B.Sc. Sem- IV (H)- CC 9
Economic Botany
By

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ECONOMIC BOTANY

Economic botany is the study of the relationship between people (individuals and cultures) and plants.

Economic botany intersects many fields including established disciplines such as agronomy, anthropology, archaeology, chemistry, economics, ethnobotany, ethnology, forestry, genetic resources, geography, geology, horticulture, medicine, microbiology, nutrition, pharmacognosy, and pharmacology.

Economic botanists are scientists who study the interactions between humans and plants. That makes the field of Economic Botany as far flung and diverse as both the human and plant life on our planet. Economic botanists study human-plant interactions from a variety of different angles.

Presented by Dr. K. Chaudhury

In a 1958 essay at the conference that founded the Society for Economic Botany, David J. Rogers wrote, **"A current viewpoint is that economic botany should concern itself with basic botanical, phytochemical and ethnological studies of plants known to be useful or those which may have potential uses so far underdeveloped. Economic botany is, then, a composite of those sciences working specifically with plants of importance to [people]."** Closely allied with economic botany Is **Ethnobotany** which emphasizes plants in the context of **Anthropology**.

Purpose and Objectives:

Knowledge Systems

Economic Botany sometimes focuses on the processes as well as the products involved in plant cultivation.

Uses of Plants

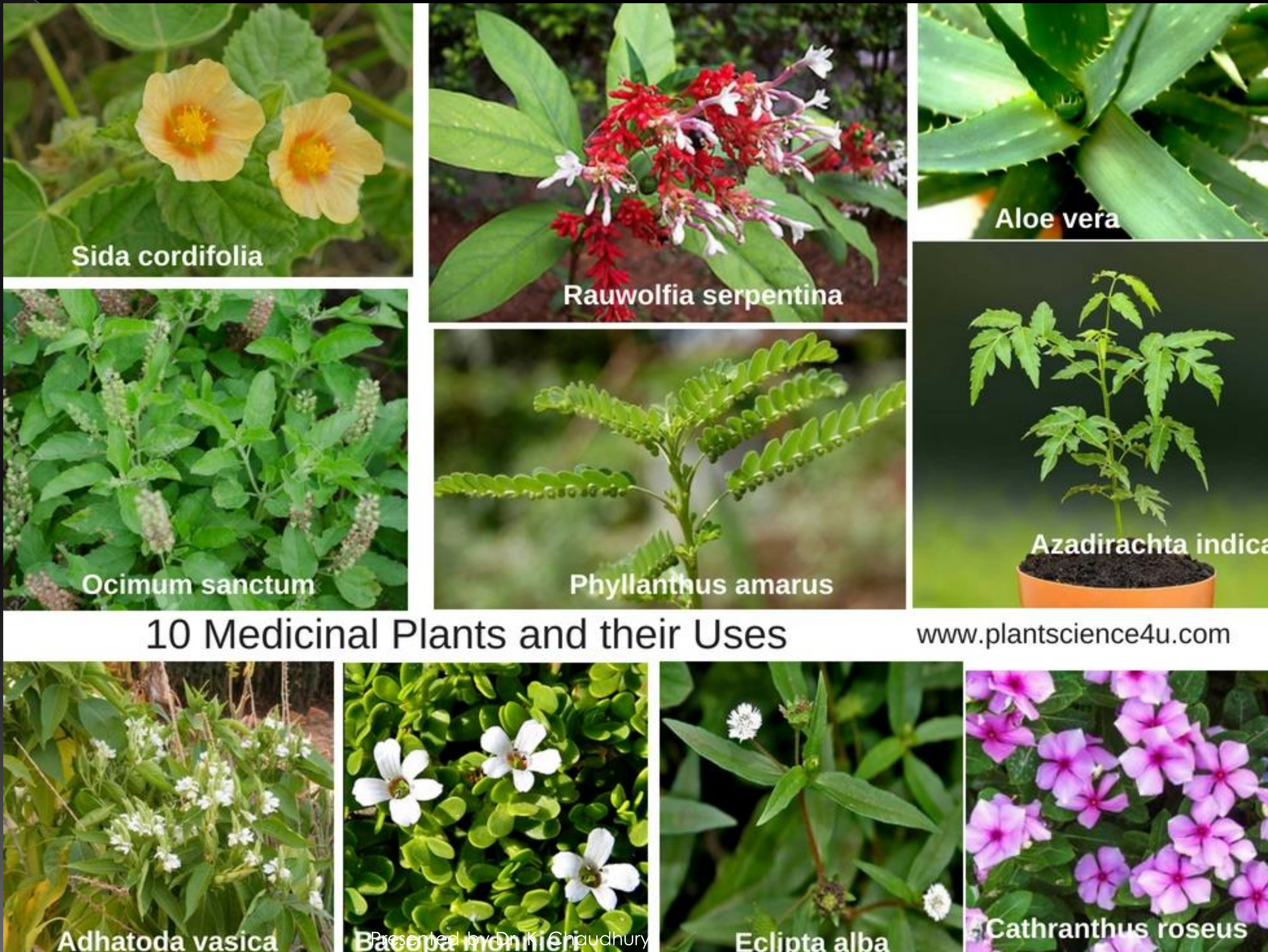
We can also study how plants are used. In the past this has meant lists of cultures and their preferred plant sources for food, clothing, shelter, medicine, ritual or aesthetics.

Ecology, Evolution and Systematics

Studies of the evolution of cultivated plants include the processes of domestication and the relationship between natural and human selection of specific plant traits.

Landscapes and Global Trends

The impacts of human activity on the landscape and biological diversity are also of increasing concern to ethnobotanists. The effects of human presence can be seen in every ecosystem they inhabit.



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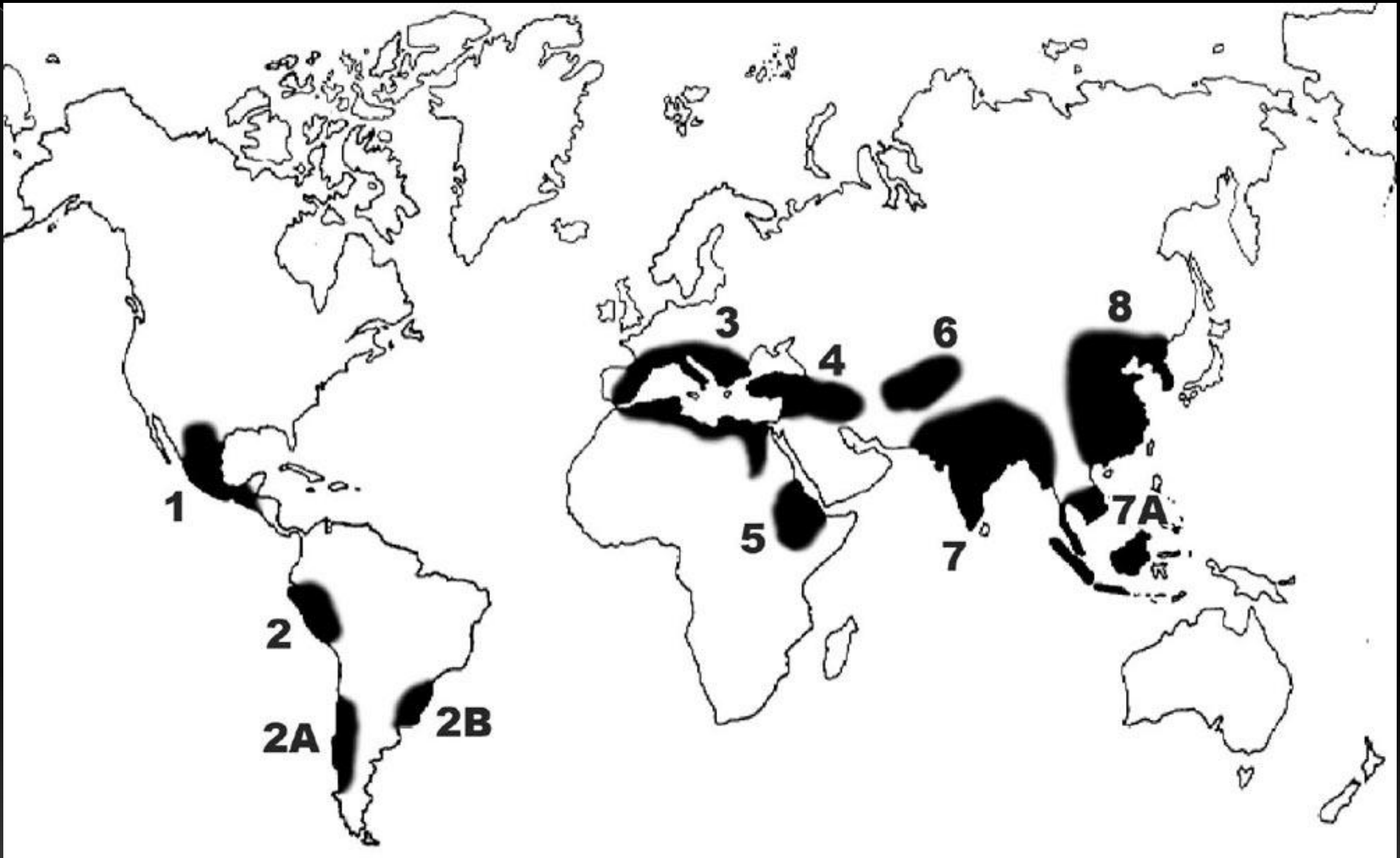
CENTER OF ORIGIN OF PLANTS

A **center of origin** (or **center of diversity**) is a geographical area where a group of organisms, either domesticated or wild, first developed its distinctive properties. They are considered as centers of diversity. Centers of origin were first identified in 1924 by **Nicolay Ivanovich Vavilov.**

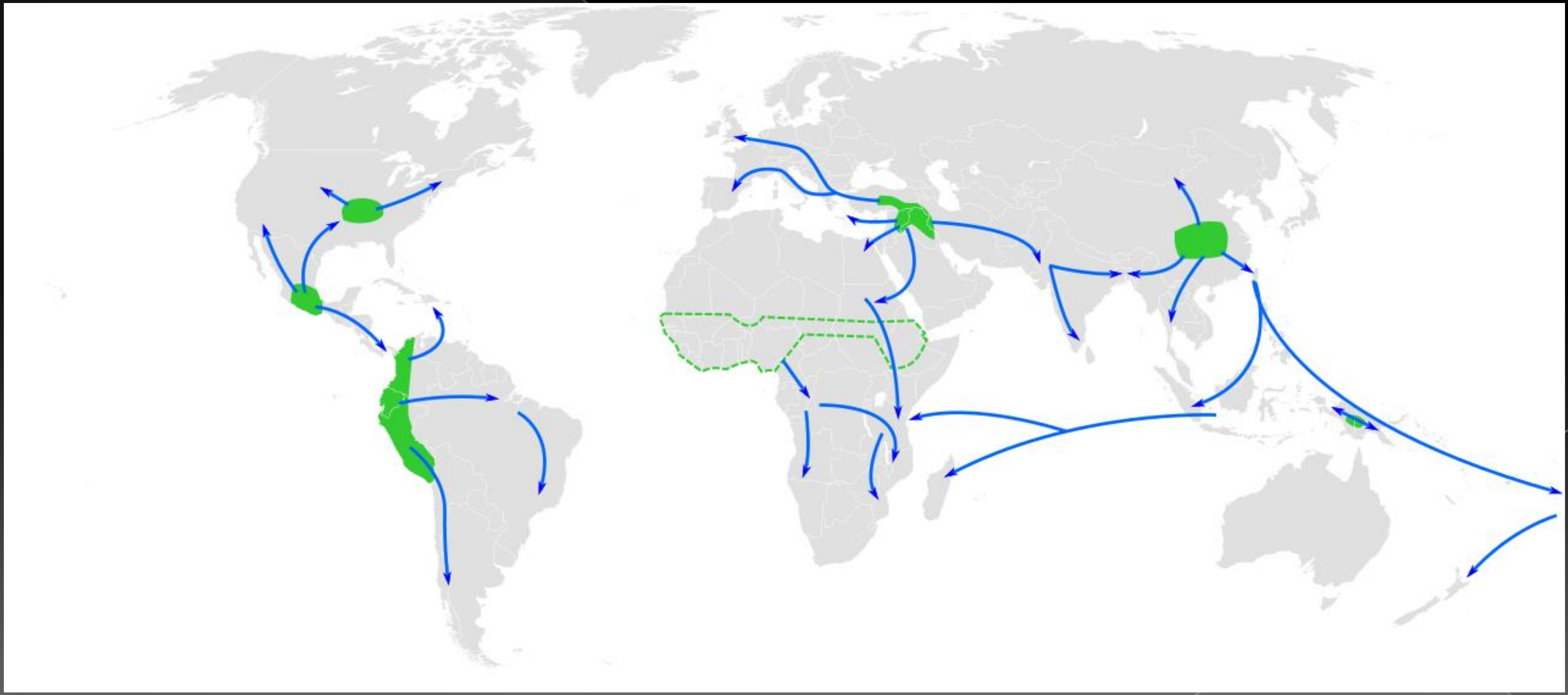
A Vavilov Center (of Diversity) is a region of the world first indicated by Nicolai Vavilov to be an original center for the domestication of plants. For crop plants, Nicolai Vavilov identified differing numbers of centers: three in 1924, five in 1926, six in 1929, seven in 1931, eight in 1935 and reduced to seven again in 1940.



Vavilov centers of origin: (1) Mexico-Guatemala, (2) Peru-Ecuador-Bolivia, (2A) Southern Chile, (2B) Paraguay-Southern Brazil, (3) Mediterranean, (4) Middle East, (5) Ethiopia, (6) Central Asia, (7) Indo-Burma, (7A) Siam-Malaya-Java, (8) China and Korea.

Later in 1935 Vavilov divided the centers into 12, giving the following list:

1. Chinese center 2. Indian center 3. Indo-Malayan center 4. Central Asiatic center 5. Persian center 6. Mediterranean center 7. Abyssinian center 8. South American center 9. Central American centeR 10. Chilean center 11. Brazilian-Paraguayan center 12. North American center



For the purpose of establishing the centers of type-formation or the centers of diversity the 'differential phyto-geographical method' was applied (Vavilov 1935). It can be described by the following steps:

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1935). It can be described by

1. A strict differentiation of the plants studied into Linnaean species and intraspecific groups by all available means of various disciplines beginning with morphology, agrobotany, phytopathology, cytology and recently by molecular methods.

2. Delimitation of the distribution areas of these plants and, if possible, also of the distribution areas in the remote past when communication and seed exchange were more difficult than at present.

3. A detailed determination of the composition of the varieties and races of each species, and a general system of the genetic variability within the different species.

4. Establishment of the distribution of the genetic variability of the forms of a given species as far as regions and areas are concerned, and the establishment of the geographical centers where these varieties are now accumulated. Regions of maximum diversity, usually also including a number of endemic types and characteristics, can also be centers of type-formation.

5. For a more exact definition of the center of origin and type-formation it is necessary to establish the geographical centers of concentrations of species that are botanically closely related as well.

6. Finally, the establishment of the areas of diversity of wild subspecies and species that are closely related to the cultivated species in question should be used for amendment and addition to the area defined as area of origin, when the differential method for studying races is applied to them.

Center	Plants
1) South Mexican and Central American Center	Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica. • **Grains and Legumes:** maize, common bean, lima bean, tepary bean, jack bean, grain amaranth • **Melon Plants:** malabar gourd, winter pumpkin, chayote • **Fiber Plants:** upland cotton, bourbon cotton, henequen (sisal) • **Miscellaneous:** sweetpotato, arrowroot, pepper, papaya, guava, cashew, wild black cherry, chochenial, cherry tomato, cacao.
2) South American Center	62 plants listed; three subcenters ***2) Peruvian, Ecuadorean, Bolivian Center:*** • **Root Tubers:** Andean potato, Other endemic cultivated potato species. Fourteen or more species with chromosome numbers varying from 24 to 60, Edible nasturtium • **Grains and Legumes:** starchy maize, lima bean, common bean • **Root Tubers:** edible canna, potato • **Vegetable Crops:** pepino, tomato, ground cherry, pumpkin, pepper • **Fiber Plants:** Egyptian cotton • **Fruit and Miscellaneous:** cocoa, passion flower, guava, heilborn, quinine tree, tobacco, cherimoya, coca ***2A) Chiloe Center*** (Island near the coast of southern Chile) • Common potato (48 chromosomes), Chilean strawberry ***2B) Brazilian-Paraguayan Center*** • manioc, peanut, rubber tree, pineapple, Brazil nut, cashew, Erva-mate, purple granadilla.

3) Mediterranean Center	Includes the borders of the Mediterranean Sea. 84 listed plants • **Cereals and Legumes:** durum wheat, emmer, Polish wheat, spelt, Mediterranean oats, sand oats, canarygrass, grass pea, pea, lupine • **Forage Plants:** Egyptian clover, white clover, crimson clover, serradella • **Oil and Fiber Plants:** flax, rape, black mustard, olive • **Vegetables:** garden beet, cabbage, turnip, lettuce, asparagus, celery, chicory, parsnip, rhubarb, • **Ethereal Oil and Spice Plants:** caraway, anise, thyme, peppermint, sage, hop.
4) Middle East	Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan. 83 species • **Grains and Legumes:** einkorn wheat, durum wheat, poulard wheat, common wheat, oriental wheat, Persian wheat, two-row barley, rye, Mediterranean oats, common oats, lentil, lupine • **Forage Plants:** alfalfa, Persian clover, fenugreek, vetch, hairy vetch • **Fruits:** fig, pomegranate, apple, pear, quince, cherry, hawthorn.
5) Ethiopia	Includes Abyssinia, Eritrea, and part of Somalia. 38 species listed; rich in wheat and barley. • **Grains and Legumes:** Abyssinian hard wheat, poulard wheat, emmer, Polish wheat, barley, grain sorghum, pearl millet, African millet, cowpea, flax, teff • **Miscellaneous:** sesame, castor bean, garden cress, coffee, okra, myrrh, indigo, enset.
6) Central Asiatic Center	Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tadjikistan, Uzbekistan, and western Tian-Shan. 43 plants • **Grains and Legumes:** common wheat, club wheat, shot wheat, peas, lentil, horse bean, chickpea, mung bean, mustard, flax, sesame • **Fiber Plants:** hemp, cotton • **Vegetables:** onion, garlic, spinach, carrot • **Fruits:** pistacio, pear, almond, grape, apple.

7) Indian Center	Two subcenters ***7) Indo-Burma:*** Main Center (India): Includes Assam, Bangladesh and Burma, but not Northwest India, Punjab, nor Northwest Frontier Provinces, 117 plants • Cereals and Legumes: chickpea, pigeon pea, urd bean, mung bean, rice bean, cowpea, • Vegetables and Tubers: eggplant, cucumber, radish, taro, yam • Fruits: mango, tangerine, citron, tamarind • Sugar, Oil, and Fiber Plants: sugar cane, coconut palm, sesame, safflower, tree cotton, oriental cotton, jute, crotalaria, kenaf • Spices, Stimulants, Dyes, and Miscellaneous: hemp, black pepper, gum arabic, sandalwood, indigo, cinnamon tree, croton, bamboo, turmeric, ***7A) Siam-Malaya-Java:*** statt Indo-Malayan Center: Includes Indo-China and the Malay Archipelago, 55 plants • Cereals and Legumes: Job's tears, velvet bean • Fruits: pummelo, banana, breadfruit, mangosteen • Oil, Sugar, Spice, and Fiber Plants: candlenut, coconut palm, sugarcane, clove, nutmeg, black pepper, manila hemp.
8) Chinese Center	A total of 136 endemic plants are listed in the largest independent center • **Cereals and Legumes:** e.g. rice[9] broomcorn millet, Italian millet, Japanese barnyard millet, sorghum, buckwheat, hull-less barley, soybean, Adzuki bean, velvet bean • **Roots, Tubers, and Vegetables:** e.g. Chinese yam, radish, Chinese cabbage, onion, cucumber • **Fruits and Nuts:** e.g. pear, Chinese apple, peach, apricot, cherry, walnut, litchi, orange • **Sugar, Drug, and Fiber Plants:** e.g.sugar cane, opium poppy, ginseng camphor, hemp.

CROP DOMESTICATION AND LOSS OF GENETIC DIVERSITY

The process of plant domestication has been aptly described as a continuum of increasing codependence between plants and people

Domestication is a complex evolutionary process in which human activities lead domesticated crops to phenotypically and genetically diverge from their wild ancestors (Michael and Dorian, 2009. Recent plant domestication by human beings began about 12,000 years ago, when our ancestors domesticated the main food, fruit, and ornamental crops in current human society (Rachel et al., 2012; Rachel and Michael, 2013).

The Rosaceae family includes numerous perennial woody fleshy fruits apple (*Malus pumila* Mill.), pear (*Pyrus communis* L.), peach (*Amygdalus persica* L.), apricot (*Armeniaca vulgaris* Lam.), and plum (*Prunus salicina* Lindl.)] that have an extraordinary range of variations in the sizes and shapes of fleshy fruits and seeds due to human domestication efforts (Joseph, 2017; Xiang et al., 2017). Therefore, the fruit crops of Rosaceae family are excellent materials for investigating the domestication history and phenotypic divergences of perennial woody fruit trees.

Domesticated plant species are found in 160 taxonomic families. Approximately 2500 species have undergone some degree of domestication, and 250 species are considered to be fully domesticated.

The evolutionary trajectory from wild to crop species is a complex process. Archaeological records suggest that there was a period of pre-domestication cultivation while humans first began the deliberate planting of wild stands that had favorable traits. Later crops likely diversified as they were grown in new areas, sometimes beyond the climatic niche of their wild relatives.

These processes led to the so-called domestication syndrome, that is, a group of traits that can arise through human preferences for ease of harvest and growth advantages under human propagation.

Domestication implies the action of selective sweeps on standing genetic variation, as well as new genetic variation introduced via mutation or introgression.

Furthermore, genetic bottlenecks during domestication or during founding events as crops moved away from their centers of origin may have further altered gene pools.

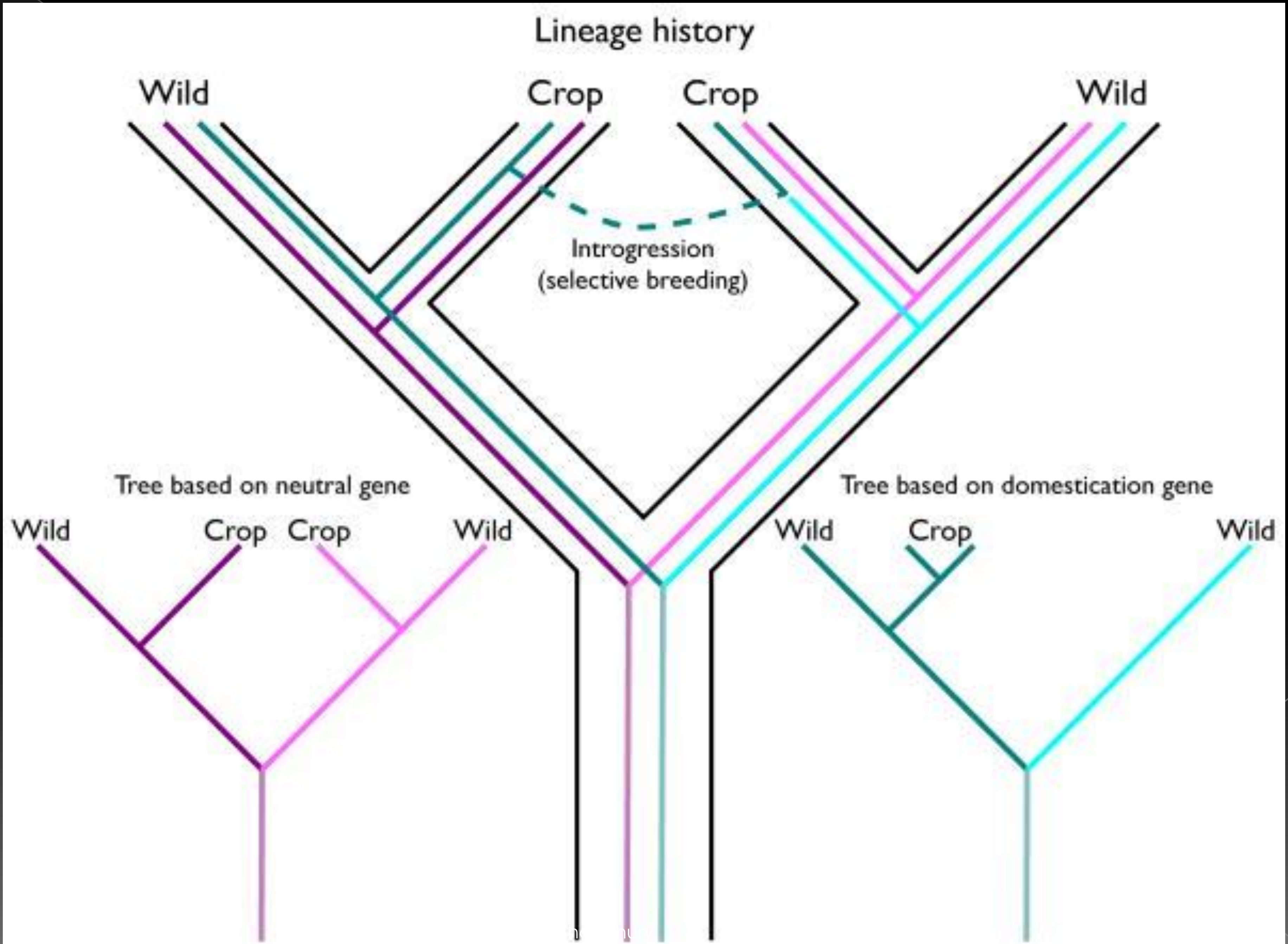
After domestication, only favorable haplotypes are retained around selected genes, which creates a valley with extremely low genetic diversity. These ‘selective sweeps’ can allow mildly deleterious alleles to come to fixation, and may create a genetic load in the cultivated gene pool.

MANIFESTATION OF PHENOTYPE IN CROP DOMESTICATION

- Domestic species usually undergo dramatic phenotypic and physiological changes in response to strong artificial selection.
- Usually show lower adaptability to their original harsh wild environments and even acquire "domestication syndrome",
- Loss of dormancy, loss of seed shattering, and increased fruit or grain size in plants and less aggression.

It has been postulated that mutations in a few loci might have contributed to major domestication traits. Genome-wide scans for signatures of artificial selection further indicated that a small percentage of genes were affected during domestication, such as 2~4% of genes in maize and 6.67% of genes in soybean, and revealed that domestic species usually showed decreased genetic diversitY and increased linkage disequilibrium compared with its wild relatives.

Gene	Crop	Trait	Causative change	Classification	Sel'n[a]	Prevalence	Refs
Domestication genes							
Vrs1 (*six-rowed spike 1*)	Barley	Inflorescence structure	Premature stop (insertion, deletion, or AA change)	Domestication	N.T.	Subset of domesticates	[92]
tb1 (*teosinte branched1*)	Maize	Plant and inflorescence structure	Regulatory change	Domestication	Yes	All domesticates	[16,93]
tga1 (*teosinte glume architecture 1*)	Maize	Seed casing	AA change	Domestication	Yes	All domesticates	[94]
sh4 (QTL 4 responsible for the reduction of grain shattering)	Rice	Shattering	Regulatory and AA change	Domestication	Yes	All domesticates	[69,71]
PROG1 (*PROSTRATE GROWTH 1*)	Rice	Plant structure	AA change	Domestication	Yes[b]	All domesticates	[18,19]
qSH1 (QTL for seed	Rice	Shattering	Regulatory	Domestication	No	Subset of	[70,71]



Lineage history
Wild
Crop
Crop
Wild
Introgression
(selective breeding)
Tree based on neutral gene
Wild
Crop
Crop
Wild
Tree based on domestication gene
Wild
Crop
Wild

EVOLUTION OF NEW CROP/VARIETY

Three genetic factors or forces, viz:
(1) Polyploidy,

(2) Introgression, and

(3) Mutations have played significant role in the evolution of various crop plants.

These three factors aid in the process of evolution by way of inducing additional genetic variability, which is a basic requirement for selection to operate.

Hybrid polyploidy has played significant role in the evolution of crops like wheat, tobacco, cotton, Brassica, oat, etc. Examples of artificially produced allopolyploids include triticale, strawberry and loganberry.

1. **Evolution of Bread Wheat:**

Wheat is a cereal crop of global importance. It belongs to the genus Triticum of the family Poaceae (old Gramineae). There are three types of species in the genus Triticum, viz., diploid, tetraploid and hexaploid. The somatic chromosome number of these species is 14, 28 and 42, respectively. Bread wheat (Triticumaestivum) is the predominantly cultivated species, which belongs to the hexaploid group. Other cultivated species are T. monococcum in diploid group and T. turgidum in tetraploid group.

TABLE 39.1. Different species of the genus Triticum (Sears, 1974)

Common name and ploidy	*Species*	*2n number*	*Genome symbol*	*Remarks*
Einkorn-Diploid [2N = 2X]	**Triticum monococcum**	14	AA	Cultivated
	Unknown species	14	BB	Wild
	Triticum dichasians	14	CC	Wild
	Triticum tauschii	14	DD	Wild
Emmer/Durum Tetraploid [2n = 4x]	**Triticum turgidum**	28	AABB	Cultivated
	Triticum timopheevii	28	AAGG	Wild
Bread/ClubWheat Hexaploid [2n = 6x]	**Triticum aestivum**	42	AABBDD	Cultivated

Parents	*Triticum monococcum*		×	Unknown species	
Genome	AA [2n = 14]		↓	BB	[2n = 14]
F_1		Sterile	AB [2n = 14]		
			↓		
Chromosome doubling		Fertile	AABB [24 = 28]		
			Triticum turgidum		
Parents	*Triticum turgidum*		×	*Triticum tauschii*	
Genome	AABB [2n = 28]		↓	DD [2n =14]	
F_1		Sterile	ABD [2n = 21]		
			↓		
Chromosome doubling		Fertile	AABBDD [2n = 42]		
			Triticum aestivum		

Fig. 39.1. Probable origin of hexaploid bread wheat (**Triticum aestivum**).

2. Evolution of Upland Cotton:

Cotton is one of the major fibre crops of global importance. It is grown in more than sixty countries in the world. Cotton belongs to the genus Gossypium of the family Malvaceae. There are about 50 species in the genus Gossypium. Some of them are diploid [2n = 26] and some tetraploid [2n = 52], Out of 50 species, only four species are cultivated, viz., G. arboreum, G. herbaceum, G. hirsutum and G. barbadense (Table 39.2).

TABLE 39.2. Some important species of Gossypium

Common name and ploidy	*Species*	*2n number*	*Genome symbol*	*Remarks*
Asian Diploid	Gossypium arboreum	26	AA	Cultivated
	Gossypium herbaceum	26	AA	Cultivated
African Diploid	Gossypium africanum	26	AA	Wild
American Diploid	Gossypium thurberi	26	DD	Wild
	Gossypium raimondii	26	DD	Wild
Upland Tetraploid	Gossypium hirsutum	52	AADD	Cultivated
Egyptian Tetraploid	Gossypium barbadense	52	AADD	Cultivated

Parents	G. africanum	×	G. raimondii
Genome	AA [n = 13, large]	$\downarrow$	DD [n = 13, small]
F_1	Sterile	$\downarrow$	AD [2n = 26]
Chromosome doubling	Fertile		AADD [2n = 52]
			Like G. hirsutum

Fig. 39.2b. Probable origin of **G. hirsutum** as proposed by Phillips (1963)

3. Evolution of Tobacco:

Tobacco is a narcotic plant which belongs to the genus Nicotiana in the family Solanaceae. It is a native of America, but now it is grown in all the countries of South and South-East Asia. There are two cultivated species of tobacco, viz., Nicotiana tabacum and N. rustica. Both these species are tetraploid (2n = 48). The wild species are diploids.

TABLE 39.3. Some important species of the genus Nicotiana

Name of species	*2n number*	*Ploidy level*	*Remarks*
Nicotiana sylvestris	24	Diploid	Wild
Nicotiana tomentosa	24	Diploid	Wild
Nicotiana paniculata	24	Diploid	Wild
Nicotiana undulata	24	Diploid	Wild
Nicotiana tabacum	48	Tetraploid	Cultivated
Nicotiana rustica	48	Tetraploid	Cultivated

(*a*)	Parents	*N. sylvestris*	×	*N. tomentosa*
	Chromosome	[n = 12]	↓	[n = 12]
	F_1		Sterile [2n = 24] ↓	
	Chromosome doubling		Fertile [4n = 48] *N. tabacum*	
(*b*)	Parents	*N. paniculata*	×	*N. undulata*
	Chromosome	[n = 12]	↓	[n = 12]
	F_1	Sterile	[2n = 24] ↓	
	Chromosome doubling	Fertile	[4n = 48]	N. rustica

Evolution of Potato:

Potato is an important vegetable crop of global importance. It belongs to the genus Solanum in the family Solanaceae. The commercially cultivated potato (Solanum tuberosum) is native of Central and South America from where it has spread to other parts of the world.

TABLE 39.5. Some tuber bearing species of the genus Solanum

Name of Species	*2n Number*	*Ploidy level*	*Remarks*
Solanum stenotomum	24	Diploid	Cultivated
Solanum sparsipilum	24	Diploid	Wild
Solanum tuberosum	48	Tetraploid	Cultivated

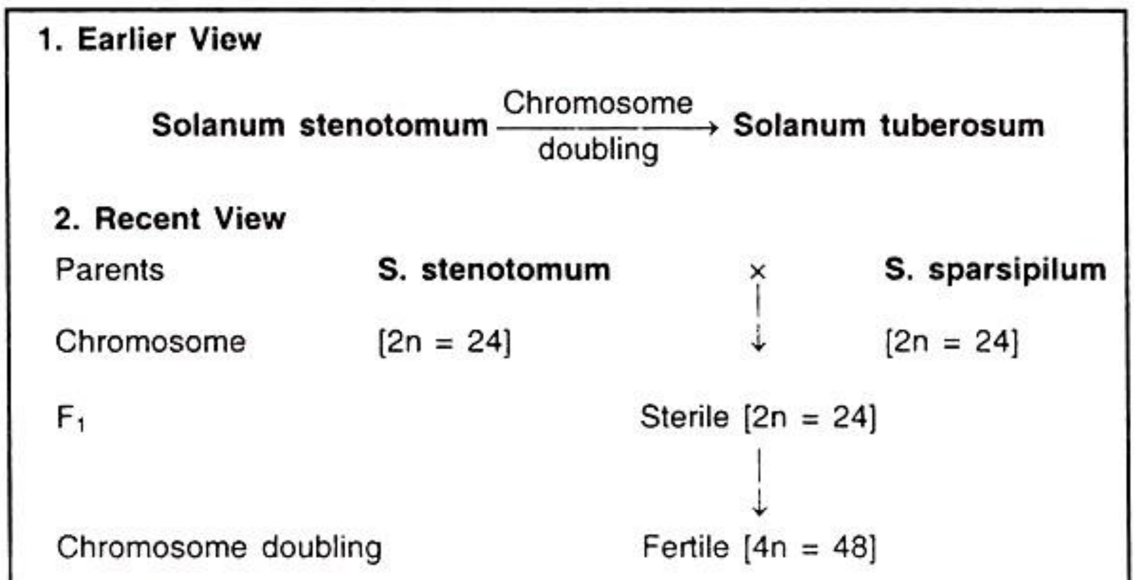


Fig. 39.5. Probable origin of cultivated tetraploid potato

Evolution of Maize:

Maize is a cereal crop of global importance. It belongs to the genus Zea of the family Poaceae (old gramineae). It is grown both for food and fooder purposes. Maize is native of America from where it has spread to other parts of the world. Maize (Zea mays) is the only species in the genus Zea. It has two close relatives, viz., Gamagrass (Tripsacum) and Teosinte (Euchlaena).

Evolution of Rice:

Rice is a staple food of global importance. It belongs to the genus Oryza in the family Poaceae (old Gramineae). It is grown in India and China from time immemorial. South and South-East tropical Asia is considered to be the native place of predominantly cultivated species of rice, Oryza sativa, because vast diversity of this species is found in this region.

Importance of Germplasm Diversity

Germplasm are living genetic resources such as seeds or tissues that are maintained for the purpose of plant breeding, preservation, and other research uses.

These resources may take the form of seed collections stored in seed banks, trees growing in nurseries or gene banks, etc.

Germplasm collections can range from collections of wild species to elite, domesticated breeding lines that have undergone extensive human selection. Germplasm collection is important for the maintenance of biological diversity and food security.

In today's world, there is significant pressure to improve agricultural production by developing food crops that can not only adapt to environmental changes, but also meet the growing food demands of a constantly increasing population.

Germplasm, specifically plant genetic resources for food and agriculture, are the living material used by local communities, researchers, and breeders to adapt food and agricultural production to changing needs.

Many crops that are grown across multiple regions have limited genetic diversity due to bottlenecks from domestication, selective breeding and in some taxa, natural processes. Recurrent selection of improved cultivars over multiple generations results in an increasingly narrow genetic base for a crop, making it more vulnerable to disease and limiting its adaptability.

Importance and effort to conserve germplasm diversity:

- ❖ In order to make more efficient use of wild relatives, we need improved classifications of their relationship to crop material and to other wild species.
- ❖ Characterizing patterns of diversity within the secondary and tertiary gene pools can provide insight into which subdivisions of germplasm collections contain wild material that is most likely to increase diversity and can guide the use of wild material in breeding efforts.
- ❖ It remains a chief reservoir for many disease and abiotic stress resistance traits. Effective characterization of wild material can facilitate its more effective use.

Genetic diversity is needed to safeguard potentially vital traits that could be used to combat an unexpected future pest or adapt to the needs of the world's food supply. Plant breeders utilize genetic diversity to create improved crop varieties with traits such as yield, pest resistance and environment stress.