

# CONCISE ENCYCLOPEDIA OF CROP IMPROVEMENT

Institutions, Persons, Theories,  
Methods, and Histories



**Rolf H. J. Schlegel**

*Rolf H. J. Schlegel, PhD*

# **Concise Encyclopedia of Crop Improvement** *Institutions, Persons, Theories, Methods, and Histories*



*Pre-publication  
REVIEWS,  
COMMENTARIES,  
EVALUATIONS . . .*

**"T**his book offers a concise history of crop development. It is a handy reference for knowing our past and understanding our present. It is written by one of the few modern scientists who has lived with and met many of the people in his book or those who knew them. He has done us a great service by writing this concise history before it is lost in the momentum of the ever-expanding current research in plant breeding. One notable aspect of this book is that it is written from a European perspective, hence is particularly valuable for American readers who are well versed in our traditions, but have not always seen how global science interacts."

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Rolf H. J. Schlegel, PhD



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Who would bring it into being that there are henceforth  
growing three or four spikes, where previously only  
one spike stood, he proved its homeland a service,  
which is to be valued more highly than the deeds  
of many kings, commanders and poets.

FREDERICK II, The Great, King of Prussia (1712-1786)

## ABOUT THE AUTHOR

**Rolf H. J. Schlegel, PhD, DSc**, is Professor of Cytogenetics and Applied Genetics, with over thirty years of experience in research and the teaching of advanced genetics and plant breeding in Germany and Bulgaria. Professor Schlegel is the author of more than 150 research papers and other scientific contributions, co-coordinator of the international research projects, and has been a scientific consultant at the Bulgarian Academy of Agricultural Sciences for several years. He is currently working as an R&D director in a private company in Germany. His books include *Encyclopedic Dictionary of Plant Breeding and Related Subjects* (Haworth 2003), and he contributed “Rye (*Secale cereale* L.) - A Younger Crop Plant with Bright Future,” to *Genetic Resources, Chromosome Engineering, and Crop Improvement: Cereals, Volume 2* (Eds. R. J. Singh and P. P. Jauhar).

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# Preface

According to the World Bank, since 1960 yield growth has accounted for 92 percent of the growth of world cereal production. Genetic improvements have accounted for roughly half the yield growth of major crops. The contribution of genetic improvements to yield growth in developing countries has been similarly impressive; for example in India, yield gains in maize and rice increased by 300 percent since 1940 while sorghum, wheat, and soybean yields have doubled. It shows the great importance of *plant breeding* not only for agriculture but also for future societal development on earth.

During the past fifty years, no other branch of biology has developed so fast and as comprehensively as genetics, which analyzes the inheritance and development of microorganisms, plants, and animals, including humans. Numerous related disciplines contributed to the knowledge of the basis and structure of heritable factors, their reproduction, modification, and new entities, their intraindividual and inter-individual transfer, and their permanent interaction with natural and artificial environments. Thus, modern genetics with its many branches became a fundamental discipline of biology. Genetics also influences different fields of research and stimulates new scientific approaches, including microelectronics.

Plant breeding is a field that is strongly driven by genetics, particularly during the past century. It seems to be just the beginning of a tremendous progress of targeted modification, reconstruction, and design of plants, in addition to the other challenges of breeding.

Nevertheless, plant breeding occurred independent of the development of scientific biology, philosophy, and politics. Introduction and improvement of crop plants was simply a way to (better) feed humans and animals. That is, plant breeding is a continuous process of optimization of plants for specific environments and utilization. The

19th century clearly shows that breeding activities and progress were performed without knowledge of Mendelian laws; clearly, though, breeding is also a social process. To take the most obvious sense in which this is true, there would be no professional breeders without education, societal support for the research stations, universities, and private businesses within which breeding takes place.

Because of the enormous growth in knowledge, the complexity of inheritance and breeding, and the highly specialized genetic and agricultural research, an understanding of the step-by-step (and later more systematic development) of breeding can become obliterated.

This book is a modest approach to gathering the many data, information, persons, methods, and historical developments—which are now spread across a wide range of references—into one volume. There is no similar book available on the market in English, German, French, or Spanish. The author felt that it was time to fulfill a certain need for this in the literature. This topic is usually only mentioned in introductory chapters of textbooks, papers, or college/university lessons. Moreover, this is done mostly in reference to progress in genetics, not from an original point of view.

At present, it is difficult to provide students with a historical summary in a comprehensive manner without pointing at the numerous literature references. And this becomes increasingly difficult owing to the rapid development of present plant breeding and biotechnology.

As plant breeding and adequate research becomes more and more a global task of private enterprises and several national and international organizations, the exchange of information and communication usually takes place in English, which is the predominant language in this sphere. This book can therefore be of advantage for a worldwide readership. Students of plant breeding, genetics, biotechnology, or biology might not be the only beneficiaries—breeders, teachers, or other interested persons may also benefit.

The plentitude of results, methods, and crops make it difficult for the author to consider the complete area of breeding history and to convey all knowledge based on personal experience. However, it offers the advantage of being a single representation that is more systematic than contributions authored by different authors and views. I hope this approach will prove to be successful.

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# User's Guide

This book provides a representative selection of information from the large amount of data on the history of plant breeding, genetics, and methods as well as institutions and persons associated with development of breeding and breeding research. A chronological representation was used in principle. However, parallel developments in terms of countries and cultures, as well as many temporal cross-references according to methods and persons, sometimes breaks the chronological order.

To limit the book's contents to strictly historical aspects, the explanation of technical terms or methods was avoided when possible, although they are often needed for understanding. These terms have been arranged alphabetically and included in the Glossary. A term when used for the first time is set in *italics*. Moreover, all scientific names are given in italics. Special designations, titles, citations, and variety names—as well as the names of some institutions—are set within quotation marks. When Greek letters were necessary in association with some words, they were translated into English. When possible, city names, institutes, and organizations are spelled in their national language. Cross-referenced terms and names are indicated by the symbol >>>. Names of scientists and/or family names are in ALL CAPS. However, when used as an adjective (e.g., Mendelian), as a part of variety names (e.g., Tschermak's Weissshafer), or in references, only the first letter is capitalized.

Descriptions of a given person within the “gallery of breeders” (Chapter 6) may be more or less extensive depending on the data available. A semicolon has been used in those listings to separate pieces of information.

Cross-references have been provided wherever necessary for demonstrating interrelationships, organizing the material in a clear manner, and economizing space. Additional notes are given at the end of the book, arranged by chapter.



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## Chapter 1

# Introduction

The origin of new information in agriculture, horticulture, and plant breeding derives from two methods: empirical and experimental. The roots of empiricism derive from the efforts of Neolithic farmers, Hellenic root diggers, medieval peasants, farmers, and gardeners everywhere to obtain practical solutions to problems of crop and livestock production. The accumulated successes and improvements passed orally from parent to child, from artisan to apprentice, have become embedded in human consciousness via legend, craft secrets, and folk wisdom. This information is now stored in tales, almanacs, herbology, and histories; it has become part of our common culture.

More practices and skills were involved as improved germplasm was selected and preserved via seed and graft from harvest to harvest and from generation to generation. The sum total of these technologies makes up the traditional lore of agriculture, horticulture, and breeding. It represents a monumental achievement of our forebears.

Without knowledge of the development of a scientific discipline, it is not possible to judge recent achievements or to weigh the future opportunities. Otherwise, one could overestimate the present by a large margin. Plant breeding is no exception to this. Anyone who traces the development recognizes that the achievements of breeding *crop plants* (cf. Glossary) are based on centuries- and even millenium-old experiences—barley ([Figure 1.1](#)) is one example. The total number of plant species that are cultivated as agricultural, forest, or horticultural crops is estimated as nearly 7,000 botanical species. Nevertheless, it is estimated that only thirty species “feed the world” because the major crops are from a limited number of species. The

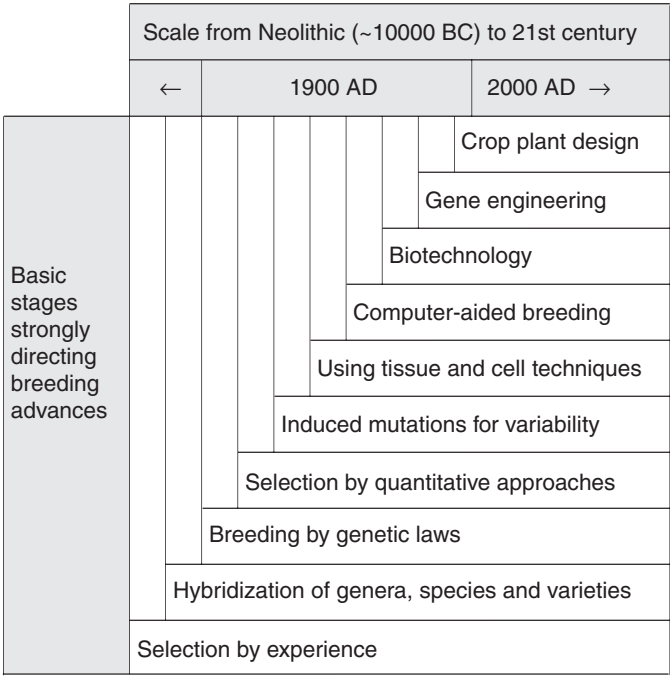


FIGURE 1.1. Major steps in plant breeding over 12,000 years of development and continuous influence by scientific achievements.

basic types of recent crops have arisen by early gathering, growing, and selection. Of course, for other crops (e.g., sugar beet, triticale, or blueberry) this step does not date back so far. Moreover, we can see how some plants actually become cultivated crops. Some fodder, ornamental, or industrial plants can be taken as examples.

Nevertheless, most crop plants are the result of a long developmental process. They derived from wild types, which are known quite well. Others are the result of spontaneous crosses, unifying the genes of two independent species within a hybrid. Under specific circumstances, the linkage of genes remains stable without a following segregation or dissociation. This is how bread wheat, domesticated plum, and rapeseed evolved.

The wild types differ from the cultivated plants not only by yield but also by many characteristics important for their existence under

growing conditions untouched by humans. Therefore, wild cereals have a brittle rachis of the spike and specially shaped awns in order to dig in the soil. Seeds and fruits of wild species are typically small. The ripening fruits shatter the seeds, such as legumes, linseed, or poppy. To prevent postripening sprouting in dry areas or frost-endangered climates, some wilds form hard-shelled seeds or show dormancy, a resting condition with reduced metabolic rate found in nongerminating seeds and nongrowing buds. Some seeds (e.g., lupins) contain bitter substances to protect against damage caused by birds and other animals. Also typical are the small and irregularly shaped tubers or beets of root crops. The wild forms are substantially less demanding than the cultivated plants in their soil and climate requirements. They grow slowly and ripen less evenly. Wild species are more pubescent. This awards them the external character of a rough, resistant, and solid plant. However, they are not, in principle, more resistant than crop plants; there are susceptible wild plants and resistant crops. In summary, wild plants are adapted to produce sufficient offspring—that is, to maintain the species. A luxuriant shape usually is not required for this and is often even adverse.

In general, the crop plants are differentiated from the wild species by the missing typical wild characters—such as seed shattering, brittle spikes, bitter fruits, or branched roots—in addition to the presence of traits that are useful in agriculture, horticulture, or forestry. The resulting cultivated plant is no longer able to exist under natural environments because of such changes. Nonshattering wheat cannot sufficiently reseed. Big and delicious strawberries are eaten by animals before ripening, and fast-growing fruit trees will break as a result of weak wood and a heavy fruit load. The modern crop plant is more or less dependent on humans for its propagation by sowing, harvest, threshing, and storage. In some crops, the degree of dependence has progressed particularly far. In maize, for example, the seeds sit so tightly on the cob that self-seeding has become impossible, whereas other cereals still shatter the grains when overripe or harvested late. This shows that crop plants still can have wild features. Examples include the burst of pods in legumes or rapeseed, seed shattering in cereals, dropping of fruits in fruit trees, long germination period in parsley, bitterness in cucumbers, deep rooting, and multigerms in sugar beet.

To be classified as a cultivar, it is important that the plant shows either a majority of or the essential traits that are different from the wild characters and/or be modified for human utilization. What is still missing can be improved by subsequent breeding.

Breeding, however, does not confine itself to supplementing useful traits but also improves the existing characteristics. Through genetic engineering, even an interspecific and an intergeneric transfer of alien characters becomes feasible, in addition to the creation of novel traits (see section 4.2.2.2).

In some cases, intensive breeding has led to a situation in which cultivars lost too many of the original wild characters. Breeding toward reintrogression of wild characters is one way out of the dilemma. The enhancement of dormancy in order to reduce preharvest sprouting was such a task in rye and oat improvement.

The origin of cultivated plants is basically a process of displacing wild characters and enriching suitable traits—a process that began thousands of years ago for wheat, barley, and millet.

## Chapter 2

# 10,000 Years of Crop Improvement

Humans have been hunters and gatherers for 99 percent of the 2 million years our species has roamed the earth. Only in the last 12,000 years have people become agriculturists. The dates of domesticated plants and animals vary by region, but most predate the 6th millennium BC and the earliest may date from 10,000 BC. According to carbon dating, wheat and barley were domesticated in the Middle East in the 8th millennium BC; millet and rice in China and south-eastern Asia by 5500 BC, and squash in Mexico by about 8000 BC. Legumes found in Thessaly and Macedonia are dated as early as 6000 BC. Flax was grown and apparently woven into textiles early in the Neolithic period (4500-1800 BC). The most sweeping technology change for humans occurred in prehistory: the use of tools, the discovery of fire, and the invention of agriculture. In addition, climatic changes during the late Pleistocene—with the consequent shift of vegetation as a whole and encouragement of particular plant species to prosper and spread—have been suggested as another reason for the emergence of agriculture.

As with agriculture, plant breeding arose as a part of human development beginning in ancient times. Cultivation, the first step toward domestication, begins (at least for seed crops) with human planting of harvested seeds to provide a new crop. The harvested seeds represent a selected sample of the total variability, biased toward those characteristics of the population particularly attractive to humans and/or having the least efficient mechanisms for seed dispersal. Seeds planted by humans are, to some extent, protected from the pressure of natural

selection; this, together with changes in the population size, will lead to changes in variability of the crop in time.

At least six regions of domestication have been identified, including Central America, the southern Andes, the Near East, Africa (Sahel and Ethiopia), Southeast Asia, and China (>>> N. I. VAVILOV). Agriculture is thus one of the few inventions that can be traced back to several locations. From these foci, agriculture was progressively disseminated to other regions, including Europe and North America.

Actually, there are two theories on the origin of agriculture: a single origin with diffusion versus multiple independent origins. The “single origin plus diffusion” concept is articulated in a thoughtful essay by CARTER (1977). However, the presently accepted dogma is that agriculture arose as independent inventions in various parts of the world at different times. There is evidence that agriculture originated in the Middle East over 10,000 years ago. Recent studies show that Southeast Asia could stand in the same tradition.

At the old cultural centers of the world—China, Egypt, Asia Minor, around the Mediterranean Sea, Central and South America—agriculture (often with irrigation) has been practiced for thousands of years. Evidence of the importance attached to wheat, rice, soya, millet, and sorghum can be found in a regulation of the Chinese emperor CHEN-NUNG from about 2700 BC. It describes the custom of annual spring sowing, ceremonially carried out by the emperor himself.

The oldest excavation of cereals with characters of a cultivar was made in Jarmo (Kurdistan/Iraq) (HELBÆK, 1959); it was dated to the 7th millennium BC. The wild species *Triticum dicoccoides* and the cultivated type *T. dicoccum* were identified. As compared with natural conditions, even the earliest agricultural activities brought modified environments for the plants cultivated. Plant species—those that humans recognized as worthy to grow and probably used already at the time of collectors—were first classified as primary crop plants: wheat, barley, millet, rice, soybean, cotton, potato, or maize.

However, the changed conditions did not directly modify the wild types toward a cultivar. Rather, those genotypes that showed better performance, adaptation, and propagation under the culture conditions of humans became predominant among the diverse mixture of phenotypes. This is called a choice or *selection* process. It also happens in

nature, but the selection contributes exclusively to the maintenance of the species and not the improvement of particular traits for human utilization. Despite the geographically diverse distribution of the domestication centers, we can identify a remarkably similar set of traits that have been selected in widely different crops. These traits jointly make up the “domestication syndrome” (HAMMER, 1984). They result from the selection of spontaneous mutations that occurred in wild populations and were selected at various stages of growth of these wild plants, for example, spikelet nonshattering in *Avena abyssinica* grown in barley fields or pod indehiscence and flat seed in the weed *Vicia sativa* grown in lentil fields. Another example is the initially rare semi-tough-rachised (domestic) phenotypes of wild einkorn (*Triticum monococcum*) that could have achieved fixation within twenty or thirty generations of selection.

The inheritance of traits has been investigated numerous times. Initially, they were analyzed as Mendelian traits because many of them display qualitative variation and discrete phenotypic segregation classes. More recently, for a limited number of crops (maize, bean, tomato, rice, and millet), these same traits have been analyzed by *quantitative trait locus* (QTL) approaches, which are more powerful because they allow a genomewide analysis of influence on several traits at the same time. It was shown that their state is often controlled by recessive alleles at one or, at most, two or three loci. Furthermore, the joint involvement of these genes accounts for most of the phenotypic variation, suggesting a high *heritability*. Finally, many of the genes are located in a limited number of linkage groups (chromosomes), and on these linkage groups they are sometimes closely, although not tightly, linked.

When humans first began to mechanize the harvest by using primitive tools, bigger spikes rather than smaller ones were preferentially selected. From the Romans, a harvest wagon is known that was pushed into a stand of cereals with the help of a donkey and two farmers (Figure 2.1). By fingerlike tools on the front side of the wagon, the spikes were pulled off and fell into a basket. This led to selection of larger spikes and the reduction of genotypes showing smaller growth habit. The consequence was a stepwise improvement of the cultivars. In addition, one can assume that some growers consciously attempted to make improvements in traits and species.

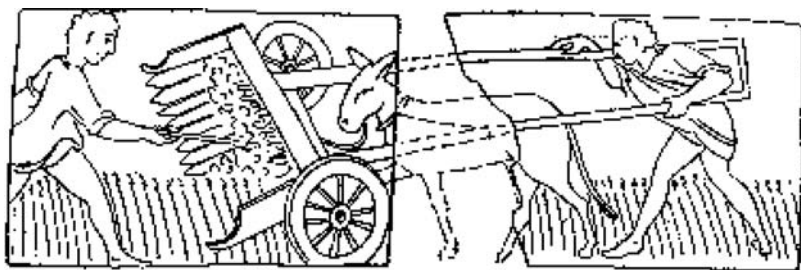


FIGURE 2.1. Reconstruction of a Gallo-Roman mow wagon (the Trevires' harvester, an ingenious piece of agricultural machinery described notably by PLINY the younger: "In the vast fields of Gaul, large harvesters, with blades fixed at one end, are pushed on their two wheels across the crop by an ox yoked in the opposite direction. Uprooted in this way, the ears of corn fall into the harvester.") Source: H. SCHMALZ (1969), found in 1958 on two limestone reliefs in Buzenol and Arlon (Belgium) dated to the first half of the 3rd century AD, The Musee Luxembourgeois, Arlon.

Another factor probably led to an increase of cultivated species. Close to early settlements, some species became more enriched and showed better growth than those on distant and poorer soils. In time, the area of settlement was enriched with nutrients by animal and human excrement and other waste. Plant species that had not been recognized as worthy to collect or to grow on poor places were now recognized as suitable crop plants. Hemp, poppy, castor, cabbage, beets, mangold, carrots, parsley, and some pharmaceutical plants became such cultivated species. These plants particularly like nutrients and are called *anthropochores*. One of the latest plant species that seems to have so become a crop plant is stinging nettle (*Urtica dioica*). There are breeding approaches for different end uses.

In this context, a third origin of cultivated plants must be mentioned. Within the fields of primary crop plants grew many weeds, for example, brittle wild rye occurred within stands of emmer wheat. As long as these weeds were poor wild types, they were eliminated during the harvest from cropped plants because of their brittleness, dispersal fruits, or small grain size. However, as soon as the accompanying weeds became adapted to the ripening time and cropping conditions of the main crop or showed other inheritable features useful for humans, they were also used as crop plants, often when the main crop suffered

from drought or winter killing. Important crop plants—such as rye, oats, buckwheat, pea, lentil, white mustard, gold-of-pleasure (*Camelina sativa*), rocket salad (*Eruca sativa* syn. *E. vesicaria*), and spergularia (*Spergularia maxima*)—originated within emmer wheat and barley and within emmer wheat and linseed.

In particular, the development of rye (*Secale cereale*) can be traced back over 5,000 years. With the distribution of wheat toward northern regions, rye was superior to wheat in sub-Alpine and steppe climates. Because of its cold and nutritional tolerance, it became the predominant cereal. It reached northern Europe about the 3rd or 2nd millennium BC. The deterioration of climate some 3,000–3,500 years previous promoted rye's distribution in Central Europe. Despite the poor quality of flour, it became the most important cereal crop of Celts, Teutons, and Slavs. The cultivated oat (*Avena sativa*) followed a similar path. Prehistoric excavations seem to confirm that it came as weed within barley to Western Europe about 2,500 years ago.

The spatial scale of development of agricultural societies widely correlates with the distribution of domesticated crops. Agriculture appears to have spread at speeds averaging 1 to 5 km per year, having started around the 7th to 6th millennium BC in southeastern Europe and being completed around the 3rd millennium in northwestern Europe.

As a weed in maize and bean fields, the tomato (*Lycopersicon esculentum*) was distributed by humans from central Peru to Mexico. Only in Mexico was it cultivated, although it remained long as garden weed. The anthropochoric hemp (*Cannabis sativa*) took the way as crop plant from a weed of the Altai region of Central Asia to an accompanying plant in nomad settlements.

Crops that arose from primary crops are designated as *secondary crop plants*. Of course, new cultivated plants can develop within secondary crops. Common corn cockle (*Agrostemma githago*, Caryophyllaceae) and rye brome (*Bromus secalinus*, Gramineae) are two that show characteristics (tough rachis or grain size) that evolved under the influence of recent cultivation within rye. Within common oat (*Avena sativa*) grown in the poor soils of northwest Europe, some wild oats (*A. fatua*, *A. strigosa*, and *A. elatior*) achieved cultivated characters as well.

Surely, humans consciously affected genesis of cultivated plants by their preference for the most useful phenotypes, best seeds, and vegetative propagules for reseedling. We know today that the best-looking plants do not yield the best descendants, so it is not controversial that this practice sometimes led to improved cultivars and races.

## 2.1. THE OLD WORLD

The agriculture, horticulture, stock farming, fishery, and medicine of old Mesopotamia show extensive and versatile biological knowledge. Mesopotamian civilizations are largely based on Semitic populations that existed between the Tigris and Euphrates Rivers in what is now Iraq. The climate is winter wet and summer dry, which is particularly suitable for livestock rearing and large-scale cereal cultivation; it is the source of wild wheat and barley and also of sheep and goats. The area includes the Fertile Crescent—present-day Israel, Jordan, Lebanon, Syria, Iraq, and Iran—as well as all of Asia, southwest of Russia and the Black Sea, west of India, and Afghanistan. Spelt wheat (*Triticum spelta*)—the precursor of common hexaploid wheat (*T. aestivum*)—seems to have originated from different places of Iran and northern Caucasian regions (>>> KUCKUCK, 1959).

The agricultural history of Mesopotamia can be inferred from many sources, including cuneiform tablets and inscriptions as well as archaeological remains. The agriculture and horticulture of this region are richly annotated in biblical sources. Sumerians and Akkadians recorded long lists of plant names. In the so-called Garden Book of the Babylonian emperor MARDUK-APAL-IDELINA (8th century BC), the cultivated plants mentioned are barley, emmer and common wheat, durra millet (*Sorghum vulgare* or *S. bicolor*), beans, peas, lentil, onions, garlic, leak, beets, radish, cucumbers, melons, sesame, linseed, the carob (*Ceratonia siliqua*), olive, almond, and pomegranate. From the south (Egypt) came the date; from the southeast (India) came the fig, pomegranate, and citron; and from the north to northeast came the roses, lily, grapevine, apple, pear, peach, pistachio, plum, mulberry, quince, and walnut.

### 2.1.1. Sumeria

Sumeria was one of the advanced cultures of the 4th millennium BC, probably arising from non-Semitic populations of the East. Until recently, it was a lost culture unknown to HERODOTUS (484-424 BC). He describes exuberantly the full growth of barley and wheat: “200- to 300-fold harvests thrive (!). How beautifully the millet would thrive, it wanted conceal in order appearing not untrustworthy.” He centered Sumeria in the Euphrates Valley in the Chaldean plains. It contained the ancient city of Ur, three times its capital. Sumerians were the first to develop writing (3000 BC) in the form of cuneiform script etched on soft clay tablets, which were allowed to harden into a permanent record. Sumerians introduced canals and were among the first systematic agriculturists. By 3000 BC, there were extensive irrigation systems branching out from the Euphrates River and controlled by a network of dams and canals. The main canals were lined with burned brick and the joints sealed with asphalt. At its peak, 10,000 square miles were irrigated. The legendary SARGON I, known as Sargon the Great (2334-2279 BC), founded the Akkadian-Summerian Empire. In a tale similar to that of MOSES a thousand years later, he is discovered in a reed basket:

Akki the irrigator made me a gardener. My service as a gardener was pleasing to ISTAR and I became King. (In G. A. BARTON, *Archaeology and The Bible*, 3rd ed., American Sunday-School Union, Philadelphia, 1920, p. 310.)

### 2.1.2. Mesopotamia and Babylonia

There are rich literary sources for Mesopotamian agriculture. A cuneiform text from NIPPUR called *The Dialogue Between the Hoe and the Plow* is a source of agricultural information; it is dated between 1900 and 1600 BC but may well have older origins, perhaps belonging to the Ur III (~2100 to 2000 BC). In the 2nd millennium BC, the great civilization along the Euphrates known as Babylonia formed from the union of Akkadians and Sumerians, with Babylon as its capital. Historic figures include HAMMURABI (~1,750 BC) and NEBUCHADNEZZAR, who was the King of Babylon (605-562 BC). *The Code of Hammurabi* contains many laws concerning agri-

cultural crop practices, such as irrigation and fermentation. They produced beer from barley and wheat as well as wine from grapes and dates; vinegar was a by-product.

The Hanging Gardens of Babylon, long considered one of the seven wonders of the ancient world, was supposedly built for NEBU-CHADNEZZAR's homesick bride. Spiral pumps irrigated gardens, which were 20 m high with royal chambers located under terraces. Babylonian agricultura images include a plow containing a seed drill, beer drinking, and water lifting with a shaduf. A cuneiform tablet—the restoration of a document from 1500 BC from the ancient Sumerian site of Nippur—might be the first farmer's almanac. It consists of a series of instructions addressed by a farmer to his son, guiding him throughout the year's agricultural activities. A document tablet from the same period described a myth (INANNA and SHUKALLITUDA: "The Gardener's Mortal Sin") that reveals the agricultural and horticultural techniques of windbreaks—planting shade trees in a garden or grove to protect plants from wind and sun. A cuneiform tablet from about 1300 BC shows a map of fields and irrigation canals. An Assyrian herbalist in the 7th century BC named 900 to 1,000 plants. Examination of clay tablets in the library of King ASSUR-BANIPAL of Assyria (668-626 BC) identified 250 vegetable drugs, including asafetida, calamus, cannabis, castor, crocus, galbanum, glycyrrhiza, hellebore, mandragon, mentha, myrrh, opium, pine turpentine, styrax, and thymus. Their special cultivation and selection can be assumed.

Sumerians and Babylonians knew the sexual *dimorphism* and *dioecious* habit of the date palms. They artificially pollinated the female flowers either by hand ([Photo 2.1](#)) or by hanging the male flower bunch in the crowns of the fertile trees. The number of male trees could be kept small, and the fruit setting of the females could be increased. Planting of palm trees distributes about one male plant among 100 females (SWINGLE, 1913). In the history of breeding, this is the first documented evidence for guided *alogamy* by humans, opening the chance for breeding new varieties and broadening the genotypic variability for selection. ROBERTS (1929) reported that, in four Sahara oases, more than 400 varieties of date palms could be distinguished by size, shape, and taste of fruits. In Mesopotamia and Egypt, which



PHOTO 2.1. Assyrian relief of the period of emperor ASSURNASIRAPAL II (883-859 BC), illustrating pollination of female flowers of date palms by winged genie wearing bird masks. *Source:* Institut f. Pflanzengenetik u. Kulturpflanzenforschung, Gatersleben. Used with permission.

were better known for their breeding and handling, no other dioecious species was grown at that time.

Possibly maize is another example of early breeding-like approaches, although no record of this is available. However, primitive varieties of maize were found in a South American bat cave dated back to 4000 BC (see the following text).

### **2.1.3. Judea**

Much is known about the culture of Judea (1200-587 BC) because many books of the Bible have come to us almost intact. In the biblical literature, common agricultural and horticultural practices are discussed, but the interpretations are usually religious or moral. Still, a reading of the scriptures tells us much about the agriculture of this period. The basic roots of these “desert” people are well represented, although in these early times the annual rainfall was higher and soils more fertile than nowadays. Plants, plant products, and agricultural technology are referred to in hundreds of verses. Genetics can even be found in the Old Testament of the Bible. In Leviticus 19:19, the Is-

raelites are warned not to let their cattle breed randomly and not to sow their fields with mingled (contaminated) seed. About breeding activities, it is written further:

Yet I had planted thee a noble vine, wholly a right seed: how then art thou turned into the degenerate plant of a strange vine unto me? (JEREMIAH 2:21)

I am the true vine, and my father is the husbandman. Every branch in me that beareth not fruit he taketh away: and every branch that beareth fruit, he purgeth it, that it may bring forth more fruit . . . As the branch cannot bear fruit in it, except it abide in the vine; no more can ye, except ye abide in me. I am the vine, ye are the branches: He that abideth in me and I in him, the same bringeth forth much fruit: for without me ye can do nothing. If a man abide not in me, he is cast forth as a branch, and is withered; and men gather them and cast them into the fire, and they are burned. (JOHN 15:1-6)

In a related context, it is thought that fruits of wild figs were artificially ripened. The fruit depends on pollination by wasps (*Ceratosolin arabicus*). When sycamore (fig) was introduced to Egypt, apparently the wasp was not introduced and seeds were not produced. To ripen the fruit without pollination, the ancient system was to “scrape” the fruit with iron claws as THEOPHRASTOS of Eresus, city of Lesbos (372-287 BC), mentioned. This practice is still carried out in Egypt and Cyprus. The wounding acts to increase ethylene, which induces ripening. Ethylene is the most recent addition to the list of plant hormones. 2(chloroethyl) phosphoric acid, an ethylene-generating substance, is now commercially used to induce ripening as well as latex flow in rubber.

#### 2.1.4. Egypt

Egyptian culture dates back to the dawn of civilization, and remnants exist in a continuous 6,000-year-old record. The artistic genius engendered by Egyptian civilization and the dry climate there has made it possible to reconstruct a history of agricultural technology. Ancient Egypt is shown to be the source of much of the agricultural

technology of the Occident. From 4000 to 3000 BC these mingled peoples of the Nile valley formed a government, constructed the first pyramids, and established highly advanced agricultural technology. The ancient names for Egypt underscore the relation between the land, the people, and its agriculture. These include “*Ta-meri*,” the beloved land cultivated by the hoe; “*Ta Akht*,” the land of flood and fertile soil; “*Kmt*,” the black soil; “*Tamhi*,” the land of the flax plant; and “*Nht*,” the land of the sycamore fig tree.

The ancient Egyptian god of vegetation, OSIRIS, is credited with introducing the skills of agriculture to the Egyptians. He became the god of the dead and the underworld, following his slaying by his brother SET and restoration to life by his wife and sister ISIS. OSIRIS is sometimes depicted with green skin in paintings or in statues made from green stone, reflecting his aspects of agriculture, vegetation, fertility, and resurrection. He was recorded as the first to make mankind abandon cannibalism and is credited with introducing culture of the vine and fermentation of its fruit to produce wine. This may be the oldest account of a biochemical process. The legend of OSIRIS and ISIS dates back to at least 2400 BC, as recounted by the Greek historian PLUTARCH (46-120 AD). The historian Diodorus SICULUS (~1st century BC) included OSIRIS among those who had been men and were immortalized by virtue of their sagacity and good works. The story may be derived from the Sumerian goddess of fertility, ISHTAR, who could grant crops to her devotees.

Knowledge of the crops of ancient Egypt can be deduced from the artistic record, but definite proof comes from the desiccated remains of plants themselves. The chief ancient grain crops, used for bread and beer, were barley and various wheats including the diploid einkorn, the tetraploid emmer and durum wheats, and the hexaploid spelt and bread wheats. One of the ancient cereals<sup>1</sup> of Egypt—now marketed as “*kamut*”—has recently been introduced in the United States and Europe.

The vegetables of ancient Egypt included a number of root crops, leafy salad crops, legumes, and various cucurbits. The ancient root crops, such as the pungent alliums (garlic, *Allium sativum* and onion, *A. cepa*) and the radish (*Raphanus sativum*), continue to be popular in modern Egypt. Among the leafy salad crops were lettuce (*Lactuca sativa*) and parsley (*Petroselinum crispum*). There were a number of

pulses, such as cowpea (*Vigna unguiculata*), broad bean (*Vicia faba*), chickpea (*Cicer arietinum*), and lentils (*Lens culinaris*). The cucurbits included cucumber (*Cucurbita sativa*), melons (*Cucumis melo*), gourds (*Lagenaria* spp.), and later watermelon (*Citrullus lanatus*). The date and doum palm (*Hyphaene thebaica*), also known as the gingerbread palm, and the sycamore fig (*Ficus sycomorus*) are considered predynastic Egyptian fruits although the sycamore is indigenous to east and northeast Africa. Jujube, common fig, and grape were known since the Old Kingdom; carob and pomegranate were introduced in the Middle Kingdom; olive and apple appear in the new Kingdom, and peach and pear date to the Graeco-Roman period.

About 2,000 species of flowering and aromatic plants have been found in tombs. An exquisite bas-relief depicting a visual representation of the fragrance from essential oils being extracted from an herb is found on the walls of the PHILAE Temple. Herb and spice plants—important for culinary, cosmetic, medical, and religious uses—were continually introduced. Pharaohs were horticulturally sophisticated and were collectors. From foreign campaigns they brought back exotic trees and plants to be grown in their palace or temple gardens. Queen HATSHEPSUT organized a plant expedition delivering living myrrh trees from Punt (Northeastern Africa) for the terraced gardens of her Temple at Deir el-Bahri in 1500 BC, and she kept records about the plants discovered. It might have been the first expedition to collect plant genetic diversity and to preserve them like gene bank material. Herbs, spices, aromatics, and medical plants included “ami” or Ethiopian cumin (*Carum copticum*), anise (*Pimpinella asisum*), caper (*Capparis spinosa*), coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), dill (*Anethum graveolens*), fennel (*Foeniculum vulgare*), fenugreek (*Trigonella foenum graecum*), marjoram (*Origanum majorana*), mint (*Mentha spicata*, *M. sativa*), mustard (*Sinapis alba*), rosemary (*Rosmarinus officinalis*), safflower (*Carthamus tinctorius*), and thyme (*Thymus acinos*). The queen’s nephew THOTHMES III (1,450 BC) had the curious plants brought from Syria carved on the walls of the Temple of Amen in Karnak, among which iris can be recognized.

Industrial and fiber crops were important in ancient Egypt. Oil of the castor bean (*Ricinus communis*) was used for illumination and as a medical plant, flax (*Linum usitatissimum*) for linen and oil, henna (*Lawsonia inermis*) for dye, papyrus (*Cyperus papyrus*) for paper,