ECONOMY BOTANY

ORIGIN AND INTRODUCTION OF CROP PLANTS, CEREALS, AND PULSES

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Introduction:

The cultivation of crop is one of the oldest occupations of mankind and probably began when he discovered that certain seeds spilled on disturbed ground, grew in some mysterious way into new plants. He collected the seeds and spread it into different regions. This is how origin and introduction of crop plants started.

We know that angiosperms provide us with most of our crops and their emergence predated the appearance of our species, *Homo sapiens*. They first appeared in the early Mesozoic or late Paleozoic era about 200-250 million years ago but fossil evidence of them is extremely limited until they began to dominate during the Cretaceous era (Hancock, 2004).

The term origin of crop plants mainly refers to the way by which the crop plants came into existence or by which these crops were derived at a particular point or a particular place. The origin of a particular crop is directly related to the place or the site or the country where it was born and domesticated for the first time. Alphonse de Candolle (1883) was the first to develop the subject of origin of domesticated plant in his book, '*Origine des Plantes Cultivée'*. Nikolai I. Vavilov, a Russian scientist and pioneer of the plant genetic resource movement, suggested the idea that many cultivated plants originated in the regions of the world called gene or diversity centers, where these plants were domesticated and then dispersed and spread to other areas of the world. These centers are characterized by the presence of dominant genes. Initially Vavilov (1926) suggested six main geographic centres of origin of cultivated plants, but subsequently (1935) increased their number to eleven. For several of these crop species, the wild ancestors still exist in the center of origin. However, today most scientists agree that centers of origin are not always equivalent to the centers of diversity because centers of diversity of different crops do not always coincide with centers of origin. Often centers of diversity do not always occupy a limited area and there might be secondary centers of diversity due to long history of continuous cultivation and introgression with wild relatives or between different races of a crop.

For the discovery of many of these economic plants, their migrations from one continent to another, and knowledge of their properties and cultivation, we are indebted to the scholars of antiquity, the ancient conquerors, the medieval merchant princes, the Spanish conquistadores and the mariners and explorers of many lands. They all took with them seeds of their native plants and in return, brought home for transplantation whatever they found fit. This is, in real sense, the introduction of plants in the new environment.

The cereals or grain crops are the most important sources of food for man and provide the basic or staple diet. They contain carbohydrates, proteins, fats, minerals and vitamins, and thus have a good nutritive value. The word ‘cereals’ is derived from *cerealia munera*, the gifts of Ceres- the Roman goddess of agriculture. The cereals were amongst the first plants to be cultivated or domesticated. They have been grown and used by man since ancient times. It is believed that barley as well as wheat was first grown in Western Asia at least 9000 years ago. This provided the basis for civilization of Mesopotamia, Sumerian, Babylon, Egypt, Rome, Italy and others. Similarly, rice served as the important cereal for the civilization in South East Asia and maize for civilization in the New World.

The legume seeds or pulses, sometimes termed ‘grain legumes’, are second only to the cereals as a source of human food and provide the much needed proteins to our predominantly vegetarian and poor population. Legumes have been an important crop ever since man started domesticating plants and have been part of our cultural heritage. Chinese literature records the cultivation of soybean between 3,000 and 2,000 B.C. Legumes also featured in the cropping systems of early Egyptian dynasties. The occurrences of pea and lentils have been reported by Helbaek (1966) at various archaeological sites such as Hacilar, Beidha and Jarmo, dating as far back as 7,500 to 6,500 B.C.

The pattern of pulse domestication is completely different from that of cereals because of their conspicuous seed dormancy. Pod indehiscence was of low value in pulse domestication and had evolved after the crop was well established and widespread (Ladizinsky, 1987). But both in the pulses and in the cereals break down of the wild mode of seed dispersal and loss of germination regulation evolved in the same way. These changes are best explained by assuming that mutations causing the loss of the wild-type adaptations were automatically selected as soon after people transferred the wild progenitors into a system of planting and reaping (Zohary, 1988).

The knowledge of origin of crops provides us with the database of agricultural diversity encountered in different regions of the world. It also helps in increasing food production by genetic improvement as the genetic resources are the raw material for plant breeding. Food grain production is linked to the economy of a nation. Unprecedented growth in world population is occurring and we need to fully exploit high-yielding varieties of crops alongwith better agricultural practices to increase the food production in spatial as well as in temporal dimensions. The knowledge of origin and introduction of a particular crop also helps in resolving some ethical issues like bio-patenting, intellectual property rights, sovereign rights and biopiracy (Gepts, 2004).

Origin of Agriculture:

Modern human beings (*Homo sapiens*) have existed perhaps for 200,000 years yet agriculture is relatively recent. For most of the human history, man was hunter and gatherer constantly roaming and seeking for food. He lived in small groups and led a nomadic life. Agriculture originated 7,000 to 13,000 years ago, somewhere in the well watered hillocks of the Indus, Euphrates, Tigris, and Nile River. The Tehuacan Valley in modern Mexico and the banks of the Yellow River in modern China are some of the other prehistoric site of ancient agricultural activity.

South East Asia with its diverse vegetation to support a stable human population with fishing and hunting economy was ideal for agricultural beginnings. However, archaeological evidence for this view is meagre. It was seed planting that led to most profound changes in the life of human beings. All early civilizations whose diets are known to us were based on seed reproduced plants such as wheat, maize or rice.

Scientists are unable to explain why man took so long to discover agriculture. There is evidence that agriculture originated independently in several parts of the world. Archeological evidence for the origin of crops points to mountainous areas of both Old World (Asia, Europe and Africa) and New World (North and South America), which have pronounced wet and dry seasons. Under such climatic conditions seeds would need to germinate, grow quickly with the onset of rains, complete their reproductive cycles and go to seed formation before summer sets in such as we see in annual plants..

Transition of Agriculture from Palaeolithic to Modern Age:

The old stone age of Paleolithic period was characterized by the absence of agriculture. Chipped stone tools and weapons were employed for hunting, fishing, and food gathering. Mesolithic period represented a transition period with scanty agriculture beginning here and there, and lasted several thousand years. Neolithic or New Stone Age was fully developed by 3000 B.C. wherein, agriculture was well developed, and polished stone tools were in use. Then, with use of metals, agriculture expanded up to the present day.

The gradual development of civilization can be traced to the management of assured food supply by deliberate planting of crops and by harvesting and storing the product. Thus, man’s food producing habits began to change slowly and in course of time he became a producer of food rather than a hunter-gatherer.

Ancient agriculture mainly involved domestication of selected wild crops and its cultivation in the field under human management.

Domestication of Crops:

Domestication of Crops occurred with the cultivation of population of early wild type crops (sown from seed gathered from wild stands). This includes the process which is selectively advantageous to rare mutant plants inheriting features necessary for survival in the wild and continues until the mutant's phenotypes starts dominating the wild crop population. e.g. wild wheat falls to the ground to reseed itself, but domesticated wheat stays on the stem when it is ripe. Probably a random mutation was much more useful to farmers and became the basis for the various strains of domesticated wheat that have since been developed.

Wild plants develop via natural selection that ensures their survival in the environment. Once a plant is domesticated, it is artificially selected to suit human needs and not necessarily for survival value. In fact, some modern cultivated plants could not even survive in the wild. e.g. seeds of corn are not dispersed due to the presence of husked ears.

Many cultivated plants originated in centres of origins, and from these centres, cultivated plants were dispersed and spread to other areas of the world. As these are often the only sources of germplasm for the continued development of new cultivars, protection of wild population is now an international goal for maintaining genetic diversity of crop plants.

According to Flannery (1973), plant domestication is known to have originated independently and almost simultaneously 6,000 to 9,000 years ago in America, Africa, and South-Western Asia.

The earliest human attempts at plant domestication occurred in Asia by 9,000 BC and involved the bottle gourd (*Lagenaria siceraria*) plant, used as a pre-ceramic technology container. The domesticated bottle gourd had reached the Americas from Asia by 8,000 BC, probably with migration of people into the continent from Asia (Erickson *et al.*, 2005). Cereal crops were first domesticated around 9,000 BC in the Fertile Crescent in the Middle East. The first domesticated crops were generally annuals with large seeds or fruits. These included pulses such as peas and grains such as wheat.

The Middle East was especially suited to these species, the dry summer climate was conducive to the evolution of large-seeded annual plants, and the variety of landscapes led to a great variety of species. As domestication took place, human beings moved from a hunter-gatherer society to a settled agricultural society. This change eventually led (some 4,000 to 5,000 years later) to the first city states and the rise of civilization itself.

According to Bryant (2003), early speculation about the origin of New World plant domestication focussed on the upland regions of the Mexico and South America. The data from the pollen analysis, recently recovered from the archaeological sites in Central America, confirms the use of early cultigens, including maize, from the San Andes site in the Mexican tropical lowlands near La Ventai Tabasco. Radiocarbon dating shows that the archaeological deposits containing cultigen pollen are 5,800 to 6,200 years old.

Domestication was gradual process of trial and error. Over time perennials and small trees began to be domesticated including apples and olives. Some plants were not domesticated untill recently such as the macadamia nut and the pecan.

In different parts of the world very different species were domesticated. In the America, squash, maize and beans formed the core of the diet. In East Asia rice and soybean were the most important crops. Some areas of the world such as Southern Africa, Australia and California and Southern part of South America never saw local species domesticated.

Over the millennia many domesticated species have become utterly unlike their natural ancestors. Corn cobs are now dozens of times the size of their wild ancestors. A similar change has occurred in between wild strawberries and domesticated strawberries.

Theories for Place of Origin and Domestication of Crops:

Initially Vavilov (1926) gave the concept of centre of diversity. He defined the centre of diversity as a centre of domestication of a particular crop. Two types of centres of diversity exist – **Primary** centre of diversity and **Secondary** centre of diversity. Primary centre is defined as the region/regions from where a particular crop originated and where the maximum diversity of that crop is present while the Secondary centre defined as those regions to which the particular crop is introduced and domesticated. At first Vavilov (1926) suggested six main geographic centres for cultivated plants, but subsequently (1935) increased their number to eleven. The main world centres of diversity as recognized and mapped by Vavilov and his associates are given below:

(1) China: A total of 136 endemic plants are listed. e.g. Foxtail millet, soybean, bamboo, crucifers, onion, lettuce, tea etc.

(2) India: 117 plants are considered to be endemic, which mainly includes rice, sugarcane, mango, orange, oriental cotton, eggplant, Sesame etc.

(2 a) South East Asia: 55 plants are listed, including rice, banana, coconut, clove, hemp etc.

(3) Central Asia: 43 plants are listed, prominent among which are common wheat, pea, common millet, buckwheat, Alfalfa, Hemp, cotton etc.

(4) Near East: 83 species are included in this region. At least nine species of wheat as well as rye are indigenous to this centre. Many of our subtropical and temperate fruits are native to this region.

(5) Mediterranean: 84 plants are known to have originated here including olives and many cultivated vegetables; forage plants; oil yielding plants (rape, black mustard) and wheats (durum and emmer).

(6) Ethiopia: Previously known as Abyssinian centre. 38 species are native to this region, includes wheat and barley, Sesame, castor bean, coffee etc.

(7) Mesoamerica (South Mexican & Central American Centre): Plants native to this region are extremely varied, and include maize, bean, squash, sweet potato, red peeper, papaya, guava, tobacco, etc.

(8) South America: This region is believed to be the native of potato, tomato, egg plant, pine-apple, rubber tree, cashew nut etc.

(8 a)The Chiloe Centre: It is an island near the coast of Southern chile. It is thought to be region of origin of common potato.

(8 b)The Brazilian –Paraguayan Centre: It is known to be the region of origin of groundnut, cassava, cashew nut, pineapple, peppers, potato, rubber etc.

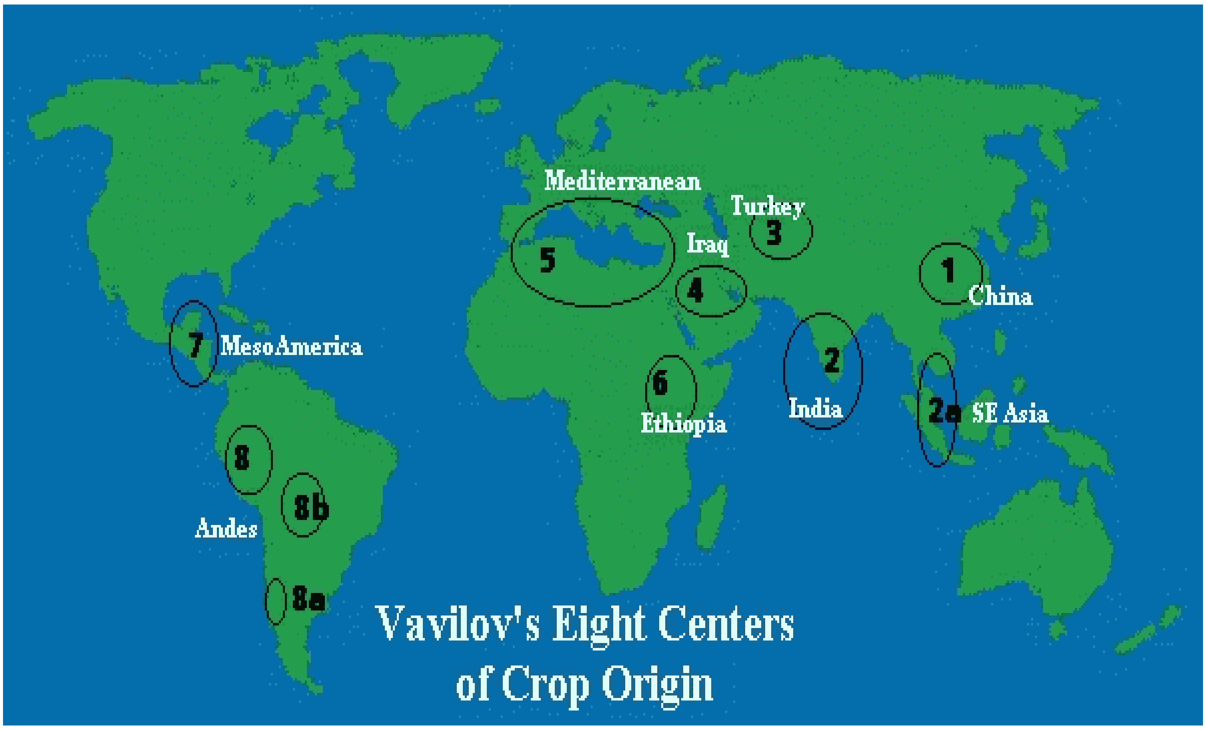


Figure 1.1. Vavilov's eight centres of crop origin

All the centers are between 20^{o}-45^{o} latitude; having mountaineous regions and temperate climate.

In 1968, Zhukovsky gave the concept of Megagene Center. It includes eleven centers:

(1) China

(2) Indochina-Indonesia

(3) Australia-New Zealand

(4) Indian Subcontinent

(5) Central Asia

(6) West Asia

(7) Mediterranean

(8) Africa

(9) Europe-Siberia

(10) Mexico and Central America

(11) North America

Harlan (1971) gave the idea of centres and non-centres which includes:

1) Three centres are well defined and having limited area coupled with three non-centres:

	Centre	Non-centre
i)	Near East	Africa
ii)	China	South East Asia and South Pacific
iii)	Mesoamerica	South America

2) Even in the centres, peripheral centres are present like:

i) Near East – having Caucasus

ii) China which is much larger and more diffuse

iv) Mesoamerica, having North East Mexico, mid-Mississippi-lower Ohio, North-West Mexico and South-West USA

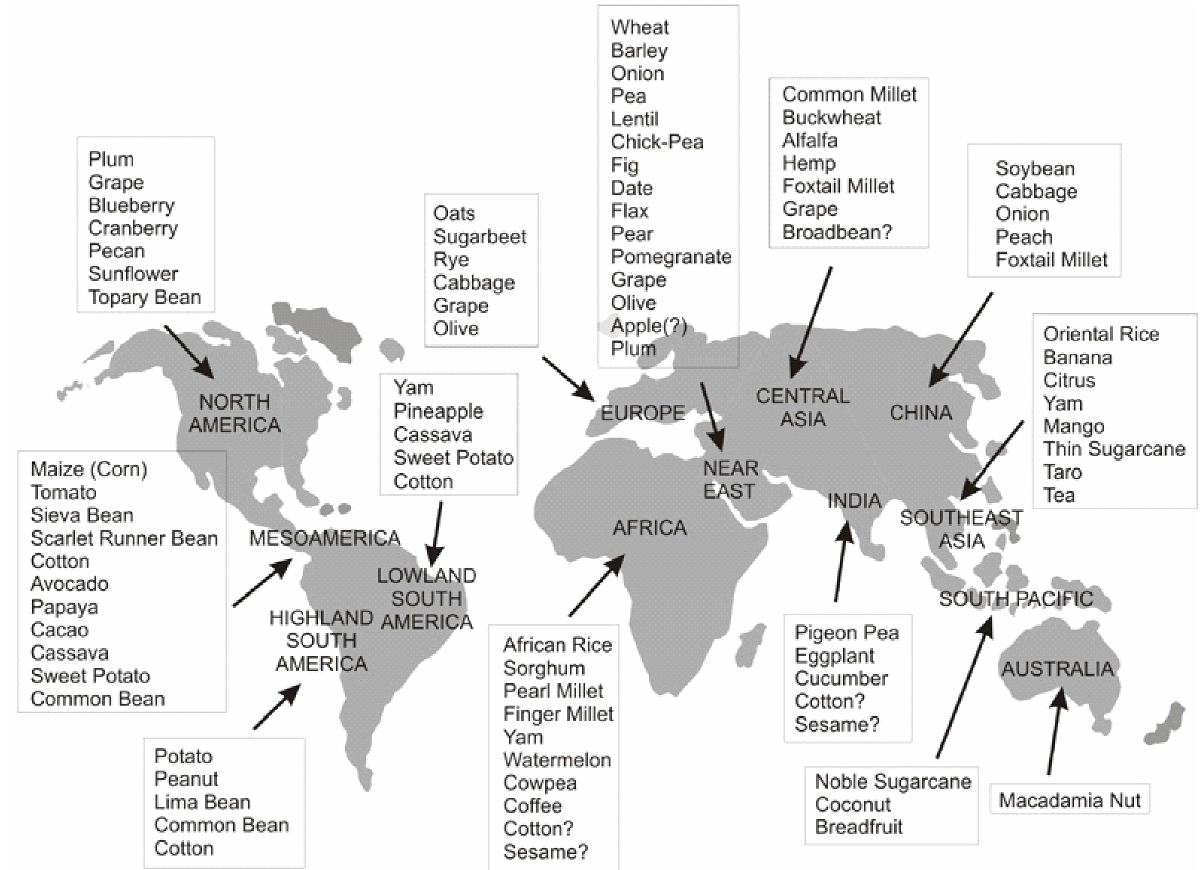


Figure1.2. Centers of Origin- regions of the world where major food crops were domesticated (Harlan, 1976).

Harlan (1992) gave his most recent theory about the centre of diversity. He considered that certain biomes or vegetation types may have been more conducive to domestication of crops than the others.

'A biome is a major regional territorial community with its own type of climate, vegetation and animal life. Biomes are not sharply separated, but merge gradually into one another over what is called an ecotone'.

He classified the biome into nine classes:

i) Tundra
ii) Evergreen Coniferous Forest (Taiga, Boreal forest)
iii) Temperate Deciduous Forest
iv) Grasslands
v) Deserts
vi) Dry Shrubland : Chaparral or Mediterranean
vii) Tropical Savanna
viii) Tropical Deciduous Forests
ix) Tropical Evergreen Forest

The distribution of these major biomes is based on the geography, annual temperature and rainfall, so for the origin and domestication of crops, geological and climatic conditions of an area are the most important factors.

With the help of theories given above and findings of the fossil evidences, one can say that the several major centres of origin of agriculture, where different species of plants were domesticated, include:

a) The Near East Centres, also known as "fertile crescent" of Mesopotamia (includes parts of Iran, Iraq, Turkey, Syria, Lebanon, and Israel) which are sites of domestication of wheat, barley, lentils, chickpeas, melons, olives, walnuts, and pistachios (about 11,000 years ago).

b) The Eastern Asia (includes China, Thailand, and India), is the site of domestication of rice, various beans such as soybean etc., bamboo, oranges (about 10,000-11,000 years ago).

c) The Mesoamerican centre (modern day Mexico, Brazil, Guatemala, Honduras) is the site of domestication of corn (maize), the common bean, squash and pumpkins, chilli peppers, and tomatoes (about 10,000 years ago).

d) Other areas in tropical America, Africa and in the Pacific Islands where root crops such as taro in the pacific, sweet potatoes and cassavas in tropical South America and Yams in Africa have been domesticated.

Contemporary Methods Used in the Study of Origin of Crops:

1. **Archaeological Method-** Buried seeds, fossilized pollen grains, and fragments of plant in the excavation of an archaeological site give us an insight to what types of plants were associated with the ancient cultures and were perhaps being eaten and cultivated by the primitive people. It also includes the tools used for the cultivation of crops, storage, grinding as well as threshing of harvested grains. Coprolites (fossilized faeces) can also be analyzed to see what types of foods were in the diet (seeds, plant fragments etc.) and how these were eaten (cooked vs. raw) by the primitive people.

2. **Historical Method-** It includes writings and drawings (art) which might depict plants and animals important to the culture concerned.

3. **Radiocarbon Dating -** Radiocarbon dating is used to determine dates/ages of archaeological materials with the help of ^{14}C ($t_{½}$ = 5,730 yrs). Plants take up atmospheric carbon dioxide in the process of photosynthesis, and are eaten by animals, so every living thing is constantly exchanging ^{14}C with its environment as long as it lives. Once it dies, however, this exchange stops, and the amount of ^{14}C gradually decreases through radioactive decay.

$$^{14}C \rightarrow {}^{14}N + {}^{0}\beta$$

By emitting a β particle (β decay), ^{14}C is changed into stable (non-radioactive) ^{14}N. The quantification of decayed ^{14}C from a dead specimen can be used to estimate the age of the specimen.

4. **Plant Sciences –** It mainly include following methods:

a. Identifying the wild ancestor of crop plant with the help of study of distribution area of the wild ancestor, study of origin of genetic diversity, and study of introgression between wild and cultivated forms.

b. By comparing wild and cultivated material on the basis of morphology, physiology and genetics.

c. By identifying changes relevant to adaptation or introduction of crops which includes study of new adaptive syndromes (a set of characters) evolved under domestication of crops, knowledge of selective forces, and study of genetic systems involved.

d. Taxonomical studies based on recognition of plants on the basis of morphological resemblance or phenotypic variations. This is the oldest method based on the comparative morphology and anatomy.

e. Molecular and Biochemical analysis includes:

i) Study at chromosome level i.e. cytogenetic analysis which includes hybridization studies in which crosses are made between wild and cultivated taxa and this is followed by examination of hybrids. Chromosome pairing at metaphase I of meiosis may indicate the degree of chromosome homology between the two plants, changes in chromosome number which includes euploids and polyploids (autopolyploids and allopolyploids) and haploids.

(ii) Molecular markers include:

a) Restriction Fragment Length Polymorphism (RFLPs): Intraspecific variations are caused by mutations. Restriction endonucleases are molecular scissors which can cut DNA into fragments on the basis of recognition of particular sites on the DNA molecule. In this way, different lengths or number of fragments are produced depending on changes in nucleotide bases in DNA. If there is a change in position or number of bases in DNA molecule of wild type plants, it can be observed by amplification of fragments from wild and mutated progenies. e.g. study utilizing RFLP markers (21 probes with three restriction enzymes) suggests that barley domestication could also have taken place outside the Fertile Crescent in Morocco (Molina-Cano *et al*., 1999).

b) Random Amplified Polymorphic DNA (RAPDs): A new DNA polymorphism assay was developed in 1990 that is based on the amplification by the polymerase chain reaction (PCR) of random DNA segments, using single primers of arbitrary nucleotide sequence. The amplified DNA fragments, referred to as RAPD markers, were shown to be highly useful in the construction of genetic maps ("RAPD mapping"). e.g. Fifty-eight accessions of sesame (*Sesamum indicum* L.), an important oil seed crop of the tropics and subtropics were analysed using random amplified polymorphic DNA (RAPD) technique. The high level of genetic diversity prevalent among the Indian collections is probably indicative of the nativity of this crop species. Similarly, the relatively lower level of polymorphism in exotic germplasm could be ascribed to the comparatively recent introductions of limited germplasm of this crop into some of the non-traditional sesame growing countries (Bhat *et al*., 1999).

c) Amplified Fragment Length Polymorphism (AFLPs): The AFLP technique is based on the selective PCR amplification of restriction fragments from a total digest of genomic DNA. The technique involves three steps: (i) restriction of the DNA and ligation of oligonucleotide adapters, (ii) selective amplification of sets of restriction fragments, and (iii) gel analysis of the amplified fragments. PCR amplification of restriction fragments is achieved by using the adapter and restriction site sequence as target sites for primer annealing. The selective amplification is achieved by the use of primers that extend into the restriction fragments, amplifying only those fragments in which the primer extensions match the nucleotides flanking the restriction sites. Using this method, sets of restriction fragments may be visualized by PCR without knowledge of nucleotide sequence. The method allows the specific coamplification of high numbers of restriction fragments. The number of fragments that can be analyzed simultaneously, however, is dependent on the resolution of the detection system. Typically 50-100 restriction fragments are amplified and detected on denaturing polyacrylamide gels. The AFLP technique provides a novel and very powerful DNA fingerprinting technique for the analysis of DNA of any origin or complexity.

d) Micro-satellites or Simple Sequence Repeats (SSRs): Microsatellites, or Simple Sequence Repeats (SSRs), are polymorphic loci present in DNA that consist of repeating units of 1-4 base pairs in length. They are typically neutral, co-dominant and are used as molecular markers. Simple sequence repeats (SSR), or microsatellites, are ubiquitous in eukaryotic genomes. e.g. study in the variation in chloroplast DNA simple sequence repeats (cp SSR) shows that cultivated soybeans originated independently in different regions from different wild gene pools and/or hybrid varieties between cultivated and wild forms (Xu *et al*., 2002).

e) DNA sequencing: DNA sequencing is the process of determining the nucleotide order of a given DNA fragment. Currently, almost all DNA sequencing is performed using the chain termination method developed by Frederick Sanger in 1975.

f) Quantitative Trait Locus (QTL): Quantitative Trait Locus is a region of DNA that is associated with a particular trait (e.g. plant height etc.). Though not necessarily genes themselves, QTLs are stretches of DNA that are closely linked to the genes. Moreover, a single phenotypic trait is usually determined by many genes. Consequently, many QTLs are associated with a single trait. These QTLs are often found on different chromosomes. Knowing the number of QTLs that explains variation in the phenotypic trait tells us about the genetic architecture of a trait. It may tell us that plant height is controlled by many genes of small effect, or by a few genes of large effect. Many qualitative traits are controlled by one Mendelian locus such as seed shattering in sorghum and pearl millet but even the traits that are usually considered as exhibiting quantitative inheritance involve few QTLs. tb1 (teosinte branched 1), conditions the dramatic alteration in plant architecture from a multistemmed, branched plant to the single-stemmed plant. Similarly, in common bean, seed dispersal (pod dehisence), seed dormancy, and photoperiod sensitivity are all determined by a few loci with effects of large magnitude (Poncept *et al*., 2004).

(iii) Biochemical markers (Proteins):

It is based on the separation of proteins and amino acids with different net charge and/or different molecular weight and/or conformation on the basis of their migration at different rates through matrix of starch or acrylamide gels. The analyzed protein types include:

a) Seed storage proteins- e.g. - phaseolin of *Phaseolus vulgaris* (common bean)

b) Isozymes- Different molecular forms of an enzyme that catalyze the same reaction are called as isozymes. Isozymes represent different genes whose products catalyse the same reaction. e.g. isozyme of *Zea mays*. Zymograms (A strip or band of electrophoretic medium showing the pattern of enzymes or isoenzymes after their separation by electrophoresis) help to identify the close wild progenitor of maize.

c) Allozymes which are variant forms of an enzyme that are coded for by different alleles at the same locus are called allozymes. e.g. The three Andean races, Nueva Granada, Peru, and Chile, differ in allozymes types which supports multiple domestications of *Phaseolus vulgaris*.

Origin and Introduction of Cereals:

The six great cereals of the world are wheat, rice, corn, barley, oat and rye. Each of them has different origin and the brief description is given below:

Wheat

Botanical Name: *Triticum sp.* Common Name: Wheat, gehun

Triticum monococcum (Einkorn Wheat) *Triticum aestivum* (Bread Wheat)

Figure: 2.1

Wheat is the most important food plant for more than one third of the world's population. Millions of people through out the world depend on wheat. It is also probably the oldest crop known to human civilization. Long before the beginning of agriculture, people gathered wild wheat for food. It is believed that agriculture originated in the Middle East when wheat was first cultivated in ancient times. There are several archaeological evidences to show the presence of carbonized wheat grains at the Neolithic sites in Jarmo in Northern Iraq, and in Central and North Eastern Europe dating back to the period 6,750 B.C. to 7,500 B.C. These and other observations suggest that wheat spread rapidly and widely throughout Asia and Europe after its domestication in the Middle East.

Vavilov classified the different types of wheats into 14 species. Other wheat taxonomists recognize either more or fewer species. All the types of wheats are classified under the genus Triticum. Triticum is the member of family Poaceae (earlier Gramineae), sub family Poideae and the tribe Triticeae. The different species of wheat can be grouped into three categories on the basis of their chromosome number which have been given in the table:

Species	Botanical Name	Common Name	Chromosomes	
			No.	Genomes
Diploid	*T. aegilopoides*	Wild Einkorn	7	**A**
	T. monococcum	Einkorn	7	**A**
Tetraploid	*T. dicoccoides*	Wild Emmer	14	**AB**
	T. dicoccum	Emmer	14	**AB**
	T. durum	Macaroni wheat	14	**AB**
	T. persicum	Persian wheat	14	**AB**
	T. turgidum	Rivet wheat	14	**AB**
	T. polonicum	Polish wheat	14	**AB**
Hexaploid	*T. aestivum*	Bread wheat	21	**ABD**
	T.sphaerococcum	Short wheat	21	**ABD**
	T. compactum	Club wheat	21	**ABD**
	T. spelta	Spelt wheat	21	**ABD**
	T. macha	**Macha wheat**	**21**	**ABD**

Table 1.1 Different Species of wheat

Source: Mangelsdorf (1953)

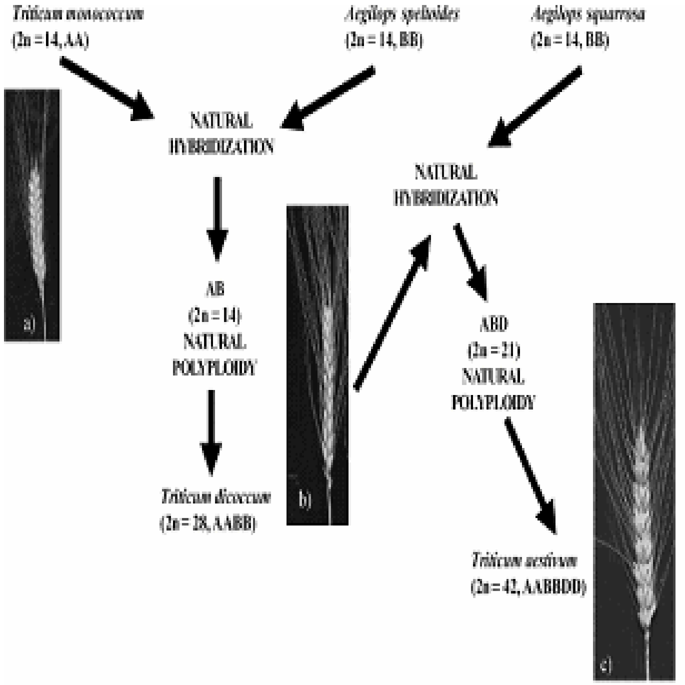
There are diploid wheats having 2n=14 chromosomes, tetraploid wheat with 2n=28 chromosomes and hexaploid wheat with 2n=42 chromosomes. Detailed cytological analysis of these wheats also revealed that there are three different genomes. The diploid wheat has been recognized, having the AA genome. The tetraploids and hexaploids are not autoploids (i.e. possessing similar genome to the diploid). They are alloploids with dissimilar genomes. The tetraploids wheat has the AABB genome while the hexaploid wheat has the AABBDD genome.

The oldest known wheat is the diploid wheat. The carbonized remains of wild einkorn and imprints of grains in baked clay have been discovered at the Neolithic site of Jarmo in Northern Iraq, dating as far back as 6,750 B.C. Wild einkorn has also been reported from several other archeological sites such as at Ali Kosh in South Western Iran, dated between 6,750 and 7,500 B.C. at Hailar, West Central Anatolia, dated at about 7,000 B.C., and Tell Mureybit (North Syria) from about 8,000 B.C. (Van Zeist and Casparie, 1968). Similar findings have also been made in deposits of the Neolithic lake dwellers and in many other sites in Central and North Eastern Europe. Apparently, there has been no appreciable change in these types of wheat over the centuries. There are, however, no records of its prehistoric occurrence in India, China and Africa.

According to Heun et al (1997), the emergence of agriculture in the near east also involved the domestication of einkorn wheat. Phylogenetic analysis that was based on the allelic frequency at 288 amplified fragments length polymorphism molecular markers loci indicates that a wild sp. of Triticum monococcum var. boeoticum lines from the Karacadag Mountain (Southern Turkey) is the likely progenitor of cultivated einkorn varieties. Evidence from archaeological excavations of early agricultural settlements nearby supports the conclusion that domestication of einkorn wheat began near the Karacadag Mountain.

The tetraploid wheat grows naturally in the Middle East, and appears to have originated as a result of natural crossing between Triticum monococcum (AA) and Triticum speltoides (Syn. Aegilops speltoides) (BB). Closely related to wild emmer is the true cultivated emmer that has arisen from T. dicoccoides by mutation, domestication and selection. Both of the emmers have covered or hulled grains. Emmer was once the most widely grown of all the types of wheats. Wild emmer and cultivated emmer have been found in the Neolithic sites of the Mureybit and Ali Kosh respectively. Ancient caves in Europe and mummies in Egypt have also yielded their grains.

The hexaploid wheats are the most recently evolved one and the most useful to men today. All the hexaploid wheats are cultivated, none having been reported to grow wild. All of them are products of hybridization of tetraploid wheat (AABB) with a wild (14-chromosomes) relative (DD), almost certainly a grass Triticum tauschii, earlier known as Aegilops squarrosa, followed by doubling of the chromosomes to give rise to a plant with six set of seven chromosomes (AABBDD). T. tauschii is a weed growing in wheat fields, from the Balkans to Afghanistan.



Synoptic chart of cultivated wheats evolution: the diploid (2n = 14, AA) forms of *Triticum monococcum* (**a**) were naturally pollinated by weed species, possible *Aegilops speltoides* (2n = 14, BB?), in about 10,000 B.C. primitive farms. The subsequent genome duplication of hybrids by natural polyploidy gave rise to several wild and cultivated tetraploid species (2n = 28, AABB) like *Triticum dicoccum* (**b**) and *Triticum durum* (Figure 2a); again, the natural pollination of the tetraploid *T. dicoccum* (b) by another weed species, *Aegilops squarrosa* (2n = 14, DD) gave rise to the hexaploid (2n = 42, AABBDD) species (**c**).

Figure: 2.2. Origin of Hexaploid Wheat

Rice

Botanical Name: *Oryza sp.*

Common Name: Chauval, Dhan, Rice

Figure: 2.3. *Oryza sativa* (Rice)

More than half of the people of the world eat rice as the main part of their diet. Nearly all the people who depend on rice for food live in Asia. The genus Oryza belongs to the tribe Oryzeae of the subfamily Poideae. Most taxonomists have identified about 20 species of rice out of which only two species are cultivated and are of economic importance. Of the two cultivated species, Oryza sativa L. is by far the most important and is now extensively cultivated throughout the warmer region of the world, whereas the cultivation of the other species, Oryza glaberrima Steud. is confined to tropical West Africa. There is close similarity between the two species: the only differences are in glume pubescence, ligule size and color of pericarp which is red in Oryza glaberrima. Interestingly, intermediate forms between the two species occur.

Oryza sativa has originated in South East Asia. The exact place and date of its origin or domestication is not known with certainty. It has been cultivated in China for nearly 5,000 years. Archaeological evidence from the Yung Shao excavations in China shows the remains of rice. These have been dated to 2,600 B.C. There are many religious ceremonies associated with rice since ancient times. There are other evidences also which suggest that rice may have originated in China.

Another view is that rice may have originated in India and then spread to China and other parts of South East Asia. Archeological excavations from Lothal in Gujarat dating back to 2,300 B.C. have revealed charred grain of rice. Lothal is considered to be a Southward extension of the Harappa and Mohenjo-daro culture of Indus Valley civilization. Similar findings have been discovered from Rangpur (2,000-1,800 B.C.), Navdatoli (1,550-400 B.C.), and Hastinapur in Uttar Pradesh (1,000-800 B.C.) (Kochhar, 1998). There are also records of rice in ancient Hindu scriptures and literature.

International Rice Research Institute (IRRI) was set up in the Philippines by the joint efforts of the Ford and Rockfeller Foundations to study this important cereal crop plant. From 1962 to 1965, samples of rice from different parts of the world were collected to build up a germplasm bank. More than 10,000 varieties of rice were recognized and interestingly about 60% of these varieties were found in India. This suggested that there was a great genetic diversity in the rice grown in this country. From an evolutionary point of view this is important because greater the diversity is, more are the chances of adaptation to the newer environment. The cultivation of rice in marshy areas with intervening mountains as well as the presence of wild species in the region has helped in the natural selection of different varieties.

Besides these evidences, there are numerous traditional uses of rice in religious ceremonies in India. These are associated with birth, marriage, and even death, suggesting that rice is of ancient origin in India. From India, rice may have spread to China, Indochina, Japan and other South East Asian regions. It may also have spread westwards to Iran, Iraq, Egypt, and neighbouring areas.

Origin of rice may also be looked from a taxonomic angle. The monophyletic hypothesis suggests that the two cultivated species: Oryza sativa and Oryza glaberrima have evolved from a common ancestor. The search for this ancestor has shown the occurrence of a wild rice Oryza longistaminata (also called Oryza perennis) which could be the progenitor of both the cultivated species. The origin of Oryza longistaminata is traceable to the Gondwana Land of super continent. Due to continental drift and splitting of this super continent, the present day Africa, Madagascar, South East Asia, Australia, South America, Antarctica etc. were formed in pre-historic times (Continental drift theory by Alfred Wegener, 1915). The original ancestral species of rice found in the Gondwana Land adapted to the regions in West Africa and South East Asia. This led to the evolution of Oryza sativa on one hand and Oryza glaberrima on the other.

More than 8,000 different rice varieties are known to exist in the world, of which over 4,000 have been identified in India alone (Leonard and Martin, 1963). The extent of variation in morphological and physiological features within Oryza sativa is greater than in any other cereal. The innumerable varieties encountered within Oryza sativa fall into two distinct races, which merit the status of subspecies, japonica and indica (Kato et al., 1928). The indica group comprises all of the cultivated forms of tropical regions of India, Indochina, the Philippines and Southern China; while the japonica group includes the cultivated rice varieties of the subtropical regions of Japan, Korea and Northern China. Marked sterility barriers exist between the subspecies. These two major groups of cultivated rices of Asia cross with each other well but hybrids between them are largely sterile because of meiotic irregularities. There is yet another race javanica which includes some intermediates from Indonesia that are referred to as 'bulu' varieties.

The chief morphological and physiological differences between the *indica* and *japonica* group are summarized in the table:

Character	*Indica subspecies*	*Japonica subspecies*
Climatic adaptability	**Tropical monsoon**	**Warm temperature**
Tolerance to adverse conditions	**High**	**Moderate**
Resistance to diseases	**Fairly resistant**	**Less resistant**
Photoperiodic responses	**Predominantly photosensitive (short day)**	**Photoperiod insensitive**
Fertilizer responsiveness	**Low**	**High**
Lodging	**Susceptible**	**Resistant**
Vegetative period and growth	**Long, vigorous growing, leafy (late maturing)**	**Short, lack vegetative vigor (early maturing)**
Tillering habit	**Profuse tillering**	**Moderate tillering**
Nature of culm	**Long and weak stalks**	**Short and stronger stalks**
Foliage color and form	**Broad and pale green**	**Narrow and dark green**
Husk pubescence	**Sparse, short**	**Dense, long**
Shattering quality	**Susceptible**	**Resistant**
Grain size	**Usually long, narrow, flattened**	**Short and thick**
Endosperm	**Translucent**	**Chalky**
Seed dormancy	**Present**	**Absent**
Yield potential	**Medium**	**Low**
Cooking quality	**On cooking, grains do not turn sticky**	**Grains soften rapidly and become mushy**

Table: 1.2 Chief morphological and physiological differences between the *indica* and *japonica* group

(Source: Kochhar, 1998)

Maize

Botanical Name: *Zea mays* L.

Common Name: Maize, Makai, Bhutta

Figure: 2.4. *Zea mays* (Maize)

Maize or corn is one of the three major cereals which are the chief sources of energy in the human diet. In the order of world grain production, maize ranks second, after wheat. Rice is a close third. Maize is the most widely distributed cereal crop with a very interesting history of its origin. It is perhaps America’s greatest gift to mankind. Maize has an amazing number of uses as food for man, livestock, and feed and for making many kinds of non-food products.

The name ‘maize’ is derived from a South American Indian Arawak – Carib word “Mahiz”. It was first used for food about 10,000 years ago by Red Indians living in the area now called Mexico. For hundred of years, these tribal people gathered the grains from wild plants before they learnt to grow corn themselves. Thus, it was also called as “Indian corn” although this did not refer to the Asian country “India” in any way.

The genus Zea is classified in the tribe Maydeae of the family Poaceae/Gramineae. There is only one species, Zea mays which is known only in cultivation. Closely related to this genus are two other New World genera, Tripsacum (called gama grass which is used as fodder in North America) and Euchlaena (called Teosinte, believed to be the closest wild relative of maize). Some taxonomists do not recognize Euchlaena as a separate genus and have transferred all the species of this genus to Zea.

The several thousand varieties of maize are classified into seven principal group on the basis of endosperm and floral bract or glume character.

a) **Pod corn** (Zea *mays* var. *tunicata):* Pod corn is considered to be a primitive type and is believed to be one of the progenitors of maize. Pod corn, dating as far back as 5,600 B.C. has been found as the archaeological deposits in the Tehuacan Vallley, Mexico. It is of no commercial importance.

b) **Pop corn** (*Zea mays* var. *everta)*: It contains higher percentage of hard starch with a little soft starch in the centre. However, the kernels are smaller and when exposed to high temperature, they explode and the grains is literally turned inside out, thus forming a snow white, fluffy, palatable mass. This phenomenon is known as 'popping'.

c) **Flint corn or Yankee corn** (*Zea mays* var. *indurata)*: In flint maize, the central part of the endosperm consists of soft starch, completely surrounded on all sides by a very hard, transparent endosperm.

d) **Dent corn** (*Zea mays* var. *indentata)*: It is the most widely grown type of maize and is characterized by a depression or 'dent' at the top of the kernel where it is chiefly composed of soft starch that easily form a paste with water.

e) **Soft corn or flour corn** (*Zea mays* var. *amylacea)*: The kernels are made up primarily of almost entirely of soft starch with a very thin layer of hard, flinty starch kernel and show little or no denting.

f) **Sweet corn** *(Zea mays* var. *saccharata)*: The kernels have a relatively large proportion of sugar to starch. Sweet corn is characterized by its translucent, horny appearance when immature and wrinkled condition at maturity.

g) **Waxy corn** (*Zea mays* var. *certaina)*: When the endosperm of this maize is cut or broken, it appears waxy. Waxy starch consists entirely of the branched molecule, amylopectin.

All these types of maize were already in existence in Pre-Columbian times and it is necessary to find out which is the most primitive one. Pod corn in believed to be the most primitive. In this variety each grain (seed) is enclosed by glumes or floral bracts. The entire cob is again enclosed by the bracts. This is not cultivated but is preserved in some localities to understand the origin of the earliest cultivated maize. The other primitive type of corn is pop corn. Crossing pod corn with pop corn has helped in producing a genetic reconstruction of the ancestral form of maize.

Archaeological findings, genetic studies and other evidences have been used to study the origin of maize:

a) Asiatic Origin of Maize: Dhawan (1964) reported the occurrence of very primitive type of maize from the foothills of the Himalayas. These were called "Sikkim Primitive 1" and "Sikkim Primitive 2". They have morphological and cytological characteristics of the most primitive kind and can be called "Living fossils". However, there is neither other evidence to corroborate this view on the Asiatic origin of maize nor any explanation on how it spread to the New World in pre-historic times.

b) New World Origin of Maize: There is considerable evidence to establish the view that maize is the 'gift of the New World to the mankind'. This cereal was widely spread and used as the basic food plant in all Pre-Columbian ancient civilizations in America. Extensive research work carried out by Mangelsdorf, Reeve, Mac Neish and Wilkes, has established an American origin of maize. The region from Gautemala to Southern Mexico is believed to be the centre of origin of maize.

According to Pope *et al.* (2001), archaeological research in the Gulf Coast Tabasco reveals the earliest record of maize cultivation in Mexico. The first farmers settled along beach ridge and lagoons of the Grijalva river delta. Pollen from cultivated *Zea* appears with evidence of forest clearing about 5,100 B.C. Large *Zea sp*. pollen, typical of domesticated maize (*Zea mays*), appears about 5,000 B.C. old.

When America, as the site of origin of maize is accepted, it is necessary to determine the ancestors of modern cultivated maize. There are many interesting observations related to the origin of maize: –

(i) The ancestor of modern cultivated maize is maize itself and not any other related grass. In 1954 when the first skyscraper was constructed in Mexico, fossil pollen grains were found at a depth of 70 m. These were dated to be about 80,000 years old of the last interglacial period.

(ii) Excavations of archaeological sites at the Bat cave in New Mexico have been carried out since 1948. These have identified some very primitive settlements which may have been inhabited by ancient people for several thousand years. These people practiced a very primitive form of agriculture and primitive pattern of sanitation. Preserved corn cobs were found in refuse heaps. These were very small measuring only 2-3 cm long and have been determined to belong to the period 3,600 B.C. Several other such primitive cobs have also been excavated from other ancient sites in different parts of Mexico. An interesting discovery was made in 1960 by Mac Neish from the Coxcatlon cave in the Tehuacan valley in Southern Mexico. Well preserved corn cobs as old as 5,200 B.C. have been identified. These cobs could be considered as the original wild maize, because of their primitive characteristics. The pod corn which is believed to be the most primitive type of corn is of this type. Mangelsdorf (1974) in his book "Corn, its Origin, Evolution and Improvement" concludes that cultivated maize originated from ancestral maize.

(iii) Extensive studies by Mangelsdorf have shown that the pod corn is the most primitive type of corn. The pod character in corn is controlled by genes on the Tutus locus on the fourth Chromosome. The Tutus locus is strongly pleiotropic and affects many different characteristics of the maize plant. A genetic reconstruction of conceptual maize has been possible by crossing pod corn with pop corn and back crossing the hybrid. These studies suggested that cultivated corn originated from wild ancestral corn in the New World.

(iv) The closest relatives of corn are Teosinte (*Euchlaena mexicana*) and gama grass (*Tripsacum dactyloides*). These are not the ancestors of wild maize, but they evolved along with ancestral wild and hybridized with it. Some of the characteristics of these grasses are found in cultivated maize.

(v) The recent discovery of a perennial grass identified as *Zea diplo-perensis* provides important facts about relationships of *Zea mays* with other types of corn.

Barley

Botanical Name: *Hordeum vulgare* L. Common Name: Barley, Jau, Jav.

Syn. *H. sativum*

Barley is one of the oldest cereals which was cultivated by man at the dawn of the civilization. This cereal grain has been closely associated with wheat. Barely as well as Einkorn was probably the first cultivated crop by man. There are archaeological evidences from the famous Neolithic site of Jarmo in Iraq which suggests that this cereal may have first been cultivated about 6,500-7,000 B.C. It is also believed that barely may have originated in Abyssinia (Ethiopia) in North East America; and also in Eastern Asia in the region comprising China, Japan, Tibet and Nepal. These two regions can be referred to as centres of diversity and the type of barely sown in these regions are distinct. In the North East African centre, the predominant cultivated type of barley is of the two rowed type. Each spike has two rows of grains. This is called Hordeum vulgare var. distichum (or Hordeum distichum L.) and it is quite similar to a wild species called Hordeum spontaneum. In the eastern or Asian Centre, the six-rowed barley is commonly cultivated. Each spike has six rows of grains. The plant is referred to as Hordeum vulgare var. hexastichum.

The antiquity of barley is also shown by other evidences. Illustration of the Roman goddess of agriculture - Ceres shows ears of barley plaited in her hair. Ancient Greek and Roman coins also depict barley. Carbonized grains from the Swiss lake dwelling as well as jar of grain of the six-rowed barely are amongst the oldest specimens of this cereal which are preserved in the world museum.

Vavilov suggested that barely spread out from two centres, North Africa and East Asia. This suggestion was based on botanical and ecological information. The actual centre of origin of this cereal could be in the region between North West Indies and Abyssinia.

Rye

Botanical Name: *Secale cereale* L. **Common Name: Rye**

Cultivated rye probably originated from wild perennial weedy species of the genus *Secale* in Central Eurasia. There are several wild species of rye which can be cultivated and can sometimes exist both as a weed and as a pure crop. The centre of origin of rye overlaps with the centre of origin of the other bread cereals, wheat, barely and oats. However, rye is believed to be of more recent origin than the other cereals.

Oats

Botanical Name: (i) *Avena sativa* L. **Common Name: (i) Common oat**

(ii) Indian oat

Oats were first cultivated in the Iron Age in Europe. Archaeological remains dated to first millennium B.C. have been found in Switzerland, Germany, and Denmark. Oats were apparently unknown to the ancient Egyptian, the Hebrews, the Greeks, the Romans, the Chinese, and the people of India.

Vavilov in 1926 showed that oats occurred as weeds in wheat fields in Persia and suggested that the ancestors of the cultivated oats may have been native of Asia. Oats probably originated in the Asia Minor (Trans Caucasian region).

The common cultivated species Avena sativa is not known in the wild state and is believed to have descendant from the wild oat Avena fatua L. somewhere in Asia Minor or South Eastern Europe. Another view says that Avena byzantina C. Koch itself perhaps a subspecies of the wild red oat, Avena sterilis L., is more likely to be the progenitor of at least certain forms of Avena sativa.

Origin and Introduction of Legumes (pulses):

The family Fabaceae is a large family of flowering plants. The term legume in the botanical sense refers to the entire plant as well as to the fruit which is a simple, dry, dehiscent pod. All the cultivated legumes consumed as food are classified in the subfamily Papilonatae (also known as Papilionoideae, or Faboideae, or Lotiodeae).

The different legumes may or may not have the same origin and introduction in the new region and should be treated individually.

Archaeological remains of Pisum, Vicia and Lens have been discovered by Renfrew (1966) from Neolithic sites in Greece. In the New World, the common bean may have been the first to be domesticated with remains dating as far back as 4,975 B.C. from Tehuacan valley in Mexico. Fragments of lima bean (Phaseolus lunatus) or common bean, as well as beans of the genus Canavalia have been reported in dried human excreta (desiccated faeces or coprolites) in coastal Peru, dating back to 3,000 B.C. Kaplan et al. (1973) have reported the occurrence of common bean and lima bean in deposits in the inter-montane Peruvian valley, dating to about 6,000 B.C. This report also lends support to the hypothesis that agriculture has been a completely independent origin in two areas in the New World.

The origin and domestication of different pulses are given below:

Pigeon Pea

Botanical Name: ***Cajun's cajan*** **L.** **Common Name: Pigeon pea, red gram, Congo pea**

Figure: 3.1. *Cajanus cajan* (Pigeon Pea)

The plant is probably a native of Africa where it is often found naturalized. It was cultivated in Egypt as early as 2,000 B.C. (Purseglove, 1974). It was probably brought to India at an early date and diversified into many types.

Chickpea

Botanical Name: ***Cicer arietinum*** **L.** **Common Name: Chickpea, gram, Bengal Gram, Chana**

This is one of the oldest pulse crops known to be cultivated in Asia and Europe since ancient times. Helbeak (1966) has reported the occurrence of archaeological remains of chickpea dated 5,450 B.C at Hacilar in Turkey and 4,000 B.C. from Palestine.

Gram, like other important pulses, is not known in a wild state and has been recorded only in cultivation. It is believed to have originated in Western and South Western Asia – in the area lying between the Caucasus and the

Himalayan Mountain. From here it spread to Southern Europe, Iran, Egypt and India. The plant has also been introduced into tropical America, Africa and Australia but is of little importance in these areas.

Cluster Bean

Botanical Name: *Cyamopsis tetragonoloba(* L.) Taub **Common Name: Cluster bean, guar**

The plant is probably indigenous to India although it has never been observed in wild state. It has been cultivated in India for fodder and green manure, while the green, immature fruits are used as vegetable. It is now cultivated extensively in India, Indonesia, Myanmar, parts of Central Africa and in the arid South Western United States to tap its industrial potentials. In India, two cultivars of *C. tetragonoloba* are generally recognized, the giant and the dwarf; the former possesses large pods and seeds.

Horse Gram

Botanical Name: *Dolichos uniflorus* Lam. **Common Name: Horse gram**

The plant is native of Southeast Asia and is now distributed throughout the tropics, especially India, Malaysia, Mauritius, Sierra Leone, Transvaal and the West Indies.

Hyacinth Bean

Botanical Name: *Lablab purpureus(* L.) Sweet **Common Name: Hyacinth bean, bonavist bean, Lubia bean, Sein bean Indian bean**

Syn. *Dolichos lablab* L.

Syn. *Dolichos purpureus* L.

Hyacinth bean is native to India, where it grows in wild. It is now cultivated extensively in India, South and Central America, the East and West India, China and Africa, especially in Egypt and Sudan.

Grass Pea

Botanical Name: *Lathyrus sativus* L. **Common Name: Grass pea, Chickling vetch or pea, lathyrus pea, Khesari dal**

The grass pea, known in India as the khesari dal, is of very ancient cultivation, and probably originated in Southern Europe and Western Asia. Its archaeological remains have been found at Jarmo, dating as for back as 6,000 B.C. Similar findings have also been recorded from Neolithic sites in Hungary and Switzerland.

It is grown as a winter crop in India, Iran, Southern Europe and parts of Africa and South America.

Lentil

Botanical Name: ***Lens esculenta*** **Moench** **Common Name: Lentil**

Syn. Lens culinaris Medik

This is one of the oldest leguminous crops, believed to be indigenous to South Western Asia and the Mediterranean region. From these areas it spread northward to Europe, eastward to India and China, and southward to Ethiopia. Lentils have been esteemed as a food since biblical times and formed a common food of the ancient Greeks, Jews, Egyptians and Romans. Lentils are found with field pea and horse bean in the earliest agricultural sites in the Near East. The occurrence of archaeological remains of lentils, dated back to 7,500 to 6,500 B.C, has been reported from Hacilar, Beidha and Jarmo (Helbaek, 1966). Likewise, seeds of *Lens* have been reported from Neolithic deposits in Greece.

Common Bean

Botanical Name: ***Phaseolus vulgaris*** **L.** **Common Name: Common bean, French bean, Kidney bean, haricot bean, Runner bean, Snap bean, Salad bean.**

Figure: 3.2. *Phaseolus vulgaris* (Common Bean)

It is of New World origin and is cultivated in many parts of the tropics and subtropics, and in temperate regions. It has been cultivated throughout North, Central and South America. Remains of common beans, dated to 4,975 B.C. have been found in the caves of the Tehuacan valley in Mexico. Vessels containing bean have been recovered from the Pre-Inca tombs in Peru. The remnants of common beans and lima beans have been recorded from archaeological deposits in the inter-montane Peruvian valley, and dated to about 6,000 B.C. The common bean was introduced into Europe in the sixteenth century by the Spaniards and Portuguese and was later carried to Africa and other parts of the world. The crop is grown extensively in Brazil, the United States of America, Mexico, Italy, and Turkey. Beans are grown in India in the hilly regions.

Black Gram

Botanical Name: *Phaseolus mungo* **Common Name: Black gram, wooly pyrol, Urd**

The legume has been under cultivation in India since ancient times. According to Vavilov (1926), this pulse originated in India, and central Asia which is recognized as a secondary centre for its spread. It is suggested that the *Phaseolus mungo* probably originated from the wild species *Phaseolus trinervius* or *Phaseolus sublobatus* commonly grown in India. It has been introduced in many tropical and subtropical regions by Indian immigrants.

Carbonized grains of black gram have been recovered from the Chalcolithic site, Navdatoli-Maheshwar (India), dated to 1,660-1,440 B.C.

It is grown in many tropical and subtropical countries, mainly in India, Iran, Malaysia, East Africa and the Southern parts of Europe. It is also grown to a limited extent in South and Central America and the West Indies.

Green Gram

Botanical Name: *Phaseolus aureus* **Common Name: Green gram, mung, golden gram, Penara**

Like *Phaseolus mungo*, *Phaseolus aureus* too is of ancient cultivation in India and has not been found in the wild states. It is supposed to be a native of India and Central Asia. Besides India, this pulse is cultivated in South-East Asia, some parts of Africa, the West Indies and the United States of America.

Moth Bean

Botanical Name: *Phaseolus aconitifolius* **Common name: Mat or moth bean**

The moth bean is probably a native of India, Pakistan and Myanmar where it grows wild and appears to have been recently domesticated. At present it is largely grown in India, Sri Lanka, China, Pakistan and the South Western United States, particularly in Texas and California.

Pea

Botanical Name: *Pisum sativum* L. **Common Name: Pea, garden pea, Field pea, Matar**

Figure: 3.3. *Pisum sativum* (Pea)

As in the case of many other widely cultivated plants, *Pisum sativum* has not been found as a wild plant. It has been known in cultivation since ancient times. Excavations of Neolithic sites dating as far back as 7,500-6,500 B.C. have shown carbonized pea seeds. They were first discovered in the Near East in Jarmo and other sites. Later similar findings were made from other Neolithic sites in Europe. The Russian Botanist, Vavilov (1951) suggested that the garden pea may have originated in Ethiopia, or the Mediterranean and Central Asia with a centre of diversity in the Near East. On the other hand the French Botanist De Candolle was of the view that "this species seems to have existed in Western Asia from the South of Caucasus to Persia before it was cultivated". Interestingly, a wild plant of *Pisum arvense* which is closely related to *Pisum sativum* occurs in Russia. An important observation about *Pisum* is that all the species are self pollinating diploids and they intercross freely. Thus the actual origin of the cultivated garden pea has not been established. The plant has been cultivated since the Greek and Roman times. It was probably domesticated in Central or Western Asia and it later spread to other parts of the world.

The crop is cultivated extensively in countries having a cool climate especially in the Northern Hemisphere. Europe, United States of America, Canada, China, Ethiopia, India and Japan are the major producers of pea.

Cow Pea

Botanical Name: *Vigna unguiculata* L. **Common Name: Cowpea, Catjang Cowpea Lubia**

Cow pea is an important pulse crop cultivated since ancient times in Africa and Asia. There are references to this pulse crop in ancient Sanskrit literature also. In Africa this legume is widespread both in the wild state as well as in cultivation. On the basis of all the evidence, it is now believed that the cultivated cowpea originated in Central Africa from where it spread in early times through Egypt or Arabia to Asia and the Mediterranean. It was brought to the West Indies in the sixteenth century by the Spaniards and was introduced to America in about 1700 A.D. Cowpeas are now widely distributed throughout the tropics and subtropics.

Soybean

Botanical Name: *Glycine max*. **Common Name: Soybean, Bhat, Ram Kurthi**

Soybean originated in China. It is perhaps the oldest crop cultivated in the oriental region. The cultivated soybean – *Glycine max* is not found in the wild state. It is believed to have arisen from G*lycine soja* (also called *Glycine ussurjensis)*. This slender, prostrate, twining legume occurs wildly in many parts of Eastern Asia. Another wild species, *G. tomentella* (or G. *tomentosa)* could have contributed to the origin and evolution of the cultivated *G. max* hybridizing with *G. soja.* Soybean was carried to Europe by French missionaries in 1740 and to the United States in 1804. It ranks high among the leguminous crops in its nutritional value (protein content as high as 43%, oil 20%).

Pea Nut

Botanical Name: ***Arachis hypogaea*** **Common Name: Peanut, Monkeynut**

Moongphali

Figure: 3.4. *Arachis hypogaea* (Pea Nut)

The groundnut is believed to have originated in South America. According to Vavilov (1951), this plant was first domesticated in the Brazilian – Paraguayan region. The area of the valleys of Paraguay and Parana rivers is the most likely centre of origin of this legume. No wild plant of this important crop has been found. But several other species grow in the wild and all of them produce geocarpic fruits. Excavation in coastal Peru dating back to 800 B. C. shows the cultivation of groundnut. From South America, this legume spread to other parts of the world. It was commonly found in the West Indies but not in the United States in Pre-Columbian times. Groundnut was introduced to the old World in the 16th century when the Portuguese took the seeds from America to Africa. The Spaniards introduced it into the Philippines. It then spread to China, India, Japan, Malaysia and other parts of the world.

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