, 114, 425
B. nigra, 25, 217, 345
B. oleracea, 25
B. rapa, 25, 106, 114, 168
Brassicaceae, 14, 20, 22, 135, 164, 168, 209, 239, 245, 338, 345
Bromopsis erecta, 138
Bromus secalinus, 96, 245
Bryophyta, 131
Cakiletea maritimae, 99
Calluna, 160, 245
C. vulgaris, 147, 149, 164, 169, 356, 357
Calluno-Ulicetea, 98, 123
Caltha, 244
Camelina, 20-21, 338, 402
C. alyssum, 122, 337
C. sativa, 20-21, 337-338, 402
C. sativa ssp. microcarpa, 337
C. sativa ssp. pilosa, 337
C. sativa ssp. sativa, 337-338
Campanula, 245
C. rapunculus, 348
Campanulaceae, 348
Cannabaceae, 345
Cannabis sativa, 21, 334-335, 345
C. sativa ssp. sativa, 334-335
C. sativa ssp. spontanea, 334
Capparis spinosa, 116, 191
Capsella bursa-pastoris, 345
Carduus crispus, 111
Carex, 244
C. acuta, 15
C. elata, 15
C. flava, 15
C. hostiana, 15
C. inflata, 15
C. lepidocarpa, 15
C. nigra, 14-15
C. oederi, 15
C. otrubae, 15
C. riparia, 339
C. rostrata, 15
C. serotina, 15
C. trinervis, 15
C. vesicaria, 15
C. vulpina, 15, 340
Carpinus, 366
C. betulus, 168, 364
Carthamus tinctorius, 217, 402
Carum carvi, 114
Caryophyllaceae, 123, 209, 341-342
Cassia, 17
C. fistula, 20
Castanea, 244
Caulacelinion platycarpus, 114
Caylusea hexagyna, 102, 104
Cenchrus ciliarus, 103
Centaurea cyanus, 115, 123, 157, 170, 238, 349, 356
Centropodia forskalii, 103
Cerastium, 245
C. fontanum forskalii, 103
Cerinophyllaceae, 167
Ceratophyllum, 167
Charetea fragilis, 98
Chelidonium majus, 108
Chenopodiaceae, 123, 160, 167, 342, 356, 376
Chenopodium album, 29, 33, 115, 167, 342
C. frcifolium, 164
C. murale, 209, 211, 217-218
C. polyspernum, 115
C. rubrum, 110
Cicer arietinum, 18, 21, 64, 75, 77, 326-328, 399
C. arietinum ssp. arietinum, 326-328
C. reticulatum, 326
Cicercula, 18
Cichorium endivia, 114
Cirsium, 29
C. vulgare, 111, 349
Citellus colocynthis, 103-104
C. lanatus, 187, 218, 404
Citrus, 245-246
Cladium mariscus, 187
Clusia, 14
Clusiaceae, 14
Coix lacryma-jobi, 20
Colchicum, 245
Comarum palustris, 187
Compositae, 14
Coniochaeta lignaria, 165
Coniochaetaceae, 165
Convulvulaceae, 346
Convolvulo-Filipenduletea, 99
Convulvulus, 157, 205
C. arvensis, 115-116, 209-211, 217, 346
Conyza canadensis, 96
Coriandrum sativum, 217, 384
Cornus, 245
Coronilla, 245
Corylus, 159-160, 359, 361, 364-366
C. avellana, 21, 30, 164, 168, 225
Crambe maritima, 28
Crassulaceae, 39
Crotalaria aegyptiaca, 45, 103-104
C. microphylla, 102, 104
Cruciferae, 14
Cucumis melo, 240, 404
C. sativus, 30, 217, 404
Cucurbitaceae, 245
Cupressaceae, 132, 166
Cuscuta epilinum, 122
Cymbalaria muralis, 108, 110
Cynosurus cristatus, 138
Cyperaceae, 164, 167, 217-218, 244, 339-340, 355
Cyperus, 217-218
  C. conglomeratus, 103-104
  C. esculentus, 95, 123
Dactylis glomerata, 138
Danthonia decumbens, 87
Datura, 245
  D. stramonium, 115
Daucus carota, 54, 114, 225, 347
Dennstaedtiaceae, 165-166
Dichanthium foveolatum, 89, 103-104
Digitalis, 96
Digitaria, 249
Digitario-Setarion, 114
Dipsacaceae, 348
Dipsacus fullonum, 348
Echinochloa, 249
  E. colona, 209
  E. crus-galli, 108
Eleocharis, 217-218
  E. palustris, 340
Elytrigia repens, 111, 115
Emex spinosa, 209-210
Empetraceae, 356
Empetrum, 245
  E. nigrum, 169, 187, 356, 357
Emys orbicularis, 363
Epilobieta angustifolii, 99
Epilobium hirsutum, 343
Epipactis palustris, 29
Equisetum arvense, 131
Eragrostis cilianensis, 102
  E. ciliaris, 45, 102-105
  E. ciliaris var. laxa, 105
Eresia tetralix, 147, 149, 169, 346
Ericaceae, 123, 143, 169, 346, 355-356
Erigeron, 147, 159
  E. vaginatum, 167
Erodium, 244
  E. cicutarium, 343
Erophila verna, 115
Ervum, 19
Eucalyptus, 154
Euphorbia, 244
  E. granulata, 102, 207
  E. helioscopia, 209, 343
  E. prostrata, 207
Euphrasia, 96
Faba, 13-14, 19
Faba vulgaris, 13
Fabaceae, 13-14, 27, 48, 116, 123, 135, 239, 244, 247, 343-344, 399, 432
Fabales, 13
Fagaceae, 167-168
Fagopyrum, 244
  F. esculentum, 21, 114, 148, 369
Fagus, 244, 364, 366
  F. sylvatica, 164, 167
Fallopa convolvulus, 115-116, 157
Far, 19
  F. adoreum, 19
Farsetia ramosissima, 89, 103
Festuca gigantea, 167
  F. rubra, 106, 138
Festuco-Brometea, 98
Ficaria verna, 137, 246
Ficus, 42
  F. carica, 218, 225, 243, 345, 399, 404-405
  F. sycomorus, 61, 405
Filicales, 131
Foeniculum vulgare, 348
Formica rufa, 32
Forskålía tanacissima, 89, 103
Fragaria vesca, 344
Franguletea, 99
Fraxinus, 244, 360-361, 365-366
  F. excelsior, 169, 362
Fumaria officinalis, 116, 340-341
Fumariaceae, 340-341
Fumario-Euphorbion, 114
Fungi, 27, 131, 143, 161, 189
Galanthus, 161
Galeopsis, 115
  G. bifida, 15
  G. speciosa, 15, 347
  G. tetrahit, 15, 157
Galinsoga, 157
Galio-Urticetea, 99
Galium, 161, 205, 217, 244
  G. aparine, 115, 346
  G. spurium, 95
  G. verum, 169
Gentiana, 245
Geraniaceae, 343
Geranium, 244
  G. phaeum, 343
Gisekia pharnaceoides, 104
Glycine max, 23
Gossypium, 425
Gramineae, 14, 138
Gratiola, 96
Grossulariaceae, 342
Guttiferae, 14
Gymnosperms, 132, 135, 166, 239
Halopeplis perfoliata, 45
Hedera, 365
H. helix, 37, 134, 164, 170, 363
Helianthemum, 356
Helianthus annuus, 31, 69, 71, 81, 187, 240, 384, 407
Helicoon dubium, 165
H. fuscosporum, 165
Hieracium pilosella, 164
Hippophae, 353
H. rhamnoides, 355
Hippuridaceae, 97
Hippuris vulgaris, 96
Holosteum umbellatum, 115
Homo sapiens, 380
Hordeum, 133, 251-252, 365, 396
H. bogdanii, 275
H. bulbosum, 126
H. cantherinum, 18
H. distichum, 16, 18
H. galaticum, 18
H. hexastichum, 18, 273
H. murinum, 275
H. spontaneum, 16
H. tetraestichum, 273
H. vulgare ssp. distichon, 16, 18, 21, 32, 92, 119, 250, 273, 277-280, 283, 287, 291, 320-321, 388, 392, 405
H. vulgare ssp. spontaneum, 16, 32, 273-274, 277-278, 320-321
Humulus lupulus, 345
Hydrodictyaceae, 165
Hyoscyamus, 245
H. niger, 111, 346
Hypericeae, 343
Hypericum perforatum, 343
Hyphaene thebaica, 17
Ilex, 38, 245, 361, 365
I. aquifolium, 37, 164, 169, 170
Indigofera, 40
I. articulata, 103-104
Ipomoea, 24
Iris, 245
I. pseudacorus, 30
Isatis tinctoria, 21
Isoetaceae, 131
Isoeto-Nanojuncetea, 99
Jatropha curcas, 425
Juglans, 245
J. regia, 12, 225, 242
Juncaceae, 245, 339
Juncaginaceae, 339
Juncus gerardii, 106
J. maritimus, 220
J. squarrosus, 339
Juniperus, 353
J. communis, 166, 354
Kickxia, 207
Koelerio-Corynephoretea, 98, 123
Labiatae, 14
Lactuca, 114, 225
L. sativa, 114
Lamiaceae, 14, 217, 244, 347
Lamium, 14
L. purpureum, 347
Lathyrus, 205
L. cicera, 331
L. hirsutus, 343
L. sativus, 18, 21, 116, 246, 330-332, 397-399
L. tuberosus, 123
Launaea capitata, 102
Leguminosae, 14
Lemnetea minoris, 98
Lens, 152, 162-163
L. culinaris, 13, 18, 21, 116, 217, 322-324, 397-399
L. culinaris ssp. culinaris, 322-324
L. culinaris ssp. orientalis, 322-323
L. esculenta, 322
Leontodon autumnalis, 164
L. saxatilis, 33-34, 349
Lepidium coronopus, 108, 207
L. sativum, 20
Liguliflorae, 164
Lilaceae, 166
Lilium bulbiferum ssp. croceum, 123
L. martagon, 166
Limonium vulgare, 36

Limosella, 96
Linaceae, 343
Linaria, 96
*Linum bienne*, 333
  - *L. usitatissimum*, 20-21, 64, 79, 114, 217, 238, 333-334, 343, 399, 402
  - *L. usitatissimum* ssp. angustifolium, 333
  - *L. usitatissimum* ssp. usitatissimum, 333-334
Lithospermum arvense, 431
Littorella uniflora, 97
*Littorelletea*, 98
Lolium, 209-210, 217
  - *L. perenne*, 33, 138
  - *L. remotum*, 122
Lonicero-Rubetea *plicati*, 99
Lotononis platycarpa, 45, 102-103
Lotus hebranicus, 103
*Lupinum*, 18
Lupinus albus, 18, 21, 217, 401
Lycopodiaceae, 131, 165
Lycopodiella inundata, 157
Lycopodium, 154
  - *L. clavatum*, 165
Lycopeus europaeus, 347
Lysimachia nummularia, 246
Malus sylvestris, 21, 190
Malva, 244
  - *M. moschata*, 164, 168
  - *M. parviflora*, 217, 345-346
Malvaceae, 168, 345, 346, 425
Matricaria discoidea, 108
Medicago, 217, 237
  - *M. intertexta*, 209
  - *M. lupulina*, 343-344
Melampyro-Holcetea *mollis*, 98
Melampyrum, 96
*Melandrium album*, 15
  - *M. rubrum*, 15
Melilition indici, 210
Melilotus indicus, 209-210
  - *M. messanensis*, 80, 209
Menyanthaceae, 170
Menyanthes trifoliata, 164, 170, 187
Mercurialis, 244
Milium, 18
*Melinio-Arhenatheretea*, 98, 123
Monsonia nivea, 103-104
  - *M. senegalensis*, 102
Montio-Cardaminetea, 98
Moraceae, 345
Morettia, 89
Moringa peregrina, 45
Musa, 24, 246
Myosotis arvensis, 115
  - *M. scorpioides*, 346
Myriophyllum, 220
Myrsinaceae, 346
Myrtus communis, 154
Najas, 218-220
*Nardetea*, 98
Narthecium ossifragum, 147
Nasturtium, 20
Neurada procumbens, 31
Nicotiana tabacum, 23
Ocimum basilicum, 113
Odonites vernus ssp. serotinus, 14
Olea, 245, 404
  - *O. europaea*, 21, 198, 218, 236-237, 241
Oleaceae, 169
Onagraceae, 343
Ophiostoma ulmi, 365
Orbiliaceae, 165
Orchidaceae, 29, 245
Orobancheaeae, 29, 96
Oryza glaberrima, 13
  - *O. sativa*, 13, 18, 21, 39, 407
Oxalis, 245
  - *O. acerosella*, 28
*Oxyccocco-Sphagnetea*, 98
Paliurus spina-christi, 126
Palmae, 14
Panicum, 19, 249, 319
  - *P. italica*, 254
  - *P. miliaceum*, 18, 21, 252-257, 320, 414
  - *P. turgidum*, 103
Papaver, 123, 136, 245
  - *P. rhoeas*, 94, 115, 157
  - *P. somniferum*, 21, 238, 340
  - *P. somniferum* ssp. *somaticum*, 340
Papaveraceae, 340
*Papaveretalia rhoeadis*, 114
Papilionoidae, 325
Parietaria judaica, 108
*Parvocaricetea*, 98
Pastinaca sativa, 114, 348
  - *P. sativa* ssp. *sativa*, 348
Pediarastum simplex, 165
Pedicularis, 96
Peganum harmala, 202
Pennisetum, 39
Persicaria hydropiper, 110
P. lapathifolia, 341
P. maculosa, 115
Petroselinum crispum, 191
Phalaris canariensis, 209
P. minor, 209-211
P. paradoxa, 209-210, 217
Phaseolus vulgaris, 397
Phoenix dactylifera, 27, 57, 143-144, 180, 182, 187, 198, 218, 402, 407
Phragmitetalia, 98
Phymatosorus scolopendria, 131
Pinaceae, 37, 132, 166
Pinguicula, 147
Pinus, 144, 160, 287, 355-356, 358-359, 361, 364, 378
P. contorta, 132
P. pinea, 236
P. sylvestris, 164, 166, 353, 360, 372
Piper nigrum, 174-175
Pistacia, 94, 245
Pisum, 326
P. humile, 322
P. sativum, 19, 21, 114, 116, 247, 322, 324-325, 397, 399
P. sativum ssp. elatius var. elatius, 324
P. sativum ssp. elatius var. pumilio, 322, 324-325
P. sativum ssp. sativum, 324-325
Plantaginaceae, 96-97, 169, 347
Plantaginetea majoris, 98, 107
Plantago, 209, 212, 245, 339, 356, 366
P. coronopus, 97, 108
P. lanceolata, 97, 164, 169, 365
P. major, 108, 158, 347
P. major ssp. major, 347
Plumbaginaceae, 123, 341
Potamogeton, 166, 172, 220
P. crispus, 212
P. lucens, 106
P. natans, 339
P. perfoliatus, 218-219
P. vaginatus, 187
Potamogetonaceae, 166, 339
Potentilla anserina, 108, 344
P. indica, 243
Prunella vulgaris, 347
Prunus domestica ssp. domestica, 344
P. dulcis, 245, 399
P. mahaleb, 245
P. persica, 20, 245
P. persica var. compressa, 20
P. persica var. persica, 20
Pseudofumaria lutea, 108-109
Pteridium aquilinum, 165-166
Pucciniella distans ssp. distans, 340
Pulicaria undulata, 103, 126
Punica granatum, 404
Pyrus communis, 344
Quercetea roborit-petraea, 99
Quercetum-mixtum, 365
Querco-Fagetea, 99
Quercus, 161, 244, 287, 359, 361, 364-366
Q. brantii, 378
Q. calliprinos, 38
Q. cerris, 38, 378
Q. cerris-type, 378
Q. coccifera, 38
Q. ilex, 38
Q. infectoria, 378
Q. ithaburensis, 38, 378
Q. libani, 378
Q. petraea, 378
Q. pubescens, 378
Q. robur, 38, 164, 168, 362, 378
Ranunculaceae, 340
Ranunculus, 244
R. aquatilis, 340
R. repens, 340
R. sceleratus, 110
R. subg. Batrachium, 14, 217-218
Raphanus, 217, 245
Reichardia tingitana, 102, 104
Rhamno-Prunetea, 99
Rhamnus, 245
R. frangula, 159
Rhinanthus angustifolius, 96
R. minor, 96
Rhodanthe humboldtiana, 29
Rhynchospora, 149
Ribes rubrum, 342
Ricinus, 244
R. communis, 113, 247
Rorippa palustris, 110
Rosaceae, 344
Rostraria pumila, 102-103
Rubieae, 169, 243, 346
Rubus, 245
R. fruticosus, 32, 225, 344
R. idaeus, 32, 225
Rumex, 209, 217, 356, 365
R. crispus, 126, 341
R. maritimus, 110
R. palustris, 110
R. vesicarius, 45, 102, 104
Ruppieta, 98
R. graveolens, 191
Saccharum officinarum, 39, 133
Sagina nodosa, 341
S. procumbens, 108
Saginetaea maritimae, 99
Salicaceae, 167
Salicetalia albae, 99
Salicornia europaea, 15, 36, 106, 342
Salix, 143, 353-354
S. alba, 167
S. caprea, 134
Saltera, 20
Sambucus, 245
S. nigra, 242, 348
Sanguiisorba minor, 356
Sapindaceae, 168, 243
Scandix pecten-veneris, 115
Scandulaceae sive speltae, 19
Scenedesmaceae, 165
Schuchzerietia, 98
Schoenoplectus lacustris, 353
Scirpus supinus, 217-218
Scleranthus annuus ssp. annuus, 341
Scolytus, 365
Scolyphularia canina, 347
Scolyphulariaceae, 14, 96, 347
Secale, 251-252, 396
S. cereale, 19, 21, 25, 114, 133, 157, 167,
248, 250, 269, 271-272, 317,
320-321, 383, 388, 414, 431
S. cereale f. c要么sopaleatum, 269
S. cereale ssp. cereale, 321, 388
S. cereale ssp. vavilovii, 250
S. iranicum, 269
S. montanum, 269
S. sylvestre, 269
S. vavilovii, 269-271
Sedo-Sclerantheretia, 98
Senna alexandrina, 20
S. italicca, 103-104
Sequoiadendron giganteum, 239
Sesamum indicum, 64, 75, 336-337,
384, 402-403, 425-426
S. indicum ssp. indicum, 336
S. indicum ssp. malabaricum, 336
Setaria, 249, 252, 319
S. italicca, 19, 21, 254-256, 320
S. italicca ssp. italicca, 254-256
S. italicca ssp. viridis, 254-256
S. viridis, 254, 320
Silene dioica, 15, 342
S. latifolia ssp. alba, 14-15
Sillago, 19
Similago, 19
Sinapis arvensis, 94, 117, 119-120,
209-210, 217
Sisymbrium officinale, 108, 111
Sitellus suslyka, 182
Solanaceae, 169, 346
Solanum, 24, 53, 245
S. dulcamara, 169, 353
S. lycopersicum, 53, 407
S. melongena, 407
S. nigrum, 346
Sonchus, 29, 211
S. arvensis, 96, 205
S. asper, 205, 349
S. oleraceus, 210
Sordaria, 165
Sordariaceae, 165
Sorghum, 248, 408, 410
S. bicolor, 39-40, 69, 80, 84, 89, 117,
406, 425, 432-433
Spalax, 182
Sparganiaceae, 339
Sparganium erectum, 30, 339
Sparticnetia, 99
Speltieta mundae, 19
Spergula arvensis, 342
Spergularia rubra, 108
S. salina, 342
Sperguletalia arvensis, 114
Sphagnaceae, 165
Sphagnum, 146-148, 164, 230, 354, 363
S. cuspidatum, 165, 368
Spinacia oleracea, 114
Stachys palustris, 347
Stellaria media, 342
**Stellarietea mediae**, 99, 112-114
Stipagrostis hirtigluma, 102
S. plumosa, 103
S. uniplumis, 102, 104
Suaeda monoica, 45
Tamarix, 180
T. aphylla, 45
T. nilotica, 43, 44
Taxaceae, 132, 166
Taxus, 361
T. baccata, 166, 239
Thalictrum, 356
Thelypteridaceae, 166
Thelypteris palustris, 164, 166
**Thero-Salicornietea**, 99
Thlaspi arvense, 345
Tilia, 143-144, 153, 244, 360-361, 364-366, 368
T. x vulgaris, 168, 362
Tipu, 19
Tragum, 19
Tribulus terrestris, 89, 102
Trichodesma africanum, 103
T. ehrenbergii, 89, 102, 104
Trichophorum cespitosum ssp. germanicum, 147
**Trifolio-Geranieta sanguinei**, 98
Trifolium, 48, 126, 217
T. alexandrinum, 53, 62, 127, 237
T. dubium, 344
T. repens, 87, 106, 108
T. resupinatum, 210
Triglochin maritima, 339
Trileurospermum maritimum, 164, 171, 349
Triraphis pumilio, 45, 102-104
Trisetum flavescens, 138
Triticaceae, 248, 396
Triticosecale, 25
Triticum, 39, 80, 133, 241, 248, 251-252, 286, 365, 393, 395
T. aegilopoides, 293
T. aestivum-compactum, 292
T. aestivum ssp. compactum, 19, 21, 291-294, 304, 317-318, 388, 396
T. aestivum ssp. macha, 291, 294, 304
T. aestivum ssp. sphaerooccum, 291-292, 294, 304
T. aestivum ssp. vavilovii, 291
T. aestivum/durum, 316, 318, 320
T. araraticum, 292
T. baeticum, 292-293
T. carthlicum, 292
T. compactum, 292
T. dicoccoides, 292
T. dicoccum, 292
T. monococcum ssp. aegilopoides, 291-295, 297, 303, 320-321
T. oriëntale, 292
T. palaeocolchicum, 292
T. parvicoccum, 293
T. polonicum, 292
T. pyramidal, 292
T. ramosum, 19
T. robus, 19
T. sinskajae, 298
T. spelta, 292
T. thaoudar, 293
T. timopheevii ssp. armeniacum, 291-292, 299, 303
T. turanicum, 292
T. turgidum, 16, 18-19, 21, 24-25, 53, 86, 144, 180, 183, 185, 207, 217-218, 237, 247, 250, 275,

T. turgidum ssp. carthlicum, 292, 294, 304


T. turgidum ssp. paleochlicicum, 291-292, 294, 304

T. turgidum ssp. polonicum, 291-292, 294, 304

T. turgidum ssp. turanicum, 291-292, 294, 304

T. turgidum ssp. turgidum, 18-19, 21, 294, 296, 301, 304, 388, 390-391, 394

T. turgidum var. mirabile, 390

T. turgidum var. pseudocervinum, 390

T. urartu, 24-25, 291, 297, 303

T. vulgare, 292

T. zhukovskyi, 25, 291, 293-294

Tuberculatisporites mamillarius, 186-187

Tulipa sylvestris, 95

Typha, 230

T. latifolia, 353

Ulmaceae, 167

Ulmus, 359, 364-366

U. minor, 164, 167, 361

Umbelliferae, 14

Urtica urens, 111

Ustilago hordei, 285

Utricularia, 147

Vaccinio-Betuletea pubescentis, 99

Vaccinio-Piceetea, 99

Vaccinium, 246

V. myrtillus, 346

Valeriana officinalis, 348

Valerianaceae, 348

Veronica, 96

V. anagallis-aquatica, 347

V. arvensis, 115

V. hederifolia, 97, 115

V. officinalis, 97

V. triphylls, 115

Vicia, 205

V. ervilia, 13, 19, 21, 328-330, 332, 398

V. faba, 13, 19, 21, 80, 113, 217, 246, 328-331, 397

V. faba var. equina, 13, 19, 21, 80, 328-330

V. faba var. faba, 13, 19, 21, 328-330

V. faba var. major, 21, 328

V. faba var. minor, 21, 328

V. faba var. minuta, 13, 19, 21, 328-329

V. faba var. paucijuga, 328-329

V. hirsuta, 16, 95, 115, 117, 120-122, 405, 414, 418

V. sativa, 13, 19, 21

V. sativa ssp. nigra, 13

V. sativa ssp. sativa, 13

Vigna unguiculata ssp. unguiculata, 80

Viola, 247

V. tricolor, 343

Violaceae, 343

Viscum, 365

V. album, 363

Vitaceae, 342, 343

Vitis, 245-246

V. vinifera, 21, 24, 190, 218, 225, 342-343, 404

Xanthium strumarium, 28, 96

Zannichellia palustris, 217-218

Zea, 13

Z. mays, 39, 69, 117, 184, 407

Zilla spinosa, 31, 89, 103-104, 126

Ziziphus spina-christi, 218, 236

Zosteretea, 98

Zygophyllum coccineum, 45, 103-104

Z. simplex, 45-46, 102-103
9.2 Subject index

Abaxial, 250-251, 278-279, 281, 303, 306-307, 312
Abiotic, 34, 93, 97, 135
Achene, 244
Achenium, 244
Acidity, 34, 106, 113, 141, 147, 188-189
Acute, 304
Adaptation, 25, 29-30, 33, 37-38, 40, 45, 108, 147, 204, 385-386, 393, 396
aDNA, 128
After-grazing, 90-91
After-ripening, 64, 68, 81, 120, 376, 382
Agadir, 86
A-genome, 291
Agrophyte, 95
Algae, 143, 165
Alkaline, 269, 296
Alkalinity, 323
Allergy, 396
Allerod, 351-353, 356, 358-359
Alliance, 97, 113-114
Allopolyploidy, 24, 291
Amurca, 73, 86
Anaerobic, 145
Angiosperm Phylogeny Group, 26, 96
Annulus, 163, 365
Anther, 132-133
Anthropogenic, 104-105, 157-158, 366
Antibiotic, 189
AP, 154, 352, 364
Arboreal, 154, 356, 364
Archeophyte, 95
Arid, 54-57, 87
Arid, 45, 182, 193-194, 378
Aril, 32, 239
Ascospore, 165
Assimilation, 35
Association, 48, 97-98, 105, 138, 294
Atlanticum, 351, 358, 360-361, 363-365, 368
ATP, 24, 47
Autopolyploidy, 24
Bacteria, 48, 129, 189
Baculata, 163
Baking, 377, 392, 396, 409, 423-424
Berry, 225, 245-246
Biennial, 113, 333
Bin, 83-85, 180, 418
Biomolecule, 128
Biotic, 34, 93, 97, 106, 136, 141
Biotope, 211, 414
Bisexual, 27, 132-133
Bog, 98, 139, 146-148, 150, 187, 368-369
Bølling, 352-353, 358
Boreal, 351, 357-361, 364, 370, 372
Brackish, 98
Bract, 34, 117, 240, 244, 249-251, 349
Brewing, 188-189
Bristle-rachised, 20, 67, 250, 295, 303, 305, 376, 381, 383-386
Broadcast-sown, 52-54, 112, 114-115, 415
Buoyancy, 225
Burning, 8, 47, 90-92, 140, 183, 193-195, 201, 203, 221, 247, 337, 365, 402
C3-plant, 38-39, 129, 410
C4-plant, 38-39, 103, 252, 410
Calcareous, 85, 101, 108, 273
Calcifuge, 269, 294, 296
Calcium, 47, 269, 294
CAM-plant, 38-39
Capsula, 245
Capsule, 131, 244-245, 336-337
Carbohydrate, 128, 133, 371, 396
Carnivorous, 147
Carpel, 27, 132, 244-245
Carpellate, 27, 133
Caryopsis, 244, 250, 275
Caulking, 230
Cerealia, 157-158, 248, 365, 379
Cesspit, 193, 203-204, 222, 224-225, 387
Chalaza, 247
Charcoal, 221, 229, 417, 423-424
Chemosynthesis, 35
Chromosome, 22-24, 291
Clavate, 163-164
Clubmoss, 157, 165
CML-classification, 106
CO₂, 35, 38, 39, 47
Coeliac disease, 396, 410
Colporate, 160
Colpus, 160-161, 163
Columella, 18-19, 68, 162-163, 189, 191, 212
Cone, 83, 131-132, 239, 294
Connate, 240
Contamination, 69, 80, 87, 91, 95, 105, 128-130, 135, 137-138, 152, 178, 182, 184, 186-187, 192, 215, 221, 227, 229, 232, 406, 419
Cooking, 377, 382, 392, 398, 409
Coring, 144, 151, 204, 367
Cotyledon, 247, 251, 322-323, 327, 330, 338
Coverage, 26, 92-93, 100-104, 124, 144, 152-153, 192, 256, 296, 363, 367, 371-372
Crossbreeding, 15
Cross-pollination, 27, 133-134, 252, 327, 388
Cultivation, 24, 47-48, 63-64, 122, 148-149, 204, 212, 229, 291, 295-296, 328, 366, 369, 378, 380-381, 393, 397, 403, 405, 407-408, 410, 416, 421
Deciduous, 38, 101, 325, 366, 378
Decumbent, 108-109, 332
Deflation, 182, 220
Deforestation, 139, 366
Dehisence, 120, 122, 244-245, 333, 336, 383-384, 417
Dehusking, 72-73, 86, 226, 377, 383, 391
Depletion, 47-48, 50, 368, 403
Desiccation, 187, 205, 216, 304, 331
Dew, 43-45, 58, 68, 103, 189, 257, 382
D-genome, 291, 396
Dicotyledon, 247
Dioecious, 27, 143, 335
Diploid, 23-25, 257, 291, 297, 305-307, 404
Disarticulation, 249, 258, 260-261, 264, 266-267, 277, 286-288, 290, 303-304, 312, 314, 320, 386
Disarticulation scar, 249-250, 260-261, 264, 267, 303-304, 320, 386
Disease, 54, 192, 295, 328, 365, 377, 396-397, 410
Dissemination, 17, 250
Disturbance, 35, 91, 104, 107, 115, 123, 125, 175, 365
DNA, 22, 24, 26, 47, 96, 128-129, 189
Dormancy, 29, 33, 87, 128, 138, 377, 385-386
Drainage, 73, 149, 369
Draining, 40, 148, 232, 269, 296, 325, 368-369
Drought, 39, 45, 46, 103, 269, 273, 287, 294, 296, 328, 353, 380
Drought-resistant, 296, 328
Drought-tolerant, 287, 380
Dryas, 352, 355-356
Dry-sieved, 216
Dung, 47-51, 54, 63, 92, 106, 111, 143, 151, 194-195, 197, 211-213, 216, 220-221, 236, 369, 378, 382, 393, 409, 413-414, 422-432
Dung cake, 92, 194, 211-213, 216, 382, 393, 409, 413-414, 424-430, 432
Echinate, 163-164
Ecotope, 97, 106
Ectexine, 162
Edaphic, 34, 123, 246
Elaiosome, 32
Eldest Dryas, 352, 358
Embryo, 247, 249, 251, 254, 267, 322, 327, 338
Endexine, 162
Endosperm, 225, 245, 247, 249, 304, 392, 395-396, 406, 409-410
Enzyme, 26, 38, 47, 189
Ephemeral, 44-46, 101-104, 376
Epicarp, 30, 239, 241, 245, 339
Epidermis, 35, 37, 171
Epipalaeolithic, 379
Epithet, 14, 16
Erosion, 47, 58, 182, 186, 215
Ethnoarchaeobotanical, 86, 204
Etnographic, 207
Eutrophic, 98, 147
Evaporation, 37-39, 41, 43, 63, 111, 190, 245, 352
Evergreen, 37, 38
Excrement, 30, 32, 111, 224-225
Exine, 159
Exocarp, 239, 241-242
Exotic, 154
Exploitation, 51, 150, 211, 366, 368, 378-380, 425
Faeces, 175, 203, 224-225, 403, 405
Fallow, 48, 104, 111, 113, 116, 122, 212, 216, 325, 433
Famine, 56, 331
Farming, 18, 219, 352, 375-378, 380, 386, 428
Fenestrate, 163-164
Fermentation, 188-189, 191
Fern, 160, 164-165
Fertility, 51, 100, 157, 248, 257, 259, 274, 325, 390
Fertilizer, 48, 50-52, 54, 431
Fertilizing, 26, 27, 43, 48, 51, 133, 139, 143, 148, 188, 239, 332, 370, 377, 388
Fibre, 64, 230, 333-335, 371, 403, 418, 425
Firewood, 393, 432
Flail, 73-74
Floatation, 229, 231-234, 399-400
Flora, 16, 22, 40, 93-96, 100, 107, 137, 139, 140, 205, 207, 212, 215-216, 254, 304, 353
Follicle, 244
Folliculus, 244
Food economy, 26, 174, 223, 377, 387-388, 405, 418, 421
Foragers, 370, 372, 377-378
Foraging, 375, 378, 380
Fossil, 244
Fossilization, 138
Fractionation, 26, 72-73, 92, 98, 128, 195, 250, 285, 305, 413
Freatophyte, 46
Fructose, 189
Fruitcoat, 225, 335
Fungus, 27, 165, 285, 355, 365
Funiculus, 32, 121-122, 246-247, 249, 331, 397
Garum, 191
Gatherer, 377
Gathering, 67, 258, 377, 379, 406
Genome, 22-25, 129, 257, 286, 291-292, 396
Germ, 138, 144, 204, 247, 249, 256, 258, 293, 311, 318, 353, 382, 416
Glacial, 146, 148, 351-353, 356-358
Glucose, 35, 38, 146, 189, 363
Gluten, 395-396, 409-410
Granary, 33, 83, 86, 179, 223, 231, 388, 405
Grazing, 47, 91-92, 123, 125-130, 206, 211, 216, 269, 369, 386, 414, 428-429
Groundwater, 34, 36-37, 40-42, 46, 50, 98, 123, 145, 147, 154, 188, 352, 363, 368
Growth-forms, 100
Gyttja, 146, 155
Habitat, 97, 106, 269, 273
Halophytic, 45
Haploid, 23
Harrowing, 47, 52, 54, 57
Health, 392, 395-396, 404
Hearth, 230, 413
Heating, 138, 188, 378, 393, 396, 413, 423, 431
Hemiparasite, 363
Herbaceous, 41, 46, 62, 94, 154, 393, 422-423, 425, 432
Herbivore, 129, 220
Hexaploid, 15, 19, 24-25, 257, 291, 302, 305, 316, 381, 394
Hilum, 32, 122, 247, 249, 251, 259, 271, 274, 276, 320, 322-323, 325-326, 329, 331
Hoe, 54-57, 87, 89, 90
Hoeing, 54, 87, 112
Holocene, 139-140, 146, 148, 178, 351, 357-359, 370, 376, 378
Holoparasite, 363
Homozygotous, 23
Humidity, 36, 40, 43, 117, 147-148, 259, 325, 397
Hunter-gatherer, 189, 360, 370-372, 377
Hybrid, 25, 257
Hybridization, 15, 24-25, 291-292, 381
Hypothesis, 200
ICBN, 13, 15, 20
ICPN, 130
Ideotype, 386
Imprint, 43, 192-193, 213, 216, 248, 267, 310, 318-320, 425, 427
Infertile, 279, 388
Inflorescence, 205, 209, 242, 248-249, 251-252, 287, 297, 334-335
Intectate, 163
Interglacial, 351
Interstadial, 351
Intine, 159
Invader, 95-96
Inventory, 101, 107, 113, 410, 415
Irrigation, 47, 50, 53, 57-63, 90, 117, 127, 130, 177, 198-199, 204, 207, 210, 212, 215-219, 258, 327, 352, 392, 410
Isotherm, 353
Isotherm, 128-130, 130, 351
Judgemental sampling, 200, 202-204, 219, 391
Kiln, 193, 402, 433
Kilocalorie, 370-371, 404
Kilogram, 415-416
Kilojoule, 370-371, 404
Labour, 73, 392, 395, 409, 421
Landnam, 365-366
Lax-eared, 208, 276, 416
Legume, 48, 135, 244, 380
Legumen, 244
Limestone, 325-326
Lithology, 154
Longevity, 33, 44, 116, 138, 159
Macronutrient, 47-48
Manuring, 47-48, 50, 130, 323, 369, 392, 431
Megasporangium, 186-187
Meiosis, 23, 160
Mericarpium, 244
Mesocarp, 241, 245
Micronutrient, 47
Microorganism, 35, 80, 145, 188-189, 191-192, 224
Microspore, 247
Micro-remain, 204, 227
Midden, 176, 178, 220, 387
Mimicry, 122
Mixing, 54, 135, 137, 178, 180, 182-183, 231-232, 234
Moisture, 36, 39, 43, 64, 80, 106-108, 115, 145-146, 149, 159, 193, 212, 244, 257, 287, 356, 382, 410, 426
Monocolpate, 161, 163
Monocotyledon, 247
Monolete, 160-161, 163-164
Monoploid, 23
Monoporate, 160, 163-164
Mud brick, 52, 56, 60, 144, 180, 184-185, 207-208, 213-218, 220-222, 228-232, 234, 414
Mutation, 24, 26, 381, 386
NAP, 154, 352, 364
Nectar, 133, 143
Neolithisation, 95, 393
Neophyte, 95
Nitrogen, 47, 48, 111, 129, 386
Nomenclature, 13, 16, 20, 97, 130
Non-arboreal, 154, 364
<table>
<thead>
<tr>
<th>Term</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-brittle</td>
<td>67, 249-250, 305, 376, 381, 385-386</td>
</tr>
<tr>
<td>Non-disarticulating</td>
<td>263-264</td>
</tr>
<tr>
<td>Non-shattering</td>
<td>258, 269, 381, 384-385</td>
</tr>
<tr>
<td>Nurag</td>
<td>75</td>
</tr>
<tr>
<td>Nutrient-poor</td>
<td>98, 139, 363</td>
</tr>
<tr>
<td>Nutrient-rich</td>
<td>98, 114</td>
</tr>
<tr>
<td>Nux</td>
<td>244</td>
</tr>
<tr>
<td>Octaploid</td>
<td>25</td>
</tr>
<tr>
<td>Off-site</td>
<td>29, 73, 204, 211</td>
</tr>
<tr>
<td>Older Dryas</td>
<td>351-353, 355-356, 358</td>
</tr>
<tr>
<td>Oligotrophe</td>
<td>147</td>
</tr>
<tr>
<td>On-site</td>
<td>73, 204</td>
</tr>
<tr>
<td>Ovary</td>
<td>132-133, 135, 239, 242, 251, 267</td>
</tr>
<tr>
<td>Oven</td>
<td>125, 229, 396, 402, 409, 413-414, 425, 430-432</td>
</tr>
<tr>
<td>Overexploitation</td>
<td>124, 369</td>
</tr>
<tr>
<td>Overgrazing</td>
<td>94, 124-126, 229, 369, 379, 393, 429, 431</td>
</tr>
<tr>
<td>Ovule</td>
<td>23-24, 26, 132-133, 135, 239-240, 247, 251, 332</td>
</tr>
<tr>
<td>Palaeobiocoenose</td>
<td>105-106</td>
</tr>
<tr>
<td>Panicle</td>
<td>117, 249, 251-252, 255, 259-260, 265, 267</td>
</tr>
<tr>
<td>Pantoporate</td>
<td>163-164</td>
</tr>
<tr>
<td>Pappus</td>
<td>29, 34, 210, 230, 349</td>
</tr>
<tr>
<td>Parasite</td>
<td>96, 143, 363</td>
</tr>
<tr>
<td>Parching</td>
<td>377, 383</td>
</tr>
<tr>
<td>PCR</td>
<td>128-129</td>
</tr>
<tr>
<td>Peat</td>
<td>144, 146-148, 150, 155, 164, 186, 230, 363, 368-369, 379, 423</td>
</tr>
<tr>
<td>Pedicel</td>
<td>119, 208-209, 217-218, 251, 261, 266, 275</td>
</tr>
<tr>
<td>Pentaploid</td>
<td>24</td>
</tr>
<tr>
<td>Perennial</td>
<td>46, 62, 87, 96, 103-104, 138, 205, 269, 274, 333, 376, 428</td>
</tr>
<tr>
<td>Perianth</td>
<td>117, 209, 217, 249, 335, 339, 340-348</td>
</tr>
<tr>
<td>Pericarp</td>
<td>225, 244, 247, 249, 251, 319</td>
</tr>
<tr>
<td>Pericolporate</td>
<td>161, 163</td>
</tr>
<tr>
<td>Periporate</td>
<td>163</td>
</tr>
<tr>
<td>pH</td>
<td>188-189</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>47, 111</td>
</tr>
<tr>
<td>Phytolith</td>
<td>128, 130</td>
</tr>
<tr>
<td>Pickling</td>
<td>188</td>
</tr>
<tr>
<td>Pingo</td>
<td>145, 148, 352, 358</td>
</tr>
<tr>
<td>Pionee</td>
<td>48, 99, 101, 110, 139, 175, 287</td>
</tr>
<tr>
<td>Pistil</td>
<td>26, 132-133, 143, 239, 242, 249</td>
</tr>
<tr>
<td>Pleistocene</td>
<td>351, 376, 378</td>
</tr>
<tr>
<td>Pleniglacial</td>
<td>351, 376</td>
</tr>
<tr>
<td>Ploidy</td>
<td>291, 305</td>
</tr>
<tr>
<td>Plough</td>
<td>54-57, 87, 123</td>
</tr>
<tr>
<td>Ploughing</td>
<td>47-48, 52, 54-56, 63, 87, 90-91, 116, 183, 194, 204, 207, 365</td>
</tr>
<tr>
<td>Pollen diagram</td>
<td>130, 153-159, 351, 356, 360, 364-367, 378-379</td>
</tr>
<tr>
<td>Pollination</td>
<td>27, 34, 133, 143, 159, 243, 377, 387-388, 404</td>
</tr>
<tr>
<td>Polyploidy</td>
<td>23-24</td>
</tr>
<tr>
<td>Pore</td>
<td>160-161, 163, 245</td>
</tr>
<tr>
<td>Postglacial</td>
<td>357-358</td>
</tr>
<tr>
<td>Potassium</td>
<td>47</td>
</tr>
<tr>
<td>Pounding</td>
<td>72, 310, 383</td>
</tr>
<tr>
<td>Preboreal</td>
<td>351, 358-359, 364</td>
</tr>
<tr>
<td>Precipitation</td>
<td>34, 36-37, 39-40, 43, 58, 93, 144-145, 147-148, 153-154, 159, 326, 352, 363, 376, 379, 392</td>
</tr>
<tr>
<td>Pressing</td>
<td>73, 188-189</td>
</tr>
<tr>
<td>Procumbent</td>
<td>108-109</td>
</tr>
<tr>
<td>Propagule</td>
<td>89</td>
</tr>
<tr>
<td>Prostrate</td>
<td>46, 63, 92, 108, 117-118, 122, 353, 417</td>
</tr>
<tr>
<td>Protein</td>
<td>25, 35, 47, 128, 130, 133, 189, 371, 396, 409</td>
</tr>
<tr>
<td>Psilate</td>
<td>163</td>
</tr>
<tr>
<td>Rachilla</td>
<td>249, 251, 261, 282, 290, 307, 390</td>
</tr>
</tbody>
</table>
Rain-fed, 58, 352
Random sampling, 78, 200-202, 219, 221, 391
Raphe, 247
Reallocation, 64, 68, 382
Reaping, 63-65, 67-68, 72, 115, 204, 211-212, 214, 220, 376, 382
Reduction, 188
Refugium, 126-127, 356
Regma, 244
Reine Proben, 106, 178
Relevé, 39, 100-104, 415
Reproduction, 24, 28, 34, 36, 68, 73, 87, 95, 108, 125, 133, 246
Reticulate, 162-164, 336
Riparian, 97, 186, 215, 217-218, 220
RNA, 47, 128, 189
Ruderal, 99, 111-112, 139, 202, 286
Saccate, 163
Salinity, 34, 45, 63, 106-107, 258, 323
Salsamentha, 191
Salting, 188, 191
Sarcocolla, 20
Scabrate, 163
Schizocarp, 243, 384
Schizocarpium, 244
Scutellum, 249-251, 253-254, 257, 298, 319-320
Season, 252
Seasonality, 112-115
Sedentism, 370, 376-377
Seed flora, 135, 137, 206
Seedcoat, 27, 29-30, 244, 246-247, 251, 322-323, 325-328, 330-331, 336, 401
Seedling, 46, 52-54, 113, 212, 386
Self-pollination, 27, 143-144, 158, 252, 365, 388
Self-fertilizing, 327
Self-pollination, 133
Semi-brittle, 250, 303, 305-306, 381, 386
Semi-shattering, 269, 383
Sepal, 132
Septum, 119-120, 245, 333-334, 345
Sexuality, 27
Shade-tolerant, 36
Shaduf, 61
Shattering, 68, 254, 258, 269-270, 336, 381
Short-lived, 123
Sibakh baladi, 51
Sibakh kufri, 51
Sickle, 64-68, 117, 127, 205, 212, 214, 308, 376, 382, 387, 410
Sieving, 71-72, 78-79, 92, 117, 193, 214, 231-232, 235-236, 238, 246, 323, 392, 397
Siliqua, 245
Silage, 245
Silo, 224, 405
Sledge, 73-76, 425
Smoking, 188
Sociability, 100, 415

Spectrum, 18, 23, 30, 124, 153-154, 387, 392, 399, 418


Spiny, 54, 92, 126, 393

Split fruit, 243-244

Sporangiophore, 131

Sporangium, 131, 146

Spore, 108, 128, 131, 133, 143, 145-146, 148, 152-154, 159-161, 163-166

Spring-sown, 259

Stamen, 27, 132-133, 249, 267

Stefanocolpate, 161

Stefanoporate, 160

Stephanocolpate, 163

Stephanocolporate, 163

Stephanoporate, 163, 164

Steppe, 101, 123, 229, 273, 294, 296, 325, 379-380, 427, 429

Steppe-forest, 379-380

Sterile, 72, 129, 191, 246, 252-253, 255, 275, 279, 282, 288-289, 297, 411

Sterility, 274

Stigma, 132-134

Stomata, 35, 37-38

Stone fruit, 241, 245, 402


Stratigraphy, 200

Stress, 35, 37, 40, 125, 258, 352

Striate, 163-164

Subassociation, 106

Subatlanticum, 351, 358, 366, 369

Subboreal, 351, 358, 364-365


Subsampling, 83, 154, 223, 230-231, 310, 392, 418

Subsistence, 375, 380, 409

Succession, 107, 137, 365-366

Succulent, 45, 62

Sweetening, 188, 191

Symbiosis, 34, 48, 387

Syndrome, 23, 387, 396

Synecoloogy, 97

Syntaxon, 97-98, 107, 123, 210

Syntaxonomy, 26, 93, 97, 113, 138

Tafla, 50-51

Taphonomy, 26, 130, 137, 173, 205, 414-415, 417

Taxon, 13-16, 18, 20, 22, 24, 94, 97, 154, 273, 291-293, 306, 399, 418

Taxonomy, 13, 16, 93, 96, 269, 293, 334

Tectate, 163

Tectum, 162-163


Territory, 371-372, 380

Testa, 246, 251

Tetrad, 160, 164

Tetrahedral, 160

Tetraploid, 15, 19, 24-25, 257, 291, 293, 299, 303, 305-306, 310, 316, 381, 390, 394

Thanatocoenose, 105-106

Therophyte, 113

Threshing, 64, 71-76, 79-80, 82, 84, 86, 92, 117-118, 174, 178, 180, 184, 189, 193-194, 201, 204-205, 207-208, 210-212, 214-216, 218, 220-221, 225, 228-229, 232, 247-250,
Tillage, 115, 125, 158
Tillering, 208, 254, 270, 297, 377, 385-386, 390, 392, 415
Tough-rachised, 305, 376
Toxic, 16, 246, 396
Transient, 33, 138
Tricolpate, 161, 163-164
Tricolporate, 163-164
Trilete, 160-161, 163-164
Triploid, 24
Triporate, 163-164
Unisexual, 27, 132, 143
Unleavened, 396
Uprooting, 63-65, 68, 74, 88, 90, 104, 207, 212, 214, 220, 308, 376, 382, 390
Utricle, 244, 339-340
Valve, 119-120, 122, 209, 245
Varve, 379
Vascular, 34, 38, 108, 147, 363, 365
Vegetable, 189, 191, 197, 403
Vernalization, 297, 385-386
Verrucate, 163
Verruculose, 325
Vesiculate, 163-164
Vitamin, 35, 371
Waterlogging, 100, 138-140, 186, 192-193, 200, 205, 235, 244, 254, 267, 319, 326, 331, 335, 397
Weeding, 52, 89, 204, 337
Wet-sieved, 399-400
Wind-dispersed, 29, 91, 96, 180, 211
Winnowing, 71-72, 76-77, 79, 92, 117, 202, 208, 214, 246, 392
Winter-grown, 328
Winter-sown, 259
Xeromorphic, 45
Xerophyte, 45, 378
Younger Dryas, 351-353, 356, 358, 380