Full-length paper

Asian Agri-History Vol. 16, No. 3, 2012 (219–235)

Significant Milestones in Evolution of Agriculture in the World

YL Nene

Asian Agri-History Foundation, Secunderabad 500009, Andhra Pradesh, India
(email: asianagrihistory94@gmail.com)

Abstract

Chronology of historical events of India has been poorly documented. Most dates of significant events are based on interpretations of contents in Sanskrit Samhitas and Puranas, archaeological evidences, and accounts written by foreigners. Chronology of Indian History was first written by European scholars, whose objectivity was always doubtful. Because India was a British colony for about 250 years and was instrumental in introducing the European system of education, no Indian could seriously question the anomalies that existed in those chronologies. Therefore generations of Indians were taught a subjective chronology. Only after India became independent in 1947, scholars of India began reinvestigation of the existing chronology and suggested changes in dates of many events. For example, the date of Rigveda was fixed by Max Müller as 1500 BC. However, scholars such as Kalyanaraman, BB Lal, David Frawley, Subhash Kak, Georg Feuerstein, and others have indicated the date of Rigveda compilation as >6000 BC. Based on an in-depth study of Vedic literature, the Asian Agri-History Foundation (AAHF) conjectured the date of Rigveda as c. 8000 BC.

As far as the chronology of events of Indian agriculture, there were only sporadic references. However, Western scholars had unearthed a lot of information on the agricultural history of West Asia, China, etc. The work carried out by AAHF has given substantial additional information on the history of Indian agriculture. The aim of the paper is to present a narration of significant events in agri-history of the world including that of India.

The author had made his first effort to prepare a chronology of agriculture, especially of India in 2000 AD (Choudhary *et al.,* 2000). In subsequent years, the author noted many errors in dating events of India made by historians from the West, starting with the fictitious “invention” of Aryan invasion of India, and wrong dating of the Vedas. It therefore became necessary to rewrite agricultural chronology and the author, under the auspices of the Asian Agri-History Foundation (AAHF), published it as an appendix in the book on agricultural heritage of India (Nene, 2007). Yet another minor revision was published in 2009 (Saxena *et al.,* 2009).

Since the AAHF has unearthed many unknown facts about the Indian agricultural heritage in the last 15 years, the author thought of freshly writing significant milestones in evolution of agriculture in the world.

Information gathered has been divided into several groups based on the dates.

30,000–10,000 BC

Hunter-gatherers

Small bands of hunter-gatherers roamed much of the world. They moved from region to region, choosing areas where food was available.

Bhimbetka caves

The Rock Shelters of Bhimbetka (or Bhim Baithaka) lie in the Raisen District of Madhya Pradesh (India), 45 km south of Bhopal at the southern edge of the Vindhyachal hills. These were discovered by the well-known archaeologist, VS Wakankar of Ujjain, Madhya Pradesh. South of these rock shelters are successive ranges of the Satpura hills. Some of the Stone Age rock paintings found among the Bhimbetka rock shelters are approximately 30,000 years old. Other paintings belong to different periods down up to Neolithic stage (Randhawa, 1980).

Natufian communities in the Levant region

The Levant is the geographical term that refers to a large area in Southwest Asia, south of the Taurus Mountains, bounded by the Mediterranean Sea in the west, the Arabian Desert in the south, and the Zagros Mountains in the east. The term normally does not include Anatolia, Caucasus Mountains, or any part of Arabian Peninsula.

The Natufian culture is the name given to the sedentary hunter-gatherers living in the Levant region of the Near East around 10,000 BC. It has been suggested that this was a step towards Neolithic agriculture (Encyclopedia Britannica, 1993).

Dog was domesticated in East Asia and Africa during this period. Domestication of dog proved useful towards sedentary life (Randhawa, 1980).

10,000–8000 BC

The Neolithic Revolution is the first agricultural revolution – the transition from hunting and gathering to agriculture and settlement. Archaeological findings indicate that various forms of domestication of plants and animals arose independently in six different regions of the world, approximately 8000 BC, with the earliest known evidence found throughout the tropical and subtropical areas of southwestern and southern Asia, northern and central Africa, and Central America (Randhawa, 1980).

The Neolithic Revolution involved far more than adoption of food-producing techniques. Sedentary societies built-up villages and towns and developed irrigation and food storage techniques to have surplus food production. The first manifestation of the entire Neolithic complex was seen in the Middle Eastern Sumerian cities and in the

Vedic civilization in Pakistan and western India (Kalyanaraman, 2000).

Animals domesticated during this period were sheep (Southwest Asia), pig, goat, and cattle. These animals provided further stability to Neolithic Revolution (Wells, 1956).

Jericho, probably the oldest known city was built in the Middle East. Jericho sits between Mt. Nebo in the east, the Central Mountains to the west and the Dead Sea to the south. In addition to these natural fortifications, Jericho also benefited from natural irrigation afforded by the Jordan River approximately four miles to the west, and from underground tributaries from the Central Mountains which fed her famous oasis. This irrigation resulted in teeming plant life and helped to transform Jericho into a flowing sea of green in an otherwise barren desert. Besides being old, Jericho is also one of the lowest cities in the world, about 800 feet (244 m) below sea level (Murphy-O'Connor, 1998).

Wheat and barley were domesticated and grown in the "Fertile Crescent". The term "Fertile Crescent" was first used by University of Chicago archaeologist, James Henry Breasted in his "Ancient Records of Egypt" in 1906. The Fertile Crescent includes modern countries, Iraq, Israel, Jordon, Lebanon, Palestine, and Syria.

8000–6000 BC

The Neolithic Revolution spreads. Animals that live in herds are amenable to domestication. If the leader of the herd is captured, the rest of the herd can easily be caught. Sheep, goats, cattle, and pigs belong to this category and were the first to be domesticated. Similarly among plants, it is the grasses that tend to grow densely, and are amenable to control by man. Most of our cereals, wheat, barley, oats, and rice are grasses.

Polished stone axe or celt was an important tool which enabled the Neolithic man to obtain a foothold in the forests. In the fire-cleared forests, man started cultivation of crops. Grains were dibbled with pointed sticks. Later, stone hoes with wooden handles were invented. Sowing of crops was largely done by women, who are credited with the discovery of agriculture.

Rigveda (c. 8000 BC) documents basic agricultural techniques of crop (barley) cultivation with a wooden plow, interculture, harvesting, threshing, and storage. Animal management skills were acquired. Besides, Rigveda, two other Vedas, Yajurveda and Samaveda, were composed (Nene and Sadhale, 1997).

Many wild wheat and barley species grew in the Fertile Crescent. Man found 14-chromosome wheat useful; that included *Triticum durum* (macaroni) and three other species. The most commonly grown wheat crop today

Since the AAHF has unearthed many unknown facts about the Indian agricultural heritage in the last 15 years, the author thought of freshly writing significant milestones in evolution of agriculture in the world.

around the world is 21-chromosome wheat, *Triticum aestivum*. Two species of barley are cultivated today: two-rowed and six-rowed. Wild ancestors of two-row barley are found in Palestine, Arabia, Asia Minor, and Transcaucasia, and of the six-rowed barley in eastern Tibet (Randhawa, 1980).

During Neolithic Revolution, additional significant developments were housing, pottery, basketry, and loom.

Agriculture and animal husbandry slowly developed in the Valley of Tigris and Euphrates, Asia Minor, Western India (Indus-Saraswati civilization), Egypt, Greece, Danubian area in Europe, Italy, southern France, Iberia, and Iran. Yajurveda was compiled during this period.

Another important crop, rice, was domesticated in Southeast Asia around 6500 BC and spread fast to other tropical/subtropical areas where water was available in plenty.

Potatoes were domesticated in the Andes Mountains around 8000 BC. The crop moved out of this region to other parts of the world only four centuries ago.

The Rock Shelters of Bhimbetka (or Bhim Baithaka) lie in the Raisen District of Madhya Pradesh (India), 45 km south of Bhopal at the southern edge of the Vindhyachal hills. These were discovered by the well-known archaeologist, VS Wakankar of Ujjain, Madhya Pradesh.

Maize, another important world crop was domesticated in Central America around 7000 BC. Aztecs and Mayans cultivated several varieties in Mexico. By 1700 AD, it spread throughout Americas. Europeans introduced it to other parts of the world in $15^{th}/16^{th}$ century AD (Wells, 1956).

6000–4000 BC

The Neolithic Revolution continued to expand to newer regions of the world. New settlements, villages, towns, and cities were established. There were surpluses of grain. Granaries were built in Western India (now Pakistan). Cow became an important component of mixed farming not only in India but also in the Middle East and Sub-Saharan Africa. The chicken was domesticated in India and Southeast Asia and then was accepted around the world as a food item.

The donkey was domesticated in Egypt and then was used in the Middle East and India for carrying load. Camel was domesticated in Arabia.

Another draft and milch animal domesticated was the water buffalo in India and China. It remains an important milch animal in India today.

Horse was yet another important animal that was most likely domesticated in Ukraine around 5000 BC. Huge herds of the wild horse, tarpan, lived in Ukraine and it was tarpan that was domesticated. Tarpans were distinguished for their speed and quality of their hooves (did not need shoes). The tarpan was probably the direct ancestor of European domesticated horse breeds. Horse was most useful in transport and plowing (Randhawa, 1980).

Apiaries made a beginning in many regions around 4000 BC, though during Rigvedic times (c. 8000 BC) honey collected from natural beehives was plentifully available. It provided a sweetener for food and a preservative. Important cereals such as wheat, barley, and rice continued to spread to areas with congenial agroclimate (Randhawa, 1980).

Asian rice was domesticated in the middle and lower Yangtze River valley in China, the Mekong River delta in Southeast Asia, and the middle Ganga valley in India. These are the most likely places where rice could have originated, domesticated, and spread to other regions (Wells, 1956).

Cassava, another important food crop was domesticated in Central America. Later it spread to Africa from Brazil, where it is a major food crop (Source: en.wikipedia.org/wiki/Cassava).

Agastya, the famous sage traveled to South India and initiated integration of South and North Indian cultures (c. 5000 BC) (Abhyankar, 2005).

Elaboration of Rigvedic thoughts were compiled by sages and are called Aranyakas and Brahmanas. Ramayana events occurred during these millennia (Nene, 2007).

The Neolithic Revolution is the first agricultural revolution – the transition from hunting and gathering to agriculture and settlement.

4000–400 BC

There is evidence of domestication of a large number of crops including peas, sesame, dates, cotton, sorghum, pearl millet, and many others.

Historians have accepted that the first light wooden plow was developed in Mesopotamia (Iraq) around 4000 BC. Recent researches have shown that the Vedic people of India were using wooden plow earlier. The same is true for the wheeled cart (Kalyanaraman, 2000).

Mahabharata events occurred during this period (c. 3000 BC). The fourth Veda, Atharvaveda was compiled around 1000 BC. Upanishads were compiled during 1500–1000 BC (Nene, 2007). Crude sugar was produced around 3000 BC from sugarcane and it provided an additional and plentiful sweetener for food, besides honey.

The Indus Valley Civilization, more correctly called the Indus–Saraswati Rivers civilization, flourished (4000–2600 BC) in Pakistan and India. This civilization was one of the two most prosperous civilizations (the other being the Sumerian) that produced surplus grain and shipped to adjacent countries in West Asia and North and East Africa (Kalyanaraman, 2000).

The first manifestation of the entire Neolithic complex was seen in the Middle Eastern Sumerian cities and in the Vedic civilization in Pakistan and western India.

Rigveda (c. 8000 BC) documents basic agricultural techniques of crop (barley) cultivation with a wooden plow, interculture, harvesting, threshing, and storage. Animal management skills were acquired.

The first moldboard plow was invented in ancient Near East and China around 500 BC. Other implements were developed as per needs by farmers in China, India, and Middle East (Source: www.computersmiths.com/chineseinvention/ironplow.htm).

Panini (c. 500 BC), the master of Sanskrit grammar, formulated 4,000 rules of Sanskrit syntax and semantics. He formulated the canonical Ashtadhyai, meaning eight chapters, which lays the foundation of the Vedanga, which is part of the understanding of Vedic religion. It was Panini who, by formalizing the theory of grammar in a scientific and comprehensive manner, laid the foundation of classical Sanskrit, moving away from Vedic Sanskrit. Panini's scientific explanation of Sanskrit grammar made it systemized and technical. The rules he laid down were flawless. There was a great deal of emphasis on brevity, logic, and linguistic expression (Vasu, 1891).

Ayurveda pioneer, Charaka (c. 700 BC) compiled "Charak-Samhita", a treatise on Ayurveda that is still used. The knowledge contained therein was used and applied to plants by Vrikshayurveda authors. Parashara, a Vedic scholar and sage, compiled a text in Sanskrit "Krishi-Parashara" around 400 BC. It can be easily called the first textbook on introductory agriculture, with chapters on seed, sowing, interculture, harvesting and threshing, basic animal husbandry, and rainfall prediction (Sadhale, 1999).

400 BC–1000 AD

Amarsimha (lexicographer), compiled Amarkosha – a Sanskrit lexicon (c. 200 BC). The Tamil classic, Tholkappiar was compiled by Tholkappiam (c. 200 BC). It contains information on agriculture.

Fishing apparently became common in Egypt with river Nile having abundant fish. Fresh and dried fish was a very important food item. Simple reed boats served for fishing woven nets, baskets made from willow branches, harpoons, and hook and line were all being used. Big fishes were clubbed to death. Fish continued to be an important food item in the Hellenic civilization. In India, the Pandyas (a classical Tamil Kingdom), were known for the pearl fishery as early as 100 BC. The seaport Thoothukudi (Tuticorin) was known for deep sea pearl fishing. Pearl trade flourished. It was during this period Chinese developed the art of fishing for food.

The successors of Vedic civilization made tremendous progress during this period. Kautilya, the mentor of Chandra Gupta

Horse was yet another important animal that was most likely domesticated in Ukraine around 5000 BC. Huge herds of the wild horse, tarpan, lived in Ukraine and it was tarpan that was domesticated.

Maurya, helped establish Mauryan Empire in northern India in 325 BC. Kautilya (321–296 BC) wrote "Arthasastra" in Sanskrit. It is a remarkable document that describes how to organize and administer an empire. Arthasastra described four sciences of the time, one of which was "varta" meaning agriculture, animal husbandry, and trade together. He described duties of Sitadhyaksha, the Superintendent of Agriculture. The description shows advancements made by that time in crop production and animal husbandry. He also used the term "Vrikshayurveda" for the art of managing crops, especially, sowing, interculture, plant protection, etc.

Susruta (c. 400 BC), the pioneer surgeon compiled Susruta-Samhita. Another Tamil classic Thirukkural was compiled by Thiruvalluvar (c. 70 BC). It contains valuable comments on agriculture.

One of the largest lakes, the Sudarshan Lake in South Gujarat was constructed by Maurya rulers in 400 BC. It was repaired by a Saka king in the 2nd century AD. The lake irrigated fields until 10th century AD. It does not exist today.

After the collapse of Mauryan Empire, the northern half of the Indian subcontinent was ruled by the Gupta dynasty (300–600 AD). One of the scholars, Varahamihira (505–587 AD) wrote an encyclopedic work, Brhat-Samhita, in which we find chapters such as detecting groundwater, prediction of rainfall, Vrikshayurveda, etc. Methods of prediction of monsoon rainfall were based on the astrology/astronomy and it was accepted by scholars and farmers as dependable.

It was Surapala (c. 1000 AD) who wrote a complete Vrikshayurveda that included chapters on nutrition and protection. This is the first text on arbori-horticulture in the world.

Kashyapa, another sage, wrote an excellent treatise in Sanskrit, Kashyapiyakrishisukti (c. 800 AD). It describes in detail cultivation of rice. As many as 26 varieties (including scented ones) were grown by farmers.

Asian rice was domesticated in the middle and lower Yangtze River valley in China, the Mekong River delta in Southeast Asia, and the middle Ganga valley in India.

Apiaries made a beginning in many regions around 4000 BC, though during Rigvedic times (c. 8000 BC) honey collected from natural beehives was plentifully available. It provided a sweetener for food and a preservative.

Historians have accepted that the first light wooden plow was developed in Mesopotamia (Iraq) around 4000 BC. Recent researches have shown that the Vedic people of India were using wooden plow earlier. The same is true for the wheeled cart.

The Indus Valley Civilization, more correctly called the Indus–Saraswati Rivers civilization, flourished (4000–2600 BC) in Pakistan and India.

The Arab Agriculture Revolution began in 700 AD with rapidly expanding Arab Empire. The global economy established by Muslim traders across the old world enabled the diffusion of many crops and farming techniques among different parts of the Islamic world, as well as adaptation of crops and techniques from beyond the Islamic world. Crops from Africa such as sorghum, crops from China such as citrus fruits, and numerous crops from India such as mangoes, rice, cotton, and sugarcane were distributed throughout the Islamic lands. These introductions along with an increased mechanization of agriculture lead to major changes in economy, population distribution, vegetation cover, agricultural production and income, population levels, urban growth, the distribution of labor force, linked industries – cooking, diet, and clothing in the Islamic world.

Panini (c. 500 BC), the master of Sanskrit grammar, formulated 4,000 rules of Sanskrit syntax and semantics. He formulated the canonical Ashtadhyai, meaning eight chapters, which lays the foundation of the Vedanga, which is part of the understanding of Vedic religion.

1000–1600 AD

The Arab Agriculture Revolution continued until 1300 AD. Several texts in Sanskrit and other languages of India were written during this period. Besides Surapala's Vrikshayurveda, other texts written were:

1. Chavundaraya 1025 AD: Lokopakara in old Kannada (Ayangarya, 2006)
2. Someshvardeva (1126–1138 AD): Manasollasa in Sanskrit (Shamasastry, 1926)
3. Sarangadhara (1300 AD): Upavanavinoda in Sanskrit (Sadhale, 2011)
4. Chakrapani Mishra (1577 AD): Vishvavallabha in Sanskrit (Sadhale, 2004)
5. Parshurama (1500 AD): Krishi Gita in Malayalam (Mohan Kumar, 2008)
6. Hamsadeva (1300 AD): Mrigapakshishastra in Sanskrit (Sadhale and Nene, 2008)

These texts dealt with agriculture, horticulture, and fauna. Several cattle breeds were identified during this period. These included the well-known Hallikar (South India) and Ongole breeds.

Although irrigation and storage systems were built in Mesopotamia, Egypt, Iran, China, and India, the irrigation works of ancient Sri Lanka is most noteworthy. Starting from about 300 BC, in the reign of King Pandukabhaya and under continuous development for the next thousand years, was one of the most complex irrigation systems of the ancient world. In addition to underground canals, the Sinhalese were the first to build completely artificial reservoirs to store water. Due to their engineering superiority in this sector, they were often called 'masters of irrigation'. Most of these irrigation systems still exist undamaged up to now, in Anuradhapur or Polonnaruwa, because of the precise and advanced engineering. The system was extensively restored and further extended during the reign of King Parakram Bahu (1153–1186 AD). Sri Lankan technology was introduced on a large scale in South India.

Indians had innovated very effective manure, a liquid ferment called "Kunapajala", which in Sanskrit meant filthy water. It involved cooking mixed wastes of animal origin (meat, marrow, fat, skin) and fermenting them for up to 3 months. This ferment proved to be excellent manure for all kinds of plants and was widely used until 1800 AD. First description of *kunapajala* appeared in Surapala's Vrikshayurveda (c. 1000 AD). Today tea plantations in Northeast India are widely using *kunapajala* to produce organic tea.

One of the largest lakes, the Sudarshan Lake in South Gujarat was constructed by Maurya rulers in 400 BC. It was repaired by a Saka king in the 2nd century AD. The lake irrigated fields until 10th century AD. It does not exist today.

1600–1800 AD

Crop farming changes in Western Europe: The Norfolk four-course system

The system was characterized by the disappearance of the fallow year and by new emphasis on fodder crops. The movement towards change was further intensified by the invention of new farm machines, improvement in farm implements, and scientific interest and new biological theories relating to farm and animal life.

In the Norfolk four-course system, wheat was grown in the first year, followed by turnips in the second, then barley, with clover and rye grass under-sown, in the third. The clover and rye grass were grazed or cut for feed in the fourth year. The turnips were either employed for feeding cattle in open yards during winter or for feeding sheep confined in folds set up on the ground. This new system was cumulative in effect, for the fodder crops eaten by the livestock produced large supplies of animal manure. When the sheep grazed the fields, their urine and droppings fertilized the soil, so that heavier cereal yields were obtained in the following years (Howard, 1947).

Established in the Norfolk county, England, the Norfolk four-course system became fairly general on the newly enclosed farms by 1800 AD, remaining almost a standard practice on most British farms for the best part of the following century and the first three quarters of the 19th century, and was adopted by continental Europe.

An interesting aspect of livestock breeding was the admiration of all Europe for the Spanish Merino sheep, which was forbidden for export for fear of competition. It proved impossible to maintain prohibition. Merinos spread throughout the continent, but were not a success in England.

Plows and farm machinery

Probably of Dutch origin, the Rotherham plow, the main design of which has remained unchanged to this day, was first put into use in the Netherlands, England, and Scotland during the first half of the 18th century. The first factory for making plows was established in England in 1783 (Culpin, 2008).

The age of exploration that began in the mid-15th century led to discovery of edible plants previously unknown to Europeans. The Arabs had introduced sugarcane and rice to some parts of southern Europe. The voyagers to North America returned with maize, tobacco, and turkey. South America supplied potato, cocoa, quinine, some vegetable drugs, while coffee, tea, and indigo came from the Orient.

1900 AD

Power revolution on the farm

The development of agriculture between the close of the 18th century and early years of 20th century was characterized by the partial mechanization of agriculture in western Europe – especially in Great Britain – and in the previously untapped lands of Australia, New Zealand, and North America, where wild uncultivated and virtually unoccupied land was made to yield vast quantities of plant and animal crops.

Although irrigation and storage systems were built in Mesopotamia, Egypt, Iran, China, and India, the irrigation works of ancient Sri Lanka is most noteworthy. Starting from about 300 BC, in the reign of King Pandukabhaya and under continuous development for the next thousand years, was one of the most complex irrigation systems of the ancient world.

The reaper

Reaping machines had been proposed before, but not until Patrick Bell in Scotland and Cyrus Hall McCormick in the US produced their designs did this machine become a practical reality. McCormick gave first field demonstration of reaper in 1831 and obtained US Patent in 1834. After the Great Exhibition of London in 1851, the reaper slowly came into general use (Source: en.wikipedia.org/wiki/Reaper).

Plows and plowing

As settlers in the US moved westward, plowing of the black prairie soils, high in organic matter, posed a special problem to the farmers who had cast-iron and iron-patched plows. The ingenuity of John Deere, an Illinois blacksmith and plow maker of the 1830s, resulted in a new kind of plow that was made entirely of steel except for braces, beam, and handles. The one-piece share and moldboard of his first steel plow was cut from a mill-saw blade and shaped over a wooden form. This greatly improved implement not only made possible the effective plowing of the black prairie soils but also considerably lessened the animal power needed to turn the soil. Tractors are now manufactured in many countries and used worldwide (Hunt, 2001).

New fertilizers

Starting from the early 17th century, people researched other modes of fertilization, particularly those of a chemical nature. For instance, German-Dutch chemist Johann Glauber (c. 1604–1670), developed the first mineral fertilizer, which comprised saltpeter, lime, phosphoric acid, nitrogen, and potash.

Research in plant physiology and nutrition, begun in the 18th century, continued to grow in scope. The brilliant English chemist, Sir Humphrey Davy published his lectures as “Elements of Agriculture Chemistry” in 1813. A few enterprising pioneers were soon conducting field experiments with new fertilizers. The beneficial effects of saltpeter (potassium nitrate) were known in India and that led to imports of saltpeter from India. Chilean nitrate of soda and Peruvian guano were also imported. Ground bones were used in the late 18th century and bone cracking and soaking in sulfuric acid led to the production of superphosphate of lime in 1840s.

It was organic chemist Justus von Liebig (1803–1873) who discovered that plants need mineral elements such as nitrogen and phosphorus for optimal growth. His work led to a half-century of exploring the chemical needs of plants to improve on fertilizer compositions. For this, he is referred to as the “Father of the Fertilizer Industry”. Sir John Lawes (1814–1900) discovered superphosphate, which became the first chemical fertilizer.

By the 20th century, it was understood that the core plant nutrients are nitrogen, phosphorus, and potassium. Nitrogen is considered the most needed nutrient – as an essential building block for assembling amino acids, nucleic acids, and protein. Plants with less nitrogen tend to be smaller, less fruitful, and have more of a yellowish color. With that knowledge of plant chemical needs, the chemical fertilizer industry experienced significant growth, particularly after World War I, which ended in 1918.

Indians had innovated very effective manure, a liquid ferment called “Kunapajala”, which in Sanskrit meant filthy water. It involved cooking mixed wastes of animal origin (meat, marrow, fat, skin) and fermenting them for up to 3 months. This ferment proved to be excellent manure for all kinds of plants and was widely used until 1800 AD.

Established in the Norfolk county, England, the Norfolk four-course system became fairly general on the newly enclosed farms by 1800 AD, remaining almost a standard practice on most British farms for the best part of the following century and the first three quarters of the 19th century, and was adopted by continental Europe.

Although organic fertilizers are still used today throughout the world, chemical fertilizers are more popular. Also, research is still being conducted – to reduce the harmful environmental effects of fertilizer use, as well as discovering new, less costly sources of fertilizers (Wheeler, 2009).

The development of agriculture between the close of the 18th century and early years of 20th century was characterized by the partial mechanization of agriculture in western Europe – especially in Great Britain.

Awareness of plant diseases

The first ever systematic study of plant disorders was made by Indian scholars such as Surapala, a physician to king Bhimpala (died 1026 AD). Using the knowledge of Ayurveda, causes of plant disorders were attributed to imbalances of *vata, pitta,* and *kapha* and the associated symptoms with each imbalance were described. Of great significance was the treatments prescribed to manage the disorders (Sadhale, 1996).

Most agricultural scientists know about the great epidemic of late blight of potato in 1845 that led to mass starvation in Ireland and migration to Americas. It is estimated that more than one million people died of starvation and an equal number migrated to North America. Grapes were being destroyed by downy mildew and an accidental finding that copper sulfate and lime mixture (Bordeaux mixture) in France controlled the disease. All this gave a thrust to researches in plant protection.

Probably of Dutch origin, the Rotherham plow, the main design of which has remained unchanged to this day, was first put into use in the Netherlands, England, and Scotland during the first half of the 18th century. The first factory for making plows was established in England in 1783.

The 20th century

Agricultural technology has developed more rapidly in the 20th century than in all previous history. Though the most important developments during the first half of this century took place in the industrial countries, especially the United States, the scene has changed to some extent since the 1950s. With the coming of independence, former colonies in Asia and Africa have initiated large-scale efforts to improve their agriculture. Industrial countries of Europe and the US and also institutions such as the Ford and Rockefeller Foundations extended large-scale assistance to the developing countries.

The tractor

The first applications to agriculture of the four-stroke-cycle gasoline engine were as stationary engines, at first in Germany, later elsewhere. By 1890s, stationary engines were mounted on wheels to make them portable, and soon a drive was added to make them self-propelled. The first successful gasoline tractor was built in the US in 1892. Within few years several companies were manufacturing tractors in Germany, UK, and USA. The number of tractors in the more developed countries increased dramatically during the 20th century, especially in the US; in 1907 some 600 tractors were in use, but the figure had grown to almost 3,400,000 by 1950 (Pripps, 2002).

The soybean

This is an outstanding example of an ancient crop that, because of the development of new process to make its oil and meal more useful, is widely produced today.

Though first grown in the US in 1804, the soybean remained a garden plant for about 100 years. Around the beginning of the 20th century, when new varieties were introduced from Japan, farmers began growing it for hay, pasture, and green manure. In the early 1930s, a soybean oil processing method that eliminated a disagreeable odor from the finished product was developed. World War II brought an increased demand for edible oil. The food industry began using soybean oil for margarine, shortening, salad oil, mayonnaise, and other food products. Technology of processing soybeans spread from USA to other parts of the world (Source: http://www.agron.iastate.edu/courses/agron212/Readings/Soy_history.htm).

Early work in genetics

The modern science of genetics and its application to agriculture has an interesting background, built up from the work of many individuals. Gregor Mendel is generally credited with its founding. Mendel, a monk in Brünn, Moravia (now Brno, Czech) purposefully crossed garden peas in his monastery garden. He carefully sorted the progeny of his parent plants according to their characteristics and counted the number that had inherited each quality. He discovered that when the qualities he was studying, including flower color and shape of seed, were handed on by the parent plants, they were distributed among the offspring in definite mathematical ratios, from which there was never a significant variation. Definite laws of inheritance were thus established for the first time. Though Mendel reported his discoveries in an obscure Austrian journal in 1866, his work was not followed up for the next three decades. Then in 1900, investigators in the Netherlands, Germany, and Austria, all working on inheritance, independently rediscovered Mendel's paper (Source: http://en.wikipedia.org/wiki/Gregor_Mendel).

Maize (corn)

Maize originated in America, and was probably first developed in the highlands of Mexico. It was quickly adopted by the European settlers, Spanish, English, and French. The first English settlers found the northern Red Indians growing a hard-kernelled, short-duration flint variety that kept well, though its yield was low. The Red Indians in the south central area of English settlement grew a soft-kernelled, high-yielding, and long-duration dent corn. In 1812, John Lorain, a farmer living near Philipsburg, Pennsylvania, USA, consciously mixed the two and demonstrated that certain mixtures would result in a yield much greater than that of the flint, yet with many desirable qualities. The most widely grown variety of Corn Belt for many years was Reid's Yellow Dent, which originated from a fortuitous mixture of a dent and flint variety. In 1876 Charles Darwin published the results of experiments on cross- and self-fertilization in plants. Carrying out his work in a small greenhouse in his native England, the man who is best known for his theory of evolution found that inbreeding usually reduced plant vigor and that crossbreeding restored it. With the knowledge of inbreeding and hybridization at hand, there was yet to be developed a technique whereby hybrid corn with the desired characteristics of inbred lines and hybrid vigor could be combined in a practical manner. In 1917 Donald F Jones of the Connecticut Agricultural Experiment Station discovered the answer, the "double cross". The first hybrid corn involving inbred lines to be produced commercially was sold by the Connecticut Agricultural Experiment Station in 1921. The second was developed by Henry A Wallace, a future secretary of agriculture and Vice-President of the US. He sold a small quantity in 1924 and, in 1926, organized the first seed company devoted to the commercial production of hybrid corn. Because of the hybrid corn, the average yields per acre of corn rose from 2000 kg per hectare in 1933 to 7220 kg per hectare by 1980 (Sprague, 1997).

Wheat

The Rockefeller Foundation in 1943 entered into a cooperative agricultural research program with the Government of Mexico, where wheat yields were well below the world average. By 1956 per acre yield had doubled, mainly because of newly developed varieties sown in the fall instead of spring and the use of fertilizers and irrigation. The short-stemmed varieties developed in the Pacific Northwest US from the Japanese strains were then crossed with various Mexican and Colombian wheats. By 1965 new Mexican wheats were established. In 1966, India imported 18,000 tons – the largest purchase and import of any seed in the world at that time. In 1967, Pakistan imported 42,000 tons, and Turkey 21,000 tons. Pakistan's import, planted on 1.5 million acres (6,100 km^2), produced enough wheat to seed the entire nation's wheat land the following year. By 1968, William Gaud of the United States Agency for International Development was calling Borlaug's work a "Green Revolution". High yields led to a shortage of various utilities – labor to harvest the crops, bullock carts to haul it to the threshing floor, jute bags, trucks, rail cars, and grain storage facilities. Some local governments were forced to close school buildings temporarily to use them for grain storage.

In Pakistan, wheat yields nearly doubled, from 4.6 million tons in 1965 to 7.3 million tons in 1970; Pakistan was self-sufficient in wheat production by 1968. Yields were over 21 million tons by 2000. In India, yields increased from 12.3 million tons in 1965 to 20.1 million tons in 1970. By 1974, India was self-sufficient in the production of all cereals. By 2000, India was harvesting a record 76.4 million tons of wheat. The use of these wheat varieties has also had a substantial effect on production in six Latin

American countries, six countries in the Near and Middle East, and several others in Africa (Perkins, 1997).

Rice

The success of the wheat program led the Rockefeller and Ford Foundations in 1962 to establish the International Rice Research Institute (IRRI) at Los Banõs in the Philippines. A research team assembled some 10,000 varieties/land races of rice from all parts of the world and began out breeding. Success came early with the combination of a tall, vigorous variety from Indonesia and dwarf rice from Taiwan. The strain IR-8 proved capable of doubling the yield obtained from most local rices in Asia.

India soon adopted IR-8, a semi-dwarf rice variety developed by IRRI that could produce more grains of rice per plant when grown with certain fertilizers and irrigation. In 1968, Indian agronomist SK De Datta published his findings that IR-8 rice yielded about 5 tons per hectare with no fertilizer, and almost 10 tons per hectare under optimal conditions. This was 10 times the yield of traditional rice. IR-8 was a success throughout Asia, and dubbed the “Miracle Rice” (De Datta, 1981).

In the 1960s, rice yields in India were about two tons per hectare; by the mid-1990s, they had risen to six tons per hectare. In the 1970s, rice cost about $550 a ton; in 2001, it cost less than $200 a ton. India became one of the world’s most successful rice producers, and is now a major rice exporter, shipping nearly 4.5 million tons in 2006.

Identifying the cause of the so-called khaira disease of rice as a zinc deficiency in field rice, which had never been reported anywhere in the world, coincided with the large-scale testing of IR-8 in South Asia. The work was done at GB Pant University of Agriculture and Technology, Pantnagar, India by YL Nene. This was most fortunate because in the absence of solution to widespread khaira disease, IR-8 could have failed in demonstrating its high yield potential (Nene, 1966).

Hybrid cotton

Chandrakant T Patel (1917–1990) was a cotton scientist who developed the world’s first ever commercial cotton hybrid, known as Hybrid-4 (Sankar-4), in 1970, which was later cultivated commercially in the states of Gujarat and Maharashtra in India (Santhanam and Sundaram, 1997).

The pesticide issue

In 1942 Paul Hermann Müller of Switzerland discovered insecticidal properties of a synthetic chlorinated hydrocarbon, dichlorodiphenyltrichloroethane, which was first synthesized in 1874 and subsequently became known as DDT. Müller received the Nobel Prize for Physiology or Medicine in 1948 for his discovery of insecticidal properties. The next two decades saw huge amounts of pesticides of all kinds being used to control insects and other pests, pathogens, weeds, etc. (Source: http://www.nobelprize.org/nobel_prizes/medicine/laureates/1948/muller-bio.html).

Identifying the cause of the so-called khaira disease of rice as a zinc deficiency in field rice, which had never been reported anywhere in the world, coincided with the large-scale testing of IR-8 in South Asia. The work was done at GB Pant University of Agriculture and Technology, Pantnagar, India by YL Nene. This was most fortunate because in the absence of solution to widespread khaira disease, IR-8 could have failed in demonstrating its high yield potential.

Problems appeared in the early 1950s. In cotton crops standard doses of DDT and some other insecticides were found to be less effective. Resistant strains of insects had developed. In addition, the powerful insecticides often destroyed natural predators and helpful parasites along with harmful insects. At about the same time, concern also began to be expressed about the presence of pesticide residues in food, humans, and wild life. It was found that many birds and wild mammals retained considerable quantities in their bodies, accumulated along their natural food chains. The disquiet caused by this discovery was highlighted by the publication in the US of a book entitled "Silent Spring", whose author Rachel Carson (1962), attacked the indiscriminate use of pesticides, drew attention to various abuses, and stimulated a reappraisal of pest control. Thus began a new "integrated" approach which was in effect a return to the use of all methods of control in place of a reliance on chemicals alone.

Chandrakant T Patel (1917–1990) was a cotton scientist who developed the world's first ever commercial cotton hybrid, known as Hybrid-4 (Sankar-4), in 1970.

References

Abhyankar KD. 2005. Agastya a sage and a star. Current Science 89:2174–2176.

Ayangarya Valmiki S. 2006. Lokopakara (For the Benefit of People) (in old Kannada by Chavundaraya 1025 AD). Agri-History Bulletin No. 6. Asian Agri-History Foundation, Secunderabad, India. 140 pp.

Carson Rachel. 1962. Silent Spring. Houghton Miffin Company, Boston, USA. 368 pp.

Choudhary SL, Sharma GS, and **Nene YL.** 2000. Ancient and Medieval History of Agriculture and its Relevance to Sustainable Agriculture in the 21st Century. Proceedings of the Summer School held from 28 May to 17 June 1999. Rajasthan College of Agriculture, Udaipur, Rajasthan, India. 363 pp.

Culpin C. 2008. Farm Machinery. Hesperides Press. 672 pp. (www.aaapricesearch.com/Books/Author/Claude%20Culpin/0)

De Datta SK. 1981. Principles and Practices of Rice Production. John Wiley & Sons, New York, USA. 637 pp.

Encyclopedia Britannica. 1993. The New Encyclopedia Britannica. Volume 8. Encyclopedia Britannica Inc., Chicago, USA.

Howard Albert. 1947. The animal as our farming partner. Organic Gardening, Volume II, No. 3. 2 pp.

Hunt D. 2001. Farm Power and Machinery Management. Wiley-Blackwell, USA. 368 pp.

Kalyanaraman S. 2000. Saraswati. Babasaheb Apte Smarak Samiti, Bangalore, India. 1115 pp.

Mohan Kumar B. (Tr.) 2008. Krishi Gita (Agricultural Verses) (in Malayalam by Parshurama). Agri-History Bulletin No. 7. Asian Agri-History Foundation, Secunderabad, India. 120 pp.

Murphy-O'Connor J. 1998. The Holy Land: An Oxford Archaeological Guide from Earliest Times to 1700. Oxford University Press, UK. 489 pp.

Nene YL. 1966. Symptoms, cause, and control of khaira disease of paddy. Indian Phytopathological Society Bulletin 3:97–101.

Nene YL. 2007. Glimpses of the Agricultural Heritage of India. Asian Agri-History Foundation, Secunderabad, India. 902 pp.

Nene YL and **Sadhale Nalini.** 1997. Agriculture and biology in Rigveda. Asian Agri-History 1:177–190.

Perkins JH. 1997. Geopolitics and the Green Revolution. Oxford University Press, UK. 337 pp.

Pripps RN. 2002. The Big Book of Farm Tractors: The Complete History of the Tractor 1855 to Present. Town Square Book Inc., Jackson, MI, USA. 160 pp.

Randhawa MS. 1980. A History of Agriculture in India. Volume 1. Indian Council of Agricultural Research, New Delhi, India. 541 pp.

Santhanam A and **Sundaram V.** 1997. Agri-history of cotton in India. Asian Agri-History 1:235–251.

Sadhale Nalini. (Tr.) 1996. Surapala's Vrikshayurveda (The Science of Plant Life by Surapala). Agri-History Bulletin No. 1. Asian Agri-History Foundation, Secunderabad, India. 94 pp.

Sadhale Nalini. (Tr.) 1999. Krishi-Parashara (Agriculture by Parashara). Agri-History Bulletin No. 2. Asian Agri-History Foundation, Secunderabad, India. 94 pp.

Sadhale Nalini. (Tr.) 2004. Vishvavallabha (Dear to the World: The Science of Plant Life) (in Sanskrit by Chakrapani Mishra). Agri-History Bulletin No. 5. Asian Agri-History Foundation, Secunderabad, India. 140 pp.

Sadhale Nalini. (Tr.) 2011. Upavanavinoda (Woodland Garden for Enjoyment) (by Sarangadhara in Sanskrit). Agri-History Bulletin No. 8. Asian Agri-History Foundation, Secunderabad, India. 64 pp.

Sadhale Nalini and **Nene YL.** 2008. Mriga. pakshi.shastra (The Science of Animals and Birds) (in Sanskrit by Hamsadeva). Asian Agri-History Foundation, Secunderabad, India. 402 pp.

Saxena RC, Choudhary SL, and **Nene YL.** 2009. A Textbook of Ancient History of Agriculture. Asian Agri-History Foundation (AAHF), Secunderabad; and Rajasthan Chapter of AAHF, Udaipur, India. 139 pp.

Shamasastry R. (Ed.) 1926. Abhilashitarthachitamani (Manasollasa) in Sanskrit, Part III. Oriental Library Publications, University of Mysore, Mysore, India. 310 pp.

Sprague GF. 1997. Corn and Corn Improvement. American Society of Agronomy, USA. 774 pp.

Vasu SC. (Tr.) 1891. The Ashtadhyai of Panini. Volumes 1 (222 pp.) and 2 (140 pp.) Digital Library of India (www.dli.gov.in/.../advsearch_db_noregex.cgi)

Wells HG. 1956. The Outline of History, Volume 1. Garden City Books, New York, USA. 492 pp. (First published in 1920.)

Wheeler HJ. 2009. Manures and Fertilizers – A Work of Reference for All Interested in the Scientific Aspects of Modern Farming. Lightning Source Inc., USA. 412 pp.