

Biological Innovation: The new explanation of agricultural growth¹

A Longue-Durée Perspective of the European Agriculture from Roman Times to the Agricultural Revolution

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Research shows how new grain varieties or “new” crops were developed and/or improved to suit marginal soils. Every new expansion making use of marginal soils brought about an expansion in the economic life in Europe. The most important was the late introduction of the “weed” rye, while the latest in the long list of plants was the improvement of potato varieties. This expansion of plants follows the scheme as Olmstead and Rhode show using the example of grain in the USA.

1. Factors explaining economic growth

The theoretical tools to analyse economic changes are derived from the experiences of the agrarian and industrial revolutions and the time thereafter, but they are also used retrospectively to explain the economic development of the previous period. The basic explanations commonly used for economic growth are technological changes, labour force and capital growth.²

The new cliometric research of Alan L. Olmstead and Paul W. Rhode demonstrates another cause of economic growth. They have researched the productivity growth of the main agricultural products in the United States during the period 1800 to 1940.

Their conclusion regarding the cultivation of wheat was that “there was a relentless campaign to discover and develop new wheat varieties and cultural methods that would allow the wheat frontier to expand into the northern prairies, the Great Plains, and the Pacific Coast states. Without these technologies, western yields would have been significantly lower and vast areas of the United States and Canada would have been unsuitable for

¹ The term Biological Innovation refers to non mechanical innovations such as new plant varieties, fertilizers, irrigation and drainage system, improved cultural practices, and the like.

² But also for the absence of economic growth. See for instance De Martino, Francesco: *Wirtschaftsgeschichte des alten Rom*. Munich 1991. He asserts that the economic crises in the late Imperial era were due to the fact that there was not a sufficiently large working force to farm the available soils, p.336. The productivity of the working force also declined and there were no technical innovations, p. 544f.

commercial wheat production.”³ So in 1919 only 8% of the wheat acreage was planted with varieties in existence before 1840.⁴ “Mechanical innovations certainly lowered the cost of growing wheat in the West, but the binding constraint was biological. Without a biological revolution (assisted by the transport revolution), the centers of wheat production in the United States and Canada could not have assumed their late-nineteenth-century dimension.”⁵

Researchers in other scientific disciplines, for instance plant biologists, have also emphasised this view for some time now.⁶ The most famous of them is Norman E. Borlaug with his plant improvements leading to the “green” revolutions in Mexico and India.⁷ He argues that political leaders’ secret pact with industrialization was a miserable failure, viz. mechanisation and capitalization.⁸ In other words, the economic theories of the 19th and 20th centuries failed. According to Borlaug the most restrictive production factor is the lack of nutrition in the soil. Without enough nutrition high productive wheat species do not give good yields.⁹

The botanist and microbiologist Franz Schwanitz comes to the conclusion that it is not going too far to state that the colonization of the earth and the high standard of living would not have been possible without the creation of local grain species by the farmers.¹⁰

“Fundamentally agriculture is a biological process. Climate and soil composition affect production, but biological (that is, genetic) changes

³ Olstead, Alan L. and Rhode, Paul W. *Creating Abundance. Biological Innovation and American Agricultural Development*. Cambridge University Press. 2008 p. 17f

⁴ Olstead, Alan L. and Rhode, Paul W. *Creating Abundance. Biological Innovation and American Agricultural Development*. Cambridge University Press. 2008 p. 389

⁵ Olstead, Alan L. and Rhode, Paul W. *Creating Abundance. Biological Innovation and American Agricultural Development*. Cambridge University Press. 2008 p. 62

⁶ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967.

Montanari, Massimo: “Romans, Barbarians, Christians. The Dawn of European Food Culture”. In *Food. A Culinary History from Antiquity to the Present*. Columbia University Press.

Miedaneer, Thomas: *Roggen: vom Unkraut zur Volksernahrung*. Frankfurt/Main 1997

Küster, Hansjörg: “Rye” in *The Cambridge World History of Food 1*. Cambridge 2000

⁷ Borlaug, Norman E.: *Den gröna revolutionen. Veteförädlingens och dess betydelse för världsförsörjningen*. Stockholm 1970.

⁸ Borlaug, Norman E.: *Den gröna revolutionen. Veteförädlingens och dess betydelse för världsförsörjningen*. Stockholm 1970, p. 11

⁹ Borlaug, Norman E.: *Den gröna revolutionen. Veteförädlingens och dess betydelse för världsförsörjningen*. Stockholm 1970, p. 23

¹⁰ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 317

resulting from natural processes or skilful manipulations by scientists have produced a host of new plant varieties (...).¹¹

Their results put the question of the importance of the biological innovation and whether it has a central position in explaining economic change, also before the time of the agricultural revolution.

Together with the results from both economic historians named above and the plant-biologists it is now possible to carry out meaningful interdisciplinary research for the time when there is no or only very rare and incomplete statistical material.

2. The importance of agriculture and grain cultivation before the agrarian revolution

The base of the ancient European economy before the onset of the Agrarian Revolution was agriculture. What the farmers produced as surplus decided the entire economic possibilities of a country. We estimate that agriculture probably contributed between 70 and 80 percent of the monetary value of all goods produced by a country or region.¹² There are only a few exceptions to this general rule. The facts are well-known in themselves but are often overlooked in scientific studies.

The surplus produced by farmers or other persons engaged in agriculture was decisive for the entire economic perspective of a country or state, such as the Roman Empire for instance.¹³ The standard of its culture and the development of all kinds of skills, not to mention its military power, depended on the amount of agrarian surplus produced and the capacity to keep this surplus at a high level.¹⁴

However, farmers' activities were conditioned by the characteristics of the

¹¹ Book review: *Economic History Review*, 62, 4 (2009) p. 1042f D. Douglas Hurt

¹² Montanari, Massimo: *Der Hunger und der Überfluß. Kulturgeschichte der Ernährung in Europa*. Munich 1993, p. 183ff. The first reduction of vegetable consumption in favour of meat begins in the 18th century in the Netherlands and England.

¹³ Jones, A.M.H.: *The Decline of the Ancient World*. London 1968, p 30.

Duncan-Jones, Richard: *The Economy of The Roman Empire*, p. 33

Finley, Moses I.: *Die Antike Wirtschaft*. Dtv 1980, p. 112

¹⁴ In a process of agrarian growth M.M. Postan writes that agriculture first serves to provide nourishment for the growing population in the cities. Second: The higher rural incomes increase the demand for industrial products. And finally: Increasing rural productivity supplies the towns with labourers. "Fact and Relevance. Essays on historical method", Cambridge University Press 1971, p. 107

land, that is by the quality of the soil and the local climate. The measure or degree to which people were capable of adapting to these factors was of the utmost importance in determining the amount of agrarian surplus a society could produce. This holds true for the times following the decline of the Western Roman Empire and in particular to the highly developed Italian city states. “For, in all phases of its history, Italy has remained a predominantly agricultural country, and the bulk of Italian records, including those of commercial cities like Florence, relates not to trade or business or even to government, but to the land, its ownership, management and cultivation.”¹⁵

The importance of grain for Europeans was due to the fact that cereals yields are relatively high compared to other plant families and there is a possibility of storing a surplus over a long time; however, harvests are very much dependent on the fertility of the soil and the availability of fixed nitrogen.¹⁶

Accordingly, grain was the main crop produced and also the staple food consumed. It accounted for approximately 50 percent to a maximum of 70 - 75 percent of a person’s caloric intake, that is, his or her daily food consumption; at times, for example during the 10th and 11th centuries in Northwest Europe, it even reached a maximum of 75 – 85 percent.¹⁷ The higher the social class a person belonged to, the less grain he or she consumed. “European peasantries needed cereals to survive, of course, in all cases; but the cereals at their disposition were often insufficient, and had to be back up by silvo-pastoral resources.”¹⁸ This dependence on grain in such a

¹⁵ Jones, P.J.: “The agrarian development of medieval Italy”. *Deuxième Conférence Internationale d’Histoire Economique*. Aix-en Provence 1962. Paris 1965, p 70

¹⁶ Zohary, Daniel and Hopf, Maria: *Domestication of Plants in the Old World. The origin and spread of cultivated plants in West Asia, Europe and the Nile Valley*. Oxford University Press 2000 Third edition p. 16

¹⁷ Comet, Georges: “Technology and Agricultural Expansion”. In: *Medieval Farming and Technology: the impact of agricultural change in Northwest Europe*. Leiden; Brill 1997, p 15

Montanari, Massimo: *Der Hunger und der Überfluss*. Munich 1993, p 184

Livi-Bacci, Massimo: *Population and nutrition. An Essay on European demographic history*. Cambridge University Press 1991, p. 85ff.

Adam Smith, (ed Skinner, Andrew, 1980): *The Wealth of Nations*. p 292: “Corn (...) is the common and favourite vegetable food of the people, constitutes, in every civilized country, the principal part of the subsistence of the labourer.” For Adam Smith this is so important that: “Corn (...) is in all the different stages of wealth and improvement, a more accurate measure of value than any other commodity (...).

¹⁸ Wickham, Cris: *Land and Power. Studies in Italian and European Social History, 400-1200*. British School at Rome. London 1994 p. 186

large measure was the cause of famines in Europe, especially during the 17th century.¹⁹ When grain crops failed, there were no alternatives available.

2.1 The possibility of expanding the agricultural production in an ancient economy

The most available fertile soils were at the beginning of the researched time, Roman times, cultivated with nutritive pretentious plants, grain. Until the time when the agrarian revolution was general, there was no possibility of expanding production per hectare in a substantial way. Thus the main expansion of food supply had to be made through marginal soils.²⁰ The problem to solve was how to find plants that would grow there in an economical way, or to develop already known species.

All this adds up to the fact that only an analysis of the development of agriculture can help to explain the growth, stagnation or retardation of economic activity in Europe until the onset of the agricultural revolution. (Europe in this context is seen as an entity, comprising surplus and deficit areas.²¹)

3. The “new” main crops introduced

3.1 Roman Times

Wheat and barley were crops which were widely grown in the Mediterranean region long before the Roman Empire existed, but it was the Romans who succeeded in cultivating them more extensively on different soils and in different climatic zones. The extensive cultivation of naked wheat under the Republic and the Empire was a great cultural achievement according to R.J. Forbes, because the new cultivation occurred on former forest areas, where the soil was very acid.

¹⁹ Montanari, Massimo: *Der Hunger and der Überfluss*. Munich 1993, p 129 and 184
In Sweden the caloric intake for farm labourers and servant girls originating from grain was about 70 percent in the 16th century. It increased during the 17th century to 80-90 percent. Myrdal, Janken: *Jordbruket under feodalismen 1000-1700*. Borås 1999, p 245

²⁰ Massimo Livi Bacci came to the same result, but his logical argument is that the seed/harvest ratio is about the same during the whole period, the food supply per person constant, the population four times higher, and consequently the areas under cultivation have to be extended. *Europa und seine Menschen*. Munich 1991, p.33

²¹ Fernand Braudel makes a very rough estimation of the seabound grain trade in the Mediterranean area in the 16th century. A maximum 1 percent of all grain consumed went this way. *Der Alltag. Sozialgeschichte des 15.-18. Jahrhunderts*. Munich 1985, p. 130

The development/improvement of wheat was based on the fact that there was no other competing grain available for human consumption, only its cousins, for instance emmer wheat. In the first 300 years of the Roman history emmer was the main edible grain, followed by barley and then wheat.²² In Imperial times barley was mostly used to feed animals and slaves. The amount of barley produced was higher than that of wheat, but the value of wheat was higher.²³

An important rational aspect is that wheat is superior to most other cereals (e.g. maize, rice, or barley) in its nutritive value.²⁴

Agriculture on the Italian Peninsula seems to have cultivated a lot of different species of wheat, depending on the soil conditions and their susceptibility to plant disease.²⁵

Naum Jasny describes the different species and their spread under the Roman Empire. He shows the great variety of the wheat cultivation, but the picture is not completely clear. There are some errors in the translation of the classical agricultural writers' classification as well as an uncertainty as to what kind of wheat was cultivated. (One simple classification of the genus wheat is the number of chromosomes. The first group is the Einkorn. Second the Emmer group with emmer and hard wheat. The third group the Spelt with spelt and common wheat.)²⁶

The classical agricultural writer recommended wine and olives to be cultivated on marginal soils. Wine could be cultivated in almost every climate zone and on different soils, but only if the right variety was chosen. In early Imperial times the Romans had a lot of different varieties to choose

²² Flach, Dieter: *Römische Agrargeschichte*. Munich 1990, p. 250

²³ Forbes, R.J.: *Studies in Ancient Technology, Volume III*, Leiden 1955, p. 87

²⁴ Zohary, Daniel and Hopf, Maria: *Domestication of Plants in the Old World*. Third Edition. Oxford University Press 2000, p. 19

²⁵ Schmitz, Peter: *Agrarlandschaften der italienischen Halbinsel*. Berlin 1938, p. 25
What does the term "Wheat" mean? Daniel Zohary and Maria Hopf take 11 pages to explain the different varieties of the grain "Wheat". *Domestications of Plants in the Old World* Oxford University Press 2000, p. 19.

Jonathan D. Sauer writes: In archaeological records, it is difficult or impossible to discriminate between tetraploid and hexaploid free-threshing wheats. There are thousands of varieties of the two, and the naked grain looks, similar in most varieties, (...). *Crop Plants. A selection roster*. CRC 2000, p. 220.

We will use it here to mean all naked wheat.

²⁶ Jasny, Naum: *The Wheats of Classical Antiquity*. The John Hopkins Press. Baltimore 1944

from.²⁷

At the time when the Romans conquered Spain the Iberians had some vineyards, but only during the Imperial period did viticulture make such rapid strides that Spanish wines became strong competitors for Italian brands. Enormous quantities were imported to Italy.

Gaul went through the same process as Spain. The country became the centre of Europe as a wine-growing region.²⁸

The olive tree also grows well on different soils, but best of all on chalky, sandy soils. On pure chalky or sandy soils and wet soils it did not grow well. The Roman agricultural writers describe the ten best-known species of olives, their size, taste and the growing conditions.²⁹

The Romans' latest success in olive cultivation occurred in the first centuries A.D. in the area of El Jem (Latin: Thysdrus), in present-day Tunisia. Here the rainfall is less than 200 mm a year and the soils are very poor. The region can be characterized as a desert. In this dry, infertile area the Romans developed a species of olive tree and they knew how to cultivate it on extremely poor soil. The area around Thysdrus flourished during a time when other parts of the Roman Empire were beginning to suffer from economic problems.

The trees were planted far away from each other in the infertile soil. Excavations show that the root system of an olive tree can be 12 meters broad and 6 meters deep. With this huge root system it can absorb and use the sparse nutrients in the soil³⁰ The growth of the trees also depends on the water supply; less than 200 mm a year can be sufficient. The precondition is that the soil permits the rain to flow immediately down to a level where it does not evaporate and will remain until the trees need it. The quality of the water is not so important. They can grow in brackish water too.³¹

²⁷ Flach, Dieter: *Römische Agrargeschichte*. Munich 1990, p. 274f.

²⁸ Forbes, R.J.: *Studies in Ancient Technology*, Volume III, Leiden 1955, p. 121f

²⁹ Flach, Dieter: *Römische Agrargeschichte*. Munich 1990, p. 283f.

³⁰ Pansiot, Fernand Paul, Rebour, Henri: "Improvement in Olive Cultivation." *FOA Agricultural Studies No. 50*. Rome 1961. Sid. 16

³¹ Pansiot, Fernand Paul, Rebour, Henri: "Improvement in Olive Cultivation." *FOA Agricultural Studies No. 50*. Rome 1961. Sid. 52f

3.2 Arab agriculture in Southern Europe

The next agricultural expansion in the Mediterranean basin occurred in the south. The Arab conquest changed and intensified the agriculture in the conquered regions. The Arabs brought from the East subtropical plants, for instance rice, orange trees and date palms. (The latter were already cultivated in Syria, Egypt and southern Tunisia, but the Arabs brought the date palm to the other regions.) All these plants depended on irrigation. The Arabs were highly skilled at finding water and transporting it. For this purpose they also used the old Roman water constructions. "Rain, rivers and springs are the gifts of God (...)" writes S.M. Imauddin. He describes how the Arabs used scientific methods to analyse the soils in order to find out if there were enough moisture in it for agrarian use.³²

From the south of Sahara the Arabs introduced sorghum to areas where it had not previously been cultivated. It followed a route via Nubia, Upper Egypt, oases in Libya, the region around Cyrenica and some parts of Algeria, until sorghum eventually reached southern Morocco.

Rice was grown almost wherever there was sufficient water to irrigate it: in river valleys which were flooded naturally or artificially, and in swamp lands, "although its overall importance never reached that of wheat or even sorghum."³³

Hard wheat is an exception to the conclusion drawn that the plants introduced by the Arabs were dependent on irrigation. It was sown on drier soils, in steppe regions where common bread wheat cannot be grown successfully. Therefore the hard wheat gradually displaced other forms of wheat to become the principal wheat grown in the Middle East and the Muslim Mediterranean. "The plant took so well to its new environment that many new varieties appeared: Spain, the Maghreb, the eastern Mediterranean, Central Asia, the Yemen and Abyssinia, (...)"³⁴

The wealth and superiority of the Islamic lands were founded on their high

³² Imamuddin, S.M.: *The Economic History of Spain* (Under the Umayyads, 711-1031) Dacca 1963, p 75

³³ Watson, Andrew M.: *Agricultural innovations in the early Islamic world. The diffusion of crops and farming techniques 700 – 1100*. Cambridge University Press 1985, p. 15

³⁴ Watson, Andrew M.: *Agricultural innovations in the early Islamic world. The diffusion of crops and farming techniques 700 – 1100*. Cambridge University Press 1985, p. 21

agricultural standards. For the Spanish economic historian Josep Fontana these standards were based on an agrarian revolution.³⁵

The changes also influenced the southern parts of Europe, but they did not occur throughout the whole of Italy. “The only major exception was Arab Sicily, (...) where a whole array of new crops and a sophisticated irrigation network were introduced between the ninth and the twelfth century.”³⁶

The Italian economic historian Emilio Sereni supports this opinion of the Arab invasion in the 8th century and their control of the area in southern Italy until the 11th century. But in his view the Arabs also had an enormous influence on later Italian agriculture. “To this Arabic influence, (...) Sicily and southern Italy owed, in great part, that agricultural pre-eminence that (...) they preserved up into the fourteenth and, in certain sectors, the sixteenth centuries.”³⁷

Wickham and Sereni research the Arab influence from an European perspective: Their results show how the Arabs with their new plants influenced the South European agriculture. Andrew M. Watson takes the Arab view. For him it is “A Case of Restricted Diffusion”: (The subtitle of his article.) “When the new crops and associated farming techniques reached the border of Christendom, they were not quickly admitted. Rather they were kept languishing at the border (...)”³⁸ After the Christian conquerors had taken over the Arab lands, they cultivated them with traditional European plants and the Arab plants lost their importance, but they did not disappear.

3.3 The first stage of the growth of Central and Western Europe

The next agricultural growth wave in Europe affected most of Central and Western Europe and had an enormous impact on the future development of

³⁵ Fontana, Josep: *Europa im Spiegel. Eine kritische Revision der europäischen Geschichte*. Munich 1995, p. 74

³⁶ Wickham, Cris: “Early Medieval Italy. Central Power and Local Society 400-1000.” In: *New studies in medieval history*. 1981, p. 93

³⁷ Sereni, Emilio: *History of the Italian Agricultural Landscape*. Princeton University Press 1997, p.72

³⁸ Sweeney, Del (Ed.): *Agriculture in the Middle Ages. Technology, Practice , and Representation*. University of Pennsylvania Press. 1995. Watson Andrew M.: *Arab and European Agriculture in the Middle Ages: A Case of Restricted Diffusion*, p 63.

the European economy. One grain played the leading role in this growth wave. It was rye.

German technical historians write that rye is the real discovery of the early Middle Ages. It could be cultivated on poor soils and in damp-cold parts of Europe. It was also possible to make it into bread.³⁹

Massimo Montanari, who researched food habits in Europe, especially in Italy, found that rye and oats were “genuine medieval ‘inventions’”. He writes that these wild grasses were selected and cultivated from the fourth to fifth centuries on, but local variations were developed in the Early Middle Ages in Italy.⁴⁰

For Wilhelm Abel rye cultivation spread from eastern and northern Europe to the south. The first traces, he writes, will be found in what is now Denmark in about the year 100 B.C. ⁴¹ For later researcher the two grains, wheat and rye, seem to be “new imported” in the Roman Times to Germany. Wheat from the West (Gaul) and South. Rye from the German arias in the East⁴²

These different views about the origins of rye seem to be contradictory. If we look at the preconditions for the plant we can find an explanation for both views.

The first precondition is the fact that the closer a weed, rye, is to a cultivated grain, wheat, the easier it is for it to grow in the fields with this cultivated grain, because on these fields the weeds will find the nutrients they require, and will have the same growing timespan and habits.⁴³

The second precondition is that rye is less demanding than wheat as regards the quality of the soil. It also grows well in lower average winter temperatures and on more acid soils than wheat. (After deforestation the

³⁹ Hägermann, Dieter: „Technik im frühen Mittelalter zwischen 500-1000.“ *Ur Propyläen Technikgeschichte*. Berlin 1997, p. 394

⁴⁰ Montanari, Massimo: *Romans, Barbarians, Christians. The Dawn of European Food Culture*. In *"Food. A Culinary History from Antiquity to the Present* Columbia University Press. 1999, p. 173

⁴¹ Abel, Wilhelm: *Geschichte der deutschen Landwirtschaft vom frühen Mittelalter bis zum 19. Jahrhundert*. Stuttgart 1979. Sid.42

⁴² Henning, Friedrich-Wilhelm, (ed.) *Deutsche Agrargeschichte Vor- und Frühgeschichte*. Stuttgart 1997. Bender, Helmut: *Agrargeschichte Deutschlands in der Römischen Kaiserzeit innerhalb Grenzen des Imperium Romanum*, p. 305

⁴³ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 336

soils are normally too acid for wheat, but not for rye.)

Agriculture in Central and Northern Europe employed to a large extent the “moving villages” system. This means that the village moved when its cultivated soil started to produce lower yields. The Alemanni used this system in Roman times in the south-west of what is now Germany. In Denmark and southern Sweden, Scania, the system was in use in the time of the Vikings.⁴⁴ The areas with good soils, for instance loess/loam soils, were permanently cultivated.

It is possible that over the centuries the proportion of the weed rye expanded in the wheat fields, because here it had better growing conditions than wheat. In the areas with increasingly lower temperatures and poor soils rye had an increasing advantage over wheat and expanded steadily across the wheat fields. At a certain point the rye was tolerated and no longer a weed, but one of the cultivated plants.⁴⁵

At this point it is important to look at the archaeobotanical methods of measuring the historical existent of rye. In contrast to most of the other crop plants rye can be identified through both carbonized grains or grain impressions and through its pollen. Nonetheless it is difficult to prove the cultivation of rye, because it is a secondary crop plant, which as mentioned expanded as a weed and later on achieved the status of a cultivated plant. The question is when archaeobotanical methods show weeds or the crop rye. For Karl-Ernst Behre the share of rye must be more than 1% of the cereal finds to not be a weed. With this perspective he makes the following conclusion: “Rye has been found in almost all parts of Europe from around the year A.D., and soon afterwards, but it was not yet a crop plant in most places.”⁴⁶

⁴⁴ Skansjö, Sten: *Skånsk senmedeltid och renässans. Söderslätt genom 600 år*. Lund 1983, p. 74f. Hansjörg Küster shows in *Geschichte der Landschaft in Mitteleuropa*, Munich 1996 p. 164 a map showing the village of Vorbasse, Jutland to the 9th century when the willage stopped moving.

⁴⁵ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 341
Zohary, Daniel and Hopf, Maria: *Domestication of Plants in the Old World*. Third edition. Oxford University Press 2000, p. 77
Sauer, Jonathan D.: *Historical Geography of Crop Plants. A select roster*. CRC 2000, p.223

⁴⁶ Behre, Karl-Ernst: *The history of rye cultivation in Europe. Vegetation History and Archaeobotany* 1992 1:141-156

Another problem is, so E.J.T. Collins, that “pollen analysis may be misleading in that rye is a species producing an abundance of airborne pollen, distinctive and easily identified, and so tends to be over-represented in pollen layers”. He gives the following example: “Pollen analysis suggests that rye was a major crop in the Saxon period, but recently archaeological research shows this not to have been the case in the Wessex region (...) where wheat and barley were much the commonest grains.”⁴⁷

The Romans knew rye, but mostly as a weed in the wheat field. In late Imperial times the soil in some regions was largely exhausted. The farmers changed their cultivation practice from more demanding cereals to less demanding ones, like rye, oats and spelt in Northern Italy and barley and millet in the southern part of the country.⁴⁸

For Jonathan D. Sauer the “weed” rye became a part of Roman agriculture in their northern European provinces, including Germany and Britain.⁴⁹ There is some evidence that the Roman soldiers on the *limes* were consuming rye and using it for beer brewing. Rye was also partially cultivated in the sandy areas in northern part of continental Europe.⁵⁰

The question where the rye came from can now be answered. “The various archaeobotany records of rye and also etymological evidence support the view that rye growing did not begin in a particular area and then spread, but it started independently in different regions of Europe and usually in areas where arable farming was difficult.”⁵¹

The close relationship between the growth habits of rye and wheat also explains why throughout the Middle Ages both cereals were cultivated as

⁴⁷ Collins, E.J.T.: “Rye in Britain”, p119. In *Le Seigle. Histoire et Ethnologie*, eds. Devroey Jean-Pierre, Van Mol, Jean-Jacques and Billen, Claire. Centre Belge D’Histoire Rurale. Publication nr. 112.

Karl-Ernst Behre states that the pollen dispersal of rye is regarded as more than 100 times as high as that of the other cereals. *Vegetation and History and Archaeobotany*, 1992 1:pp. 141-156

⁴⁸ Montanari, Massimo: “Romans, Barbarians, Christians. The Dawn of European Food Culture.” From *Food. A Culinary History from Antiquity to the Present*. Columbia University Press. 1999, p. 173

⁴⁹ Sauer, Jonathan D.: *Historical Geography of Crop Plants. A select roster*. CRC 2000, p.223

⁵⁰ Behre, Karl-Ernst: *The history of rye cultivation in Europe. Vegetation History and Archaeobotany* 1992 1:141-156

⁵¹ Behre, Karl-Ernst: *The history of rye cultivation in Europe. Vegetation History and Archaeobotany* (1992) 1:141-156

maslin. The farmers minimized the risks. If the weather was good they would harvest more wheat; if the weather was cold and wet, they could harvest more rye.

In Central Europe the cultivation of rye expanded from the 8th to the 10th centuries. By the end of the Middle Ages it was the most important grain cultivated. On the poor sandy soils on the North Sea coast rye was sown on about 70% of the cultivated area.⁵²

In England and Wales the cultivating of rye also shows the characteristic feature, that “large scale production was limited to a few areas, normally those with a high proportion of sandy soils, or arable land above 150 metres, and otherwise localized pockets”. But rye would never be a pre-eminent grain in England. Wheat, barley, and oats maintained the position as the main grains.⁵³

Despite the climatic preconditions rye is “unadapted to Mediterranean conditions”, but it grows well on the Po basin, because here it has the same climate as in central Europe.⁵⁴ This explains the growing importance of Northern Italy.

This rapid advance of rye during this time had one great difficulty to overcome: ergotism. All over Europe where rye was cultivated, the ergot in the harvest resulted in epidemics. These were particularly widespread in the years 1042, 1076, 1089 and 1094.⁵⁵ The timing of the epidemics shows how new the grain was for the farmers who did not have time enough to learn to cope with it.

The rye flour contained ergot, spurred rye. It was extremely poisonous and could result in the loss of limbs and even death. It was a long time before the problem was completely solved. Ergotism seems to have remained a potential threat until the 18th century.⁵⁶

⁵² Behre, Karl-Ernst: “Die Ernährung im Mittelalter.” From *Mensch und Umwelt im Mittelalter*, ed. Bernd Herrmann. Stuttgart 1986, p. 80.

⁵³ Collins, E.J.T.: “Rye in Britain”, p120. In *Le Seigle Histoire et Ethnologie*, eds. Devroey Jean-Pierre, Van Mol, Jean-Jacques and Billen, Claire. Centre Belge D’Historie Rurale. Publication nr. 112.

⁵⁴ Forbes, R.J.: *Studies in Ancient Technology*, Volume III. Leiden 1955, p. 86f.

⁵⁵ Montanari, Massimo: *Der Hunger und der Überfluss*. Munich 1993, p 56.

⁵⁶ Pallach, Ulrich-Christian: *Hunger. Quellen zu einem Alltagsproblem in Europa und der Dritten Welt 17. bis 20. Jahrhundert*. dtv Dokumente. München 1986, p 288ff

3.31 The influence of rye cultivation on the cultivation system

In the Mediterranean area the main rainy season is in the winter. For the farmer this means that he has to sow grains in the autumn, so that they get enough moisture during the main growing phase. He cannot sow grains again on the same field the next autumn, because the time between harvest and sowing is too short.⁵⁷ (The exception is the area around Milan, where the harvest can be carried out very early.) All this changed with the introduction of rye in Central and Western Europe in regions with spring and summer rains. The first year the farmers sow the grain which takes the most nutrients from the soil: wheat. The second year they sow a grain requiring fewer nutrients, rye. The third year the farmers must let the soil rest (lie fallow).

This explains why the Mediterranean region and areas in Central and Southern France have a two-course rotation system and Central, Western and Northern Europe have a three-course rotation system.

A lot of researchers see the three-crop system as permitting a marked expansion in grain production, because the area under cultivation will be higher; instead of half of the soils lying fallow, only one-third of the area will now lie fallow at any time. For Ch. Parain this is “the great agricultural novelty of the Middle Ages.”⁵⁸ But this assertion does not take into account the balance of nutrients in the soil.

If the balance of nutrients in the three-course rotation system is studied, the idea of increased production must be regarded with scepticism. Braudel remarks that there are larger areas under the two-course rotation system in France than under the three-crop system. He refers to the calculations of François Sigaut. These show that there are no differences between the two systems. Braudel does not accept part of Sigaut’s conclusions, because he sees some questionable assumptions in the conversion calculations.⁵⁹

⁵⁷ Already in Roman times it was recommended to sow from the 26th of September, so that the seed could grow before the weather was too cold and wet. If sowing was carried out too late in the autumn the shoots would rot. Flach, Dieter: *Römische Agrargeschichte*. Munich 1990, p. 254

⁵⁸ Parain, Ch.: *The Evolution of Agricultural Technique*. Cambridge Economic History of Europe. Vol. 1. Second Edition. Cambridge 1966, p. 136

⁵⁹ Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 129ff. Sigaut, F.: *Pour une cartographie*.

“Three-course rotations, however, were by no means the “revolution” they are often claimed to be,” writes Georges Comet. His assertion is based on economic grounds: “On any given cultivated surface, it did not increase the value of production, for the somewhat greater proportion of spring grains on three-course rotations carried a lesser overall market value.”⁶⁰

B.H. Slicher van Bath also describes the advantages of the three-course system. He makes no calculations of the production increment, but makes a reservation: “However, it is not quite impossible for the more intensive system so to reduce the yield that the two-course system proves the more profitable after all.”⁶¹

During this first phase of expansion the area under cultivation was only a small percentage of the total surface of Western Europe. Estimates for Northern Europe and Scandinavia vary between a minimum of 1.4% to a maximum of 3%⁶² The existing villages at this time lay like islands surrounded by woods and fens. The rapidly increasing cultivation of rye was made indirectly at the expense of the woods.

Large coherent areas of field crop growing in what had previously been woodland changed the micro-climate during the summer, during the growing period. The heat protection of the previous woodlands disappeared and in the open fields the heat of the sun radiated direct into the soil. The temperatures on the coherent fields were then higher than before. This was an advantage for grain cultivation.⁶³

3.4 The expansion of some minor plants in Europe

3.4.1 The chestnut

Parallel to this development in Central and Northern Europe there were minor agrarian changes in the southern regions. The most extreme plant was the chestnut.

⁶⁰ Comet, Georges: “Technology and agricultural expansion in the Middle Ages: The example of France north of the Loire”, p 29. In *Medieval Farming and Technology. The Impact of Agricultural Change in Northwest Europe*. Brill 1997

⁶¹ Slicher van Bath, B.H.: *The Agrarian History of Western Europe A.D. 500 – 1850*. London 1963, p. 60

⁶² Abel, Wilhelm: *Geschichte der deutschen Landwirtschaft vom frühen Mittelalter bis zum 19. Jahrhunderts*. Stuttgart 1978, p. 16

⁶³ Küster, Hansjörg: *Geschichte der Landschaft in Mitteleuropa. Von der Eiszeit bis zur Gegenwart*. Munich 1996. And *Geschichte des Waldes. Von der Urzeit bis zur Gegenwart*. Munich 1998

There are some documents indicating that chestnuts were cultivated in the 5th and 6th centuries on the slopes of Montanella in Campania, south-east of Naples. Under the reign of the Langobards, after 571, laws were passed relating to the cultivation and use of chestnut wood.

Monte Amiata in Tuscany is another large and very old area of chestnut cultivation. Chestnut woods were to be found at an altitude between 350 and 1,000 metres.

The Romans brought the tree to parts of Central and Western Europe which had adequate climate conditions.⁶⁴ There is no information about how extensive the cultivation was, but we must assume that it was very low.

For the northern parts of Italy, Lombardy, Chris Wickham writes that there is very clear documentation of *castaneta* in a large variety of ninth- and tenth century texts: if there was a decline in chestnut cultivation after the sixth century, it was reversed by 800, and in the tenth century, indeed, we have signs of new plantation.⁶⁵

According to Massimo Montanari the expansion of the cultivation of the chestnut tree occurred especially in the centuries after the 11th - 13th century. This took place in the process he calls the “agrarianisation of the landscape”. One of the effects of the rye cultivation was the destruction of the woods, but in many regions in Southern and Central Europe the reverse development occurred. The cultivation of chestnut trees was intensified. The background was that the wild chestnut had been improved to become an edible species. Oak woods were cleared and edible chestnut trees were planted.⁶⁶

According to Roy Ladurie the chestnut woods in later medieval times were concentrated in mountain regions with siliceous marl from the Estremadura up to Savoy. They were cultivated on neglected soils overgrown with shrubs and were virtually non-existent on the plains or in the valleys. Chestnuts are the only edible crop for humans in these mountainous regions, for instance

⁶⁴ Küster, Hansjörg: *Geschichte des Waldes. Von der Urzeit bis zur Gegenwart*. Munich 1998, p. 104

⁶⁵ Wickham, Chris: *Land and Power. Studies in Italian and European Social History, 400-1200*. British School at Rome. London 1994 p. 192

⁶⁶ Montanari, Massimo: *Der Hunger und der Überfluß. Kulturgeschichte der Ernährung in Europa*. Munich 1993, p. 53

in the Cévennes. The soil is too acid for wheat, and rye grows poorly on this type of soil. The chestnut can be consumed in different forms; it also makes good bread⁶⁷ (Pane del albero).

At first glance the importance of chestnuts seems relatively insignificant, but the statistics for mountain villages give a different picture. In the diocese of Nîmes-Alés it is the third-most important agricultural product, after grain and vines. In fourth place was oil.⁶⁸

Le Roy Ladurie's research shows that the extent of chestnut cultivation did not change during the period after the Black Death. This is proved by the strong expansion in the period around 1350.

3.4.2 The introduction of the rice cultivation on the Po basin

As already indicated rice has been cultivated for a long time in Europe, having arrived there via Egypt, North Africa, Sicily and Spain.⁶⁹ There is evidence that the cultivation of rice was abandoned in Southern Spain following the Reconquest by the Spaniards, because the population began to suffer from various illnesses, including malaria. Another explanation is that it was abandoned because of the heavy deforestation.⁷⁰

Medieval disputes show that rice cultivation became the object of a controversy over the suitability of its exploitation. So it must have survived in one or another way. The rice cultivation was limited to the Valencian region for centuries. In 1752 its rice fields extended for 13,000 hectares. After a period of prohibition rice cultivation was permitted in the 19th century in whole Spain.⁷¹

There are no estimates for the consumption of rice, but it seems to have been low. It remained the food for the poor.⁷²

In Northern Italy there are numerous documents, for instance account

⁶⁷ Le Roy Ladurie, Emmanuel: *Die Bauern des Languedoc*. Munich 1990, p. 78ff

⁶⁸ Le Roy Ladurie, Emmanuel: *Die Bauern des Languedoc*. Munich 1990, p. 73

⁶⁹ Cinotto, Simone (red.): *Colture e culture del Riso: Una prospettiva storica*. Vercelli 2002. Montanari, Massimo: *Storie de un chicco di riso*. Sid. 46

⁷⁰ Imamuddin, S.M.: *The Economic History of Spain (Under the Umayyads, 711-1031)*. Dacca 1963.

⁷¹ Ferrero, Aldo (ed.): *Rice. Landscapes of life*. Juan Piqueras and Josep Vincent Boira: *Rice in Spain*. Vercelli 2005, p. 179

⁷² See: Leonard, Rudolf: *Agrarpolitik und Agrarreform in Spanien*. Munich and Berlin 1909.

books, dating from the 13th to 14th centuries, which indicate that it was used as medicine and for sweetmeats. The amounts used were small. The price, by contrast, was very high.⁷³ Later this changed. During the famine of 1590 the city council of Bologna distributed rice daily to hungry farmers who came to the city begging.⁷⁴

B. Ciferri has researched botanical records, but has not found any descriptions of rice during the 14th century. He could not find any references to rice in the famous work of Pier de Crescenzi.⁷⁵

Duke Galeazzo Maria Sforza (1444-1476), wrote to the monks at Santa Maria di Lucedio and asked them about their experiences with rice cultivation. He saw the monks as great “experimenters”.⁷⁶ In 1475 the duke seems to have had some good harvests, because he writes in a letter dated 27 September to his colleague, the Duke of Ferrara, on this subject. The letter was brought to the ambassador of the Duke in Milan. In it he told his colleague that he was sending him twelve bags of rice for sowing. The rice would provide a very good harvest and the Duke of Ferrara could sow it on “terreni acquitrinosi”, on marshy lands.⁷⁷

(To understand the excellent results of rice compared to wheat, here is an example for the 18th century taken from Braudel: A one-hectare rice field will yield 7,350,000 calories, while a hectare of wheat yields only 1,500,000 calories.⁷⁸)

Galeazzo’s brother, Ludovico il Moro (1452-1508), is best known for his great agricultural achievement with the mulberry tree, “il moro”. He also

⁷³ Cinotto, Simone (red.): *Colture e culture del Riso: Una prospettiva storica*. Vercelli 2002. Montanari, Massimo: *Storie de un chicco di riso*, p. 46

⁷⁴ Montanari, Massimo: *Der Hunger und der Überfluss. Kulturgeschichte der Ernährung in Europa*. Munich 1993, p.131

⁷⁵ Ciferri, B. *Lineamenti per una storia del riso in Italia. Ente Nazionale risi*. Ufficio studi. Quaderno n. 8, p. 10

⁷⁶ Other information says it was a Benedictine monastery. In the neighbourhood of Luciedo there was the Benedictine monastery, S. Genuario. Maybe there were some connections before the monastery of Luciedo was founded in 1123.

⁷⁷ Ciferri, B. *Lineamenti per una storia del riso in Italia. Ente Nazionale risi*. Ufficio studi. Quaderno n. 8, p. 17 Figure 16. “Potesse sperimentare nelle sue terre la coltivazione del riso, pianta estremamente interessante perché coltivabile anche in terreni acquitrinosi.”

⁷⁸ Braudel, Fernand: *Sozialgeschichte des 15.-18. Jahrhunderts. Der Alltag*. Munich 1985, p. 155

published rules for the cultivation of rice.⁷⁹

The early importance of rice cultivation in the Po basin can be seen in the exports from this region. It began after 1525 in the regions of Novara, Vercelli and Saluzzo.⁸⁰ All of them are situated in the western part of the Po basin, far from the Adriatic and its ports. J. A. Faber has researched the decline of the Baltic grain trade in the second part of the 15th century. He finds indications that grain production in South and West Europe grew fast, as can be seen in a production surplus. Part of this surplus was exported: rice from North Italy, maize from Spain and buckwheat.⁸¹

The first information we have about the area cultivated dates from the beginning of the 18th century. For the region of Vercelli it was 7,254 hectares, about 7% of the total surface of the region, but 32.5% was not cultivated because it was marshland, woodland or pasture. After the middle of the 18th century the land under rice cultivation began to grow rapidly.⁸²

Rice cultivation seems to be a monocultural system only in the province of Rovigo. After the canals were constructed there was a rotation system. The system varied according to the different soils. In the main regions, Vercelli, Novara and Pavia, the rotation system was wheat, pasture and rice.⁸³

At the same time as the expansion of the north Italian rice began, in the second part of 16th century, the king of France published an edict ordering the growing of rice in the Rhone delta, the Camargue. The Camargue has a Mediterranean type of climate with winter rains and dry summers. The annual precipitation is about 600 mm, but the annual evaporation can reach 1,300 mm per year. The Mistral wind blows more than 200 days a year and increases the evaporation in the plain of the delta. This supports the salinating of the soils. Therefore the attempt was unsuccessful. Only in the middle of the 19th century, after the construction of embankments to protect

⁷⁹ Cinotto, Simone Ed. *Colture e culture del Riso: Una prospettiva storica*. Vercelli 2002. Montanari, Massimo: *Storie di un chicco di riso*, p. 47

⁸⁰ Ciferri, R.: *Lineamenti per una storia del riso in Italia*. Ente Nazionale Riso. Ufficio studio. Quaderno n. 8, p. 10

⁸¹ Faber, J.A.: *Decline in the Baltic Grain Trade*. In "Acta Historiae Neerlandica" Leiden 1966, p. 124

⁸² Sereni, Emilio: *History of the Italian Agricultural Landscape*. Princeton University Press 1997, p. 305

⁸³ Piacco, Romeo: *La coltivazione del Riso in Italia*. Ente Nazionale Risi. Ufficio studi. Quaderno n. 3, p. 10

against floods of the Rhone, the creation of an irrigation system and the desalination of the soils with help of a first cultivation of other crops, did it become possible to cultivate rice.⁸⁴

3.4.3 Buckwheat

Buckwheat was the last crop to be introduced in Europe before the invasion of the American plants: maize, potato, tomato, sunflower and so on.⁸⁵

Farmers in the Low Countries began to sow the tuber buckwheat on sandy soils during the 11th century. According to J. A. Faber there are indications that production and consumption grew during the 17th century. Flanders and Brabant exported buckwheat to the Republic of Holland during the 18th century, or probably even during the second half of the 17th century. The crop was introduced at the Amsterdam Stock Exchange in 1669.⁸⁶

In the 17th and 18th centuries price lists from Bremen, Namur and Luxembourg show that buckwheat was traded regularly.⁸⁷

In France buckwheat was introduced during the 15th century. By the year 1536 it was being cultivated extensively.⁸⁸ Georges Comet writes that buckwheat was cultivated in Brittany in 1450 and that it had originated in Mecklenburg.⁸⁹ Braudel adds that the tuber had reached the highland département of Ariège after the 17th century. Here it played an important role as a staple food for the common people.⁹⁰

Diedrich Saalfeld carried out his research in the Northwest of Germany. The soils there are very fertile in places, but there are also sandy soils.

⁸⁴ Ferrero, Aldo (red.): Rice. *Landscapes of life*. Alain Audebert: *The French center of rice*. Vercelli 2005, p. 195f.

⁸⁵ Behre, Karl-Ernst: "Die Ernährung im Mittelalter." In *Mensch und Umwelt im Mittelalter*, ed. Bernd Herrmann. Stuttgart 1986, p.76

⁸⁶ Faber, J.A.: "Decline in the Baltic Grain Trade." In *Acta Historiae Neerlandica*, Leiden 1966. Sid. 125

See also Dejongh, Guy and Thoen, Erik. "Arable productivity in Flanders and the former territory of Belgium in a long-term perspective (from the Middle Ages to the end of the Ancien Régime)" in *Land productivity and agro-systems in the North Sea area*. Ed. Bas J.P. Van Bavel and Erik Thoen. Brepols 1999, p. 49

⁸⁷ Braudel, Fernand: *Sozialgeschichte des 15.-18. Jahrhunderts. Der Alltag*. Munich 1985, p. 113

⁸⁸ *Cambridge Economic History of Europe*. Volume I, p. 163

⁸⁹ Comet, Georges: "Technology and Agricultural Expansion." In: *Medieval Farming and Technology: the impact of agricultural change in northwest Europe*, Leiden; Brill 1997, p 16f

⁹⁰ Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 55f

Buckwheat was first introduced on the latter soils after the Thirty Years' War, but it was not grown extensively. Only 0.5 to 4.0% of the soil was used for growing the tubers.⁹¹

Braudel points out that the advantage of buckwheat was that it could be sown in regions with a grain harvest in July/August without any preparation of the soil. The tuber matured at the end of October. In regions where the grain harvest was late, buckwheat could not be sown. Then it had to be sown in spring.⁹²

Another method was that after a section of woodland or a coppice had been cleared, the land would usually be sown for three years with rye, oats and buckwheat. After this time growing crops was forbidden, to enable the trees to grow up again.⁹³

There is strong evidence that buckwheat was cultivated extensively. In many regions it was one of the most widely cultivated "grain" crops, but it is difficult to measure either the quantity or the value of buckwheat. If buckwheat was the first crop sown on the fields the farmers had to deliver their tithes from it, but if it was sown as a second crop, for instance after the rye harvest, the farmers could keep all of the buckwheat for themselves.⁹⁴ In this latter case there is no information recorded in the cash books.

The introduction of other "new" crops reduced the importance of buckwheat, but as late as 1900, in those regions in Europe with poor soils, buckwheat was cultivated on 10% of the land area.⁹⁵

3.44 Maize: an important crop (but not cultivated on marginal soils)

Maize demands soils with a high ratio of organic substances. This means

⁹¹ Saalfeld, Diedrich: *Bauernwirtschaft und Gutsbetrieb in der vorindustriellen Zeit*. Stuttgart 1960, p. 53

⁹² Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 55f

⁹³ Küster, Hanjörg: *Geschichte des Waldes. Von der Urzeit bis zur Gegenwart*. Munich 1998, p. 118. This system seems to have been applied in parts of Germany but not in Scotland. See: Smout, T.C., MacDonald, Alan R. and Watson, Fiona: *A history of the native woodlands of Scotland, 1500-1920*. Edinburgh University Press, 2005, p.389

⁹⁴ Lutz-Dollinger, Brigitte: *Buchweizenanbau und Buchweizenbauern in Südtirol*. Schlern-Schriften 278. Innsbruck 1986, p.17

⁹⁵ Lehmann, Heinz: *Der Deutschen Buchweizenanbau und seine Entwicklung in den letzten 100 Jahren*. Leipzig 1940, p. 6 chart 1.

that maize had to be cultivated on soils where other grains also were cultivated.

Because maize had higher yields than the minor grains, it banished the latter. In North Italy, around the year 1700, maize was substituted for millet, wash millet and rye.⁹⁶ The substitution went further, for instance at the monastery of Correzzola in the province of Padua, where maize at the end of the 18th century was substituted for barley, buckwheat and millet.⁹⁷

It was probably Columbus who brought maize seeds back to Spain after his second voyage to the West Indies. For more than a century after its arrival in Europe, the cultivation of maize was insignificant. The great changes first began in the middle of the 17th century. “It transformed the Cantabria coastal region, permitting it to maintain a much larger population than formerly and making it possible for the area to sustain a vigorous economic life.”⁹⁸

In France maize began to be sown more extensively at the end of the 17th century, especially in Aquitaine, around Toulouse. Braudel writes that maize saved the south of France, the Midi, from the “price explosion” and from the famines of the Baroque age. In the south of France maize cultivation offered some advantages. It was sown in the summer time. In a region with a traditional two course system, now the farmers had a crop for the third course. Second the grain was used for human consumption and the rest of the crop was fed to the animals. Maize was consumed and wheat was sold or exported. Toulouse became a commercial grain town.⁹⁹

Venetian traders probably brought the first maize seeds to North Italy in early 1539, but it was not until the end of the 16th century that it was cultivated on the fields. During the 17th century maize cultivation slowly

⁹⁶ For yields see: Maggiore, Tommaso e Bertolini, Marco: “Breve storia del mais.” In *Le piante coltivate e la loro storia*, ed. Failla, Osvaldo e Forni, Gaetano. Milano 2001, p. 106f. The same development is reported from other regions.

⁹⁷ Roe, Daphne A.: *A Plague of Corn. The Social History of Pellagra*. Cornell University Press 1973, p. 28. The original information is from Sette, V.: *Memoria storico-naturale sull'arrossimento straordinario di alcune sostanze alimentari osservato nella provincia di Padova*. Venice 1819.

Pier Luigi Sparggiari: *L'agricoltura negli stati parmensi dal 1750-1850*, p. 35 “guest 'ultimo (il granturco) aveva anzi provocato una notevole riduzione delle culture a spelta e a miglio.”

⁹⁸ Vicens Vives, Jaime: *An Economic History of Spain*. Princeton University Press 1969, p. 512

⁹⁹ Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 56

spread into the Po valley. In the year 1677 we find the first records about its cultivation in Milan. After that it continued to spread up the valley. Maize cultivation reached Piedmont some decades later. During the 19th century it spread down to Tuscany and South Italy.¹⁰⁰

The most important advantage of maize was of course its higher yield, but another advantage was that the grain needed only a short time to grow to maturity.¹⁰¹ This fact made it possible to cultivate maize after a harvest of fodder crops. In some cases the dependent farmer or day-labourers had the right to use the soils and to keep the maize harvest. After forty days the maize could be harvested, “quarantina”.¹⁰²

Some local examples illustrate the importance of the maize cultivation. Pier Luigi Spaggiari conducted a research project on the area around Parma during the latter part of the 17th century. The first time the crop spread slowly, because there was some concern as to whether it would exhaust the soils. During the last decade of the 18th century it spread more rapidly.¹⁰³

In 1784 the volume of maize harvested in the duchy of Parma was about 69,000 hectolitres. Two decades later it had increased to 192,000 hectolitres. This volume was considerably larger than for the harvest of wheat, which amounted to 138,000 hectolitres.¹⁰⁴

Aldo de Maddalena has drawn up price statistics for the State of Milan (Stato Milano). During the 18th century the volume of the maize harvest grew faster than for that of all other grains. If the period 1716/20 is taken as the base index 100, for the period 1776/80 the figure has increased to 268. During this period the index for the wheat harvest did not change, so that the amount was the same at the beginning of the period as it was at the end. The amounts of rye and millet decreased to 78. Maize was not the only grain crop to increase during this period, however; the rice harvest also increased by 60 percent.

¹⁰⁰ Maggiore, Tommaso e Bertolini, Marco: “Breve storia del mais.” From *Le piante coltivate e la loro storia*. ed. Failla, Osvaldo e Forni, Gaetano. Milano 2001, p. 106f.

¹⁰¹ Spaggiari, Pier Luigi: *L'agricoltura negli stati parmensi dal 1750-1850*. Tables IX och X. Appendix

¹⁰² Marie, A.: *Pellagra*. Columbia, S.C. 1910, p. 36

¹⁰³ Spaggiari, Pier Luigi: *L'agricoltura negli stati parmensi dal 1750-1850*, p.36

¹⁰⁴ Spaggiari, Pier Luigi: *L'agricoltura negli stati permensi dal 1750-1850*, p. 183, table VIII

If the harvests of rice and maize are taken together at the beginning of the period, they amounted to 550,000 “moggia”, which was about a third of the entire grain harvest, which totalled 1,440,619 *moggia*. At the end of the research period the rice and maize harvest amounted to 1,200,000 *moggia*, out of a total harvest of 2,066,492 *moggia*. This means that more than the half of the harvest consisted of rice and maize.¹⁰⁵

During this research period maize remained a crop for southern Europe, for regions near the Mediterranean climate zone.

3.4.5 Expansion of “old plants” on marginal soils

This phase of rapid development of new plants on marginal lands did not mean that the expansion of other plants had come to a stop. Here are some examples relating to the two oldest plants.

First the olive tree. Le Roy Ladurie has researched the cultivation of olive trees in the south of France from the year 1462. At this time 19% of the cultivated area was planted with olives. By 1519 it had diminished to 15%, but thereafter there was a marked expansion. Fifteen years later 42% of the area was planted only with olive trees and 36% grew in mixed fields alongside other crops. A series of hard winters stopped the expansion, but until the 19th century the tree spread northwards from the Mediterranean coast into the valleys at a rate of 10 kilometres per century.¹⁰⁶

Wine also continued to expand on marginal soils. From the beginning of the 10th until the 12th century wine cultivation expanded in Germany, but only on soils which were normally not used for agricultural production, for instance the steep slopes on the banks of the rivers Rhine, Moselle, Nahe and Saar.¹⁰⁷

Le Durie also provides an example of wine cultivation on marginal soils. He researched the situation in the town Romans. In the year 1449 it was said that Romans only could exist in this area where all or almost all the land was planted with vines. The soils were too poor and infertile for other

¹⁰⁵ De Maddelena, Aldo: *Prezzi e mercedi a Milano dal 1701 al 1860*. Milano 1974, p. 93, prospetto 1.

¹⁰⁶ Le Roy Ladurie, Emmanuel: *Die Bauern des Languedoc*. Munich 1990, p. 70ff

¹⁰⁷ Henning, F.-W.: *Landwirtschaft und ländliche Gesellschaft in Deutschland. Band 1. 800 bis 1750*. UTB. 2nd edition. 1985, p. 129f

plants. Le Durie observes that this statement is a slight exaggeration, but not much.¹⁰⁸

Malvasia is may be one of the oldest species of grape-vine. The best production will be given in a dry climate, but sub-species can be cultivated in England and Germany. A grape-vine that can be cultivated on humid soils is the Riesling. The origin vine is probably a wild species. It was first documented in 1435. Hieronymus Bock mentioned that it was cultivated on the slopes of Rhine and Moselle.

One of the oldest grape vines is possibly the Muscat. Other vines are derived from it through mutations. Traces of this variety can be found in Germany in the 10th century. It is documented as having been cultivated in Alsace in the middle of the 14th century.

The oldest grape vine in the Monferrato area is the Nebbiolo. Documents in the parish of La Morra mention “Nebbiolium” in the year 1512.

One common explanation of the growing wine consumption in the Middle Ages is the spread of Christianity and its ceremonial role. The knowledge of wine cultivation went together with the numerous Cistercian monasteries which were founded in the 12th century in many parts of Europe. This could be one reason. But the monks consumed wine from abroad and cultivated inferior qualities.¹⁰⁹ A more practical explanation is therefore its health function. During the time of the Pax Romana the cities were supplied with drinking water from outside the towns. During the insecure times of the Middle Ages the water was taken from rivers or springs within the community. The sewage holes were situated close to them. Thus the drinking water often suffered from an enormously high bacterial influx.¹¹⁰ Drinking wine was healthier. Massimo Montanari states that mixing water with wine was the most frequent way of consuming wine until the 19th century. Drinking pure wine was very rare. The wine mixture became a sort

¹⁰⁸ Le Roy Ladurie, Emmanuel: *Karneval in Romans*. Munich 1989, p. 21

¹⁰⁹ Ossendorf, Karlheinz: *Mönche als Weinbauern*. Siegburg 2000

¹¹⁰ Dirlmeier, Ulf: “Zu den Lebensbedingungen in der mittelalterlichen Stadt: Trinkwasserversorgung und Abfallbeseitigung” and Hermann, Bernt: “Parasitologische Untersuchung mittelalterlicher Kloaken.” In *Mensch und Umwelt im Mittelalter*. ed. Bernt Herrmann. Stuttgart 1986

of antiseptic agent.¹¹¹

An other important factor for wine drinking was the relation between wine and grain cultivation. In times with bad harvests the grain had to be used to feed the population, so beer brewing was often forbidden. As we have seen the wine was cultivated on less good soils and did not have an impact on grain production. It became a healthy substitution for beer.

3.5 The last magnificent vegetable on poor soils

Potato is a crop whose development is relatively well documented. Fernand Braudel reports that the biologists John Gerarde and Carolus Clusius brought the first two species to Europe in the years 1597 and 1601.¹¹² Other sources mention that Spanish botanists earlier cultivated the potato in botanic gardens.¹¹³

In the middle of the 17th century the potato left the kitchen garden and started to be cultivated in the field – initially in Germany and Austria and then later in Italy, Switzerland, Dauphiné, Burgundy, Alsace and Flanders. During this early period it was used to feed animals.¹¹⁴

Christian Vandebroeke has studied potato cultivation in the south of the Low Countries (Belgium) and France, its spread and its effects. In the western part of Flanders the potato species “American Beauty” left the botanic and kitchen garden around 1670 to be cultivated on the fields. From here potato cultivation was spread in two waves. One went from Flanders eastwards. The second went from the Vosges to the northwest. Potato cultivation reached eastern Flanders in about 1720 and Luxembourg in about 1730.¹¹⁵

In Spain, systematic cultivation began around 1768 in a region of Galicia. The breakthrough came after a famine in 1822, when farmers were forced to

¹¹¹ Montanari, Massimo: *Der Hunger und der Überfluß. Kulturgeschichte der Ernährung in Europa*. Munich 1993. Sid. 146

¹¹² Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 57. Also in *Civilisation matérielle, économie et capitalisme, Xv^e-XVIII^e siècle. Le structure du quotidien: Le possible et l'impossible* Paris 1979

¹¹³ Burton, W.G.: *The Potato*. Second Edition 1967, p. 13f.

¹¹⁴ Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 57

¹¹⁵ Vandebroeke, Christian in *Annales*, E.S.C. 25 (November-December 1970) p. 1767-1784

eat animal food. This change in consumption habits made the potato the second most important crop after grain and replaced the different species of beans in this position.¹¹⁶

In Ireland the potato is described quite early in botanical literature, but it was from the second half of the 16th century that the “creation of distinct varieties of outstanding merit may be said to date, though mention of some are to be found somewhat earlier”.¹¹⁷

Potato cultivation growth in Ireland expanded considerably at the end of the 17th and beginning of the 18th century, coinciding with a rapid increase in population. Both came to an end with the famines in the 1840s.

Ireland offered excellent conditions for potato cultivation. The soils of the pasture land were good enough for potatoes. Potatoes also need a relatively high rainfall to provide an acceptable harvest. Redcliffe N. Salaman describes the situation thus: “Ireland is not only suitable to its culture, but the potato fits in with the Irish scene as does no other crop: thus, it thrives best in deep friable soils; is an excellent crop to crop in freshly broken up grassland, is peculiar tolerant to acidity of soil, such as prevalent in insufficiently drained bog lands, and responds generously to an ample rainfall during the growing season, such as never fails over Ireland, except for a small area around Dublin.”¹¹⁸

Irish farmers also employed an old system of cultivation which seems to have suited potato growing very well. The surface of the peat was burned every year and the ashes added extra nutrients to the soil.¹¹⁹

The potato was a secondary crop compared with wheat and rye, but it provided nourishment for the poor. It was not their only source of food; depending on the landscape, their other food crops might include chestnuts, buckwheat and maize.¹²⁰

¹¹⁶ Vicens Vives, Jaime: *An Economic History of Spain*. Princeton University Press 1969, p. 512

¹¹⁷ Salaman, Redcliffe, N.: *The History and Social Influence of the Potato*. Cambridge University Press. 1949, p. 161

¹¹⁸ Salaman, Redcliffe N.: *The Influence of the Potato on the Course of Irish History*. Dublin. 1943. p. 7

¹¹⁹ Salaman, Redcliffe N.: *The Influence of the Potato on the Course of Irish History*. Dublin. 1943. p. 9f.

¹²⁰ Morineau, Michel: “The Potato in the Eighteenth Century.” In *Food and Drink in*

Before the potato was introduced the cultivation of parsnip was widespread in Europe. With the expansion of potato parsnip cultivation diminished.¹²¹

4. Plant improvements

4.1 Roman times

By the time as the weed rye came to Europe it had already gone through a long natural development. The weed rye sprout looks like wheat and is very difficult to separate from it when the farmer cleans the fields, so it grows up with the other crops. In a natural process the grain became the same size and had the same maturity time as wheat or barley and was harvested and saved as seeds for the next year.¹²²

Grain has some advantages in which it differs from the majority of flowering crops. Except for rye, grains are self-pollinating. This means that the grain can grow on the fields without the danger that it will be fertilized by wild grain species from outside the fields.

Another important advantage of grain is that a field of grain can demonstrate a variety of different characteristics. This was important when the farmer selected the seed for the next year from his harvest. Even in Roman times the farmer took the ears from his best field and stored them separately.¹²³ The selecting of the ears was dependant on what the farmers wanted: the most sturdy, disease-free, highest yielding and so on. This way of selecting ears, breeding, was also common among farmers during the entire period under research. The local farmer took the ears that resisted the local climate and his goal was a secured harvest every year. It was an “eternal” searching for new species, because the climate varied, warmer and colder periods, stem rust, a fungus, mutated and could attack the harvest and other problems occurred regularly. At the beginning of the Agrarian

History Volume 5. 1979, p. 23

¹²¹ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 357

¹²² Miedaner, Thomas: *Roggen, vom Unkraut zur Volksnahrung*. Frankfurt am Main 1997, p. 15ff

¹²³ Flach, Dieter. *Römische Agrargeschichte. Handbuch der Altertumswissenschaft*. Munich 1990, p 256

Vergil mentions the biggest kernel, not from the biggest ears. *Georgica* first book p.19. Stuttgart 1994. The principle is right, but a big kernel could be big because of an abnormality.

Revolution Europe had lot of different local grain species, “Landsorten”.

The tradition of organized plant improvements, nurseries, in Europe goes back to Roman times. Roman agricultural writers describe plant nurseries in detail, especially for the crops which were grown on marginal soils, namely wine and olives.¹²⁴ The “vitiarium” was the nursery for grape-vine.

The Romans often used plant nurseries for olives, “in contrast to classical Greece, where olive nurseries were rare”.¹²⁵ As mentioned earlier the Romans were successful in cultivating the olive tree in very dry regions. This shows that they were skilled in developing the right species of olive tree for the region and inventing the best techniques to cultivate them in a rational way. To make the trees more productive they also used grafting, a well-known technique which agricultural writers describe in detail.¹²⁶

4.2 Middle Ages and the time thereafter

4.3 Gardens

There are no general definition of the term “Garden” either in English or in German. Its multifunctional character and size make it difficult to bring into a general form.¹²⁷ The first definition problem to solve is to find the line between general agriculture and horticulture. Grain improvement plays the most important role in this research. The line between general agriculture and horticulture is open here. The next definition problem to clarify is where the improvements of other plants took place, to find the main purpose of this part of the garden. Aesthetic-pleasure and botanic gardens dominate the research of garden history. Different aspects of it are investigated.¹²⁸ But together they demonstrate the great common interest in and curiosity towards botanics in Europe. This research concentrates on one small piece of it, on the kitchen garden.

¹²⁴ Flach, Dieter. *Römische Agrargeschichte. Handbuch der Altertumswissenschaft*. Munich 1990, p 258

¹²⁵ Foxhall, Lin: *Olive Cultivation within Greek and Roman Agriculture: The Ancient Economy revisited*. Liverpool 1990, p 334

¹²⁶ Foxhall, Lin: *Olive Cultivation within Greek and Roman Agriculture: The Ancient Economy revisited*. Liverpool 1990, p 336

¹²⁷ Harvey, John: *Mediaeval Garden*. London 1981, p.1f.. Franz, Günther: *Geschichte des deutschen Gartenbaues*. Stuttgart 1984, p. 20

¹²⁸ For instance Hoyles, Martin: *The Story of Gardening*. Journeyman Press 1991, p291. “The aim of this book has been to show the connections between political, economic and social history and the history of gardening.”

There are almost no documents relating to plant improvements in the farmers' kitchen gardens during the Middle Ages. It is only through paleo-ethnological botanical excavations that we can extract knowledge about what was cultivated.

The monasteries created large gardens at an early date. The garden was normally divided into three parts: the vegetable plot, the plot for medicinal plants and the fruit orchard. At the beginning these plots were for consumption by the monks themselves. Across the centuries this changed and by the end of the Middle Ages they had developed into large-scale production enterprises.

The literature about garden cultivation from Hildegard von Bingen (1098-1179) and Albertus Magnus (1200-1280) shows considerable knowledge about garden cultivation, but the question is if the facts that they describing are their own experience or if they are based on classical Latin sources.¹²⁹ However, the fact that the monasteries carried out experiments in plant improvements and had a long scientific tradition can be seen in the work of Gregor Mendel.

Until the 12th century the kitchen gardens of castles were quite primitive. Later, as the castles began to expand in size, the kitchen gardens had the important role of supplying the inhabitants of the castle with food during sieges.

In towns you would also find kitchen gardens, but only during the late Middle Ages did they grow in importance, especially because they supplied the town with vitamins.

Paleo-ethnological botanical research also compares plants cultivated in the kitchen garden with the wild species growing in the area around the gardens. The plants differ markedly from each other and Walter Janssen concludes that this must have been due to some kind of plant improvement.¹³⁰

The excavation of medieval grain stores provides a picture of grain species.

¹²⁹ Jansson, Walter: "Mittelalterliche Gartenkultur. Nahrung und Rekreation" in Herrmann, Bernd (ed.): *Mensch und Umwelt im Mittelalter*, p. 228f

¹³⁰ Janssen, Walter: "Mittelalterliche Gartenkultur. Nahrung und Rekreation." In *Mensch und Umwelt im Mittelalter*. ed. Bernd Herrmann. Stuttgart 1986, p. 224ff

The grains of rye show a great variety in both size and form. Today, rye grain from the same field will tend to look very similar.¹³¹

Fernand Braudel gives further examples of what was grown in kitchen gardens on “the experience fields” during the period following the Middle Ages, before the plants were cultivated on a large scale: buckwheat, maize, tobacco, potatoes, beans, tomatoes, sun flower and sugar beet.¹³²

4.4 Nurseries and the seed trade

An experiment with tree seeds provides an interesting case, since it shows that people in the Middle Ages knew about plant improvement. In the year 1368 spruce seeds were sown in the neighbourhood of Nuremberg. The experiment was successful. Harry Kühnel describes how the seeds were collected, selected, stored and then how they were cultivated. He came to the conclusion that considerable knowledge and long experiments must have preceded this first successful large-scale artificial cultivation of seeds.¹³³

According to Le Roy Ladurie, during the years 1540-1550 more than 10,000 mulberry cuttings from plant nurseries were planted in Provence.¹³⁴ He also mentions that when surveyors measured the chestnut woods in 1552, they found a lot of chestnut cuttings from plant nurseries.¹³⁵

Mauro Ambrosoli emphasizes the importance of specialization of plant nurseries in Provence as early as in the beginning of the 16th century. For him the nurseries in Provence provided seed for Northern France.¹³⁶ He states: “The cultivating of forage-crops in sixteenth-century France provides a very definite example of how wild varieties were transformed into cultivated products at that time.”¹³⁷

¹³¹ Willerding, Ulrich: “Landwirtschaftliche Produktionsstrukturen im Mittelalter”. In *Mensch und Umwelt im Mittelalter*. ed. Bernd Herrmann. Stuttgart 1986, p. 247

¹³² Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 54. Mauro Ambrosoli makes the same conclusion for Italy. *The Wild and the sown. Botany and agriculture in Western Europe 1350-1850*. Cambridge University Press 1997, p. 109

¹³³ Kühnel, Harry: “Forstkultur im Mittelalter. Die Anfänge der Laubholz- und Nadelwald.” From *Europäische Technik im Mittelalter 800 bis 1400. Tradition und Innovation*. ed. Lindgren, Uta. Berlin second edition 1997, p. 122

¹³⁴ Le Roy Ladurie, Emmanuel: *Die Bauern des Languedoc*. Munich 1990, p. 85

¹³⁵ Le Roy Ladurie, Emmanuel: *Die Bauern des Languedoc*. Munich 1990, p. 79

¹³⁶ Ambrosoli, Mauro: *The wild and the sown. Botany and agriculture in Western Europe 1350-1850*. Cambridge University Press 1997, p. 81

¹³⁷ Ambrosoli, Mauro: *The wild and the sown. Botany and agriculture in Western Europe*

The monks at the previously mentioned monastery of Lucedio in Italy succeeded in cultivating rice very far north in Europe. But in this case it was not only a matter of developing a species of rice which would grow in northerly latitudes; it was also a question of how to achieve the correct growing temperatures, especially during the night. (The water was pre-warmed in ditches and then transferred into the rice field.)¹³⁸

During the 16th century in Italy forage crops were cultivated on small plots. Turnips were to be found in the farmers garden since ancient times. “Legumes do not grow spontaneously on Northern European pastures because of the acidity and wetness of the soils. Hence their survival is possible not through spontaneous reproduction but through the transformation of the agricultural environment brought about over the centuries by man.”¹³⁹

Therefore it seems that the improvement of new species also was effected through the production and exchange of seeds from far away. Mauro Ambrosoli and Thorkild Kjaergaard show how the trade in forage seeds began in West Europe in the 18th century. However, as Ambrosoli wrote, seed production is “a forgotten chapter of the history of agrarian innovations. The seed exported from France to London in the last quarter of the eighteenth century, is evidence of the lively exchange between southern and northern Europe, small peasant producers and capitalist landowners”.¹⁴⁰

The most important forage plant is clover. It has a very interesting development. Arabs cultivated it in Spain and domesticated clover remained there after the Reconquest of Andalusia. At the beginning of the 16th century it was also brought to Mexico and Peru. Here it went through a rapid development and a short time later it returned to the Spanish parts of

1350-1850. Cambridge University Press 1997, p.174

¹³⁸ This is a method know from the 11th century and was brought to perfection in the 13th century. In this special case it was the meadows in the Po basin which in the winter were flooded to protect to grass from being frozen. The forage could be harvested earlier in the spring . Sereni, Emilio: *History of the Italian Agricultural Landscape*. Princeton University Press 1997, p.133f

¹³⁹ Ambrosoli, Mauro: *The wild and the sown. Botany and agriculture in Western Europe 1350-1850*. Cambridge University Press. 1997, p. 281 and 406f

¹⁴⁰ Ambrosoli, Mauro: *The wild and the sown. Botany and agriculture in Western Europe 1350-1850*. Cambridge University Press. 1997, p. 220f.

Europe, Lombardy and the Netherlands.¹⁴¹

During this time different a species of clover was developed. “From the time of the earliest experiments it was clear that Dutch red clover was the most suitable on the ley, while English white clover was used for meadows and pastures. The rustic English varieties did not develop as well as those imported from the Continent.” Ambrosoli’s conclusion is that: “Until the first decades of the nineteenth century, European agriculture developed a great range of cultivated varieties and species, as long as the peasant economy continued to produce highly differentiated seeds with regional characteristics.”¹⁴²

During the 16th century, commercial towns in the agrarian region of Brunswick imported seeds and sold them to the farmers around the cities.¹⁴³

At the end of the 18th century grain seed began to be imported to the south Swedish agrarian province Scania. These were mainly Pomeranian and Holstein rye and Prussian and Tartar oats. The background to the imports was to gain experience of sowing seed from soils different from that in Scania.¹⁴⁴

Practical teaching also provided another way of introducing a “new” crop. There is information that at the beginning of the 18th century a farmer from Groningen in the Low Countries was called in to teach farmers in East Friesland how to cultivate buckwheat. This also shows how far the expansion of buckwheat in the Low Countries had reached during the second part of the 17th century.¹⁴⁵

In the 18th century the governments supported experiments relating to the cultivation of new plants, not always successfully as Diedrich Saalfeld reports. In the region around Göttingen the cultivation of Lucerne and

¹⁴¹ Kjaergaard, Thorkild: *Den danske Revolution 1500-1800. En økohistorisk tolkning*. Gyldendal 1992, p. 69f

¹⁴² Ambrosoli, Mauro: *The wild and the sown. Botany and agriculture in Western Europe 1350-1850*. Cambridge University Press. 1997, p. 410f.

¹⁴³ Saalfeld, Diedrich: *Bauernwirtschaft und Gutsbetrieb in der vorindustriellen Zeit*. Stuttgart 1960, p. 97

¹⁴⁴ Weibull, Carl-Gustaf: *Skånska jordbrukets historia intill 1800-talets början*. Lund 1923, p. 99

¹⁴⁵ Faber, J.A.: “Decline in the Baltic Grain-Trade.” In *Acta Historiae Neerlandica*, Leiden 1966, p. 125

Aspersett misfired during the second half of the 18th century. The same happened with the cultivation of potatoes in the Harz region during the years 1747 and 1751. This experimental cultivation attracted large government subsidies.¹⁴⁶

4.5 The potato a well-documented species

4.51 The development of potato species in Europe

The improvement of the potato is well documented and provides a good example of the development of new crop species. Fernand Braudel assumes that the European potato was descended from potatoes imported from Peru.¹⁴⁷ This is certainly correct for the early years of cultivation.¹⁴⁸ The species from the Andes in Peru were difficult to cultivate, had low yields and tasted bitter.¹⁴⁹ According to Franz Schwanitz, most of the potatoes for human consumption are descendants of tubers from Chile, which have a longer daylight time during the growing period, about the same as in Europe.¹⁵⁰ But W.G. Burton writes that new varieties from the Andigena group were constantly being raised and the selection of these under long-day conditions led over the course of time to characteristics resembling those of the Chilean group.¹⁵¹ So the initial development of new potato varieties seems to have come from two different species groups and they spread in through Europe primarily as a botanical curiosity rather than a crop.¹⁵²

Jonathan D. Sauer has pointed out an important aspect of the first potato species in Europe: the low commercial interest in cultivating potatoes, because “yields of tubers were initially very low in Europe.” They became

¹⁴⁶ Saalfeld, Diedrich: *Bauernwirtschaft und Gutsbetrieb in der vorindustriellen Zeit*. Stuttgart 1960, p. 89

¹⁴⁷ Braudel, Fernand: *Sozialgeschichte des 15.-18. Jahrhunderts. Der Alltag*. Munich 1985, p. 166

¹⁴⁸ Burton, W.G.: *The Potato. A survey of its History and of Factors Influencing its Yield, Nutritive Value, Quality and Storage*. Second completely revised edition. Wageningen 1967, p.13

¹⁴⁹ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 141

¹⁵⁰ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 112f

¹⁵¹ Burton, W.G.: *The Potato. A survey of its History and of Factors Influencing its Yield, Nutritive Value, Quality and Storage*. Second completely revised edition. Wageningen 1967, p.13f

¹⁵² Sauer, Jonathan D. *Historical Geography of Crop Plants. A select roster*. CRC Press 2000, p. 150

productive only after evolutionary change, which took a long time.¹⁵³ Linked to the achievement of plant improvements there was also a change in the method of harvesting the potato. In the case of wild potatoes the tubers grow far away from the seed potato. Plant improvement has also changed this characteristic.¹⁵⁴

Sauer states that Ireland was the first country in Europe to take tubers seriously. At first it was a minor garden plant, but after a long period of poverty and hunger some potato clones had been developed that were well adapted to Ireland, producing far more calories per acre than grain crops.¹⁵⁵

Once potatoes which tasted less bitter and with higher productivity had been developed during the last part of the 18th century, the number of species increased rapidly. In 1757 there were seven, in 1770 nine, and in 1772 forty different varieties. By the end of the 20th century there were thousands of species.¹⁵⁶

Lawson's *Agriculturist's Manual* included a list of 146 potato varieties in 1836. This number had risen to 400 by 1882.¹⁵⁷

5. Summary of plant improvements

Already in the first half of the 19th century Charles Darwin was aware of how man had selected plants and managed to develop new variations. He observed how the oldest cultivated plants, such as wheat, still yield new varieties and how this process of selection has been the great agency in the production of the most distinct and useful domestic breeds. He based his theory of natural selection on these observations. "There is no obvious reason why the principles which have acted so efficiently under domestication should not have acted under nature."¹⁵⁸

¹⁵³ Sauer, Jonathan D. *Historical Geography of Crop Plants. A select roster*. CRC Press 2000, p. 150

¹⁵⁴ Schwanitz, Franz: *Die Evolution der Kulturpflanzen*. Munich 1967, p. 93

¹⁵⁵ Sauer, Jonathan D. *Historical Geography of Crop Plants. A select roster*. CRC Press 2000, p. 150

¹⁵⁶ Braudel, Fernand: *Frankreich. 3. Die Dinge und die Menschen*. Stuttgart 1990, p. 60

¹⁵⁷ Burton, W.G.: *The Potato. A survey of its History and of Factors Influencing its Yield, Nutritive Value, Quality and Storage*. Second completely revised edition. Wageningen 1967, p. 28.

¹⁵⁸ Darwin, Charles: *The Origin of Species by means of natural selection or the Preservation of Favoured Races in the Struggle for Life*. First edition complemented with the Historical Sketch from the sixth edition. Avenel 1979, p. 441

During the last 2,000 years about 12,000 plants went through the garden cultivation before they were produced in large scale. About 3,000 of them were for human consumption.¹⁵⁹ A substantial number probably reached the gardens after the Europeans began to explore the world.

¹⁵⁹ Franz, Günther (ed.) *Geschichte des deutschen Gartenbaues*. Busch Wilhelm: *Ein einleitender Überblick*. Stuttgart 1984, p. 20