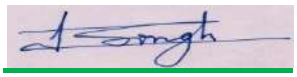

Subject: **Botany**
Class: BSc. IV-Se**m.**
Topic: Domestication, Centers of Origin
Name: **Dr. Ajai Kumar Singh,**
Associate Professor,
Department of **BOTANY,**
Faculty of: **Science,**
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E-mail: ajaiupcollege@gmail.com

DOMESTICATION OF CROP PLANTS AND CENTRE OF ORIGIN

Domestication

A plant is said to be domesticated when its native characteristics are altered such that it cannot grow and reproduce without human intervention. Domestication is thought to be the result of the development of a symbiotic relationship between the plants and humans, called co-evolution, because plants and human behaviors evolve to suit one another. In the simplest form of co-evolution, a human harvests a given plant selectively, based on the preferred characteristics, such as the largest fruits, and uses the seeds from the largest fruits to plant the next year.

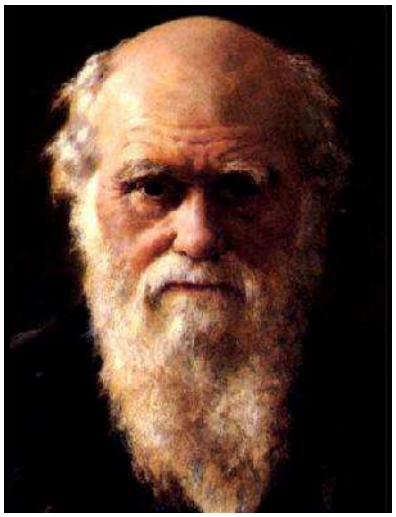
Agriculture and Man

Man's interest in agriculture started about 10,000 years ago with transition from 'gathering' to 'growing' of plants occurred. In this process, a wide array of crop variability got generated by natural means and through both conscious or unconscious selection. Historically, man has used only about 5,000 plant species worldwide to meet food and other needs. This number is just a fraction of the total world flora. With population growth, we are increasingly dependent on most productive plants. Today, only about 150 plant species are important in meeting the food (calories) needs of humans worldwide.

Rubbish-Heap hypothesis for the Origin of Agriculture

It says that early humans gathered nutritious roots and seeds for their food. Such plants actively colonized the bare areas around their dwellings, which were rich with the discarded rubbish. This natural process was obviously based on man's known food gathering activities and selection of only those useful plants which he found most suitable in tune with local habitats. Rubbish-Heap hypothesis for the origin of agriculture.

Darwin’s theory of the origin of species.



Charles Darwin was the first scientist to convincingly and comprehensively propose that all organisms descend from earlier forms of organisms that have been modified during the course of evolution (Darwin, 1859).
Groups of similar organisms would descend from a common ancestor, and tracing this evolution could bring us to the origin of species.
The most important factors determining the course of evolution were the variation in organisms and natural selection, i.e. that well-adapted organisms would propagate more, less adapted ones would tend to go under, and that offspring were able to reproduce themselves.

Stages of crop domestication

- First stage the pre-adapted wild plants with weedy tendencies and large reserves of food began to colonize the open ground around man's house. Probably seeds were dropped accidentally near the house from the natural habitats.
- Second stage Seeds were regularly harvested as food from the open ground around man's house, and fenced to protect them from domesticated cattle and other herbivores. At this stage, the man also select mutants for increased yields, palatability and other desirable traits.
- Third stage Man learnt sowing of seeds at the right time with understanding of plant for required husbandry upto harvesting.

ALPHONSE DE CANDOLLE

Renowned Swiss botanist, son of a famous botanist, Augustin-Pyramus de Candolle (1778-1841), born in Paris took over his father's botanic garden with a vast collection. de Candolle

write a massive tome on plant geography that assumed the derivation of each species from a specially created individual. Alphonse de Candolle, in his 1882 book Origine de Plantes Cultivées, was among the first to indicate regions where plant domestication may have taken place: China, Southwest Asia including Egypt, and Tropical Asia.

Dynamics of Plant Domestication

- Domestication is an evolutionary process operating under the influence of human activities. it is a slow process.
- It exhibits gradual progression from the wild state to a state of incipient domestication.
- Diverse forms that differ more and more from their progenitors develop.

- Cultivation practices adopted had a significant role in the domestication process as the cultivated field presenting a different environment from the wild habitat.

- The crop evolutionary process obviously includes changes as affected by changed environment of a cultivated field.
- The selection pressure associated with cultivation practices also results in production of weedy races.
- Cross compatibility between the cultivated and wild leads to a more potential variability. This is one remarkably elegant evolutionary process wherein barriers to gene flow maintain identity of the two types and, at the same time, limited exchange of genes releases variability.

➢ Weed plants, which are competitive with cultivated races but retain some important characters of the wild races

Factors operate in the selection process during domestication

❖ Selection of desirable traits by the cultivator while sowing
❖ Changed micro-environment through cultivation practices
❖ Differentiation - hybridization cycles between crop-weed pairs and man's selection from them.
❖ So the dynamics of domestication has resulted in great morphological changes without substantial change in the genetic background.
❖ However, speciation rarely occurs under domestication.
❖ Under domestication, modifications induced ultimately lead to the end products which are generally radically different in appearance from their wild progenitors.

The possible changes in plant species due to Domestication

➢ **Reduction/loss**
o Shattering Seed dormancy,
o Seed viability Protective coverings
o Sturdiness
o Photoperiodic response

- Number of seeds Resistance to abiotic stresses

➢ **Increase/improvement**

- Adaptability size of fruits Size of seeds,
- Palatability,
- Chemical composition,
- Susceptibility to biotic stresses,
- Yielding ability,
- Different/specific ecological preference
- Uniformly flowering and maturity Change from a perennial to annual habit,
- Change in mode of pollination cross to self pollination,
- Developing of seedless fruits

Chronological Domestication of Field Crops

Plant	Location of Domestication	Date
Rice	East Asia	9000 BC
Barley	Near East	8500 BC
Bread wheat	Near East	6000 BC
Einkorn wheat	Near East	8500 BC
Emmer wheat	Near East	8500 BC
Sorghum	Africa	2000 BC
Pearl millet	Africa	1800 BC
Chick pea	Anatolia	8500 BC
Maize	Central America	7000 BC
Cotton	Southwest Asia	5000 BC
Cotton	-do-	4000 BC
Sunflower	Central America	2600 BC

To answer following questions on the domestication of plants, Vavilov proposed the theory for Centre of Origin of the plant

- Where was the beginnings of agriculture to be sought?
- Were they independent in different regions, in different continents?
- How is the geographical localization of primitive agriculture to be explained?
- Which plants were first brought into cultivation?
- Where shall we find the primary sources of cultivated plants?
- How are modern domesticated held cultivated plants connected with their wild related types?
- How did the evolution of cultivated plants proceed?
- How are primary agricultural civilizations connected?
- Which implements were used by primitive agriculturists in different regions?

.....

Nikolai Ivanovich Vavilov (1887-1943)

- **The Outstanding Gene Hunter and Investigator of Plant Genetic Resources.**
- **One of the most outstanding Russian scientists of the twentieth century.**
- **An Agronomist Specialization in Plant Genetic Resources & Evolution**

OBJECTIVES

The vigorous, worldwide plant exploration program was planned for genetic resource management to fulfill the following objectives:

- To collect and assemble all the useful germplasm of all the crops that had potential in the Soviet Union.
- To study and classify the material.
- To utilize it in a national plant breeding programme.

Vavilov's Expeditions in search of gene

- 1921-1934: 180 expeditions of the institute around the world including 65 countries, he himself visited 52 countries.
- Vavilov's collected the plant resources throughout the world with his original phyto-geographic method.
- His know-how was the basis to determine where to go.

Vavilov Expedition Route

Collection of germplasm

Before the Second World War the collections of All-Union Institute of Plant Industry numbered

- ✓ Over 36,000 accessions of wheat

- ✓ Over 10,000 of maize
- ✓ Over 23,000 of legumes
- ✓ Around 18,000 of vegetables
- ✓ Over 12,000 of fruit and small fruit crops
- ✓ Over 23,000 of forages.

The total of accessions reached 2,50,000 in the times of N.I. Vavilov.

All this rich diversity was thoroughly studied at experiment stations in different geographical zones of the country.

CENTRE OF ORIGIN (1926)

- o Plant domestication was not at random.
- o Specific regions for start of domestication.
- o These are the center of origin.
- o Presence of wild relative is the basis for centre of origin.
- o These are the reason where wild relatives of the plant showed maximum adaptiveness.

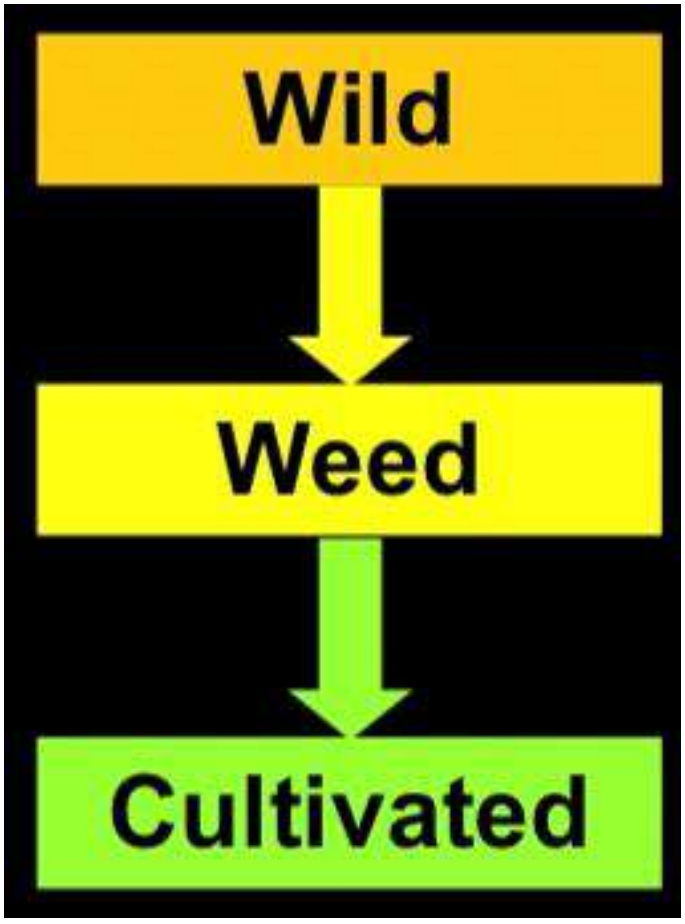
Primary Centre of Origin

All the cultivated species of the world have their origin in these primary centre of origin and later they spread to different places of cultivation.

Main features are: The number of wild species present,

- ➢ Diversity of wild species;
- ➢ Number of endemic species present;
- ➢ Sources of dominant genes

STEPS OF EVOLUTION



MUTATION? UV RADIATION?

Procedure adopted for determining the centre of origin

- ❖ Differentiating plants into specific and intra-specific taxa on morphological and genetic basis.
- ❖ Determining the area of distribution of such species and groups of species.
- ❖ Establishing the distribution of genetic diversity and determining the geographical centres where this is at its maximum, especially those centres with endemic forms/characters.
- ❖ Correlating the above distribution/diversity with the areas of concentration of nearest wild relatives

The criteria for determining the centre of origin

- ➢ Comparing centres of origin of group of cultivated plants with certain specialized parasite.
- ➢ Support the above, seek linkages/evidences from archaeology, linguistics and history.
- ➢ In later stage, the presence of wild relatives was considered an essentiality in designating a centre as 'a centre of origin'.

PRIMARY CENTRE OF ORIGIN

- o The centre comprises of a small portion (2–3% of the land area) of the earth
- o These small portions are isolated by deserts or mountain ranges.
- o Early domesticate of wild, weedy and its related forms are present in these centres

ISOLATED AREAS ?

CONFIRMATION OF WILD RELATIVE AS ANCESTOR

- ✓ Taxonomic affinities from morphological comparisons
- ✓ Crossability estimates
- ✓ F1 fertility determination
- ✓ Chromosome pairing analysis
- ✓ Phylogenetic relationship between cultivated and weedy and wild forms
- ✓ Allozyme variation

CENTRE OF DIVERSITY

- The place with maximum amount of variability of a plant species without presence of wild relatives represents its centre of diversity.
- It was also considered as Secondary Centre of Origin
- Crop diversity – the variation between and within crops and between crops and wild relatives

Sources of Diversity

According to Vavilov diversity was primarily a function of spontaneous mutation.

- Over a long period of time it was accumulate through selection.
- Strong selection pressure
- Isolation
- Inbreeding

Centre of Diversity = Centre of Origin

Presence of both Wild relatives and Variability under the control of dominant genes.

Micro Centre of Origin

The exact centres were located in several comparatively small geographic areas on the globe, especially in the mountain areas of Asia, Africa, along the Mediterranean coast and in South, Central and North America.

Vavilov felt that the maximum amount of variability is present at the periphery and the maximum concentration of dominant gene in the form of wild relatives is present at the centre of the distribution. The concentration of the dominant gene decreased towards the periphery with the increase in concentration of recessive gene mainly due to strong selection pressure, Isolation and Inbreeding.

New and Old World

New World American Continent was designated as New World. The roots and tubers and tropical fruit trees are concentrated in the Central American and Andean centers.

NEW WORLD

American Continent was designated as New World. The roots and tubers and tropical fruit trees are concentrated in the Central American and Andean centers.

Old World

- Asia, Europe and Africa continent were designated as Old World.
- Almost one third of the world's species originated in Southeastern Asia.
- Species listed 533 from Old World, 107 from New World, Total 640

On the basis of analysis from hundred of thousands of collections,
Vavilov proposed eight primary centers

OLD WORLD

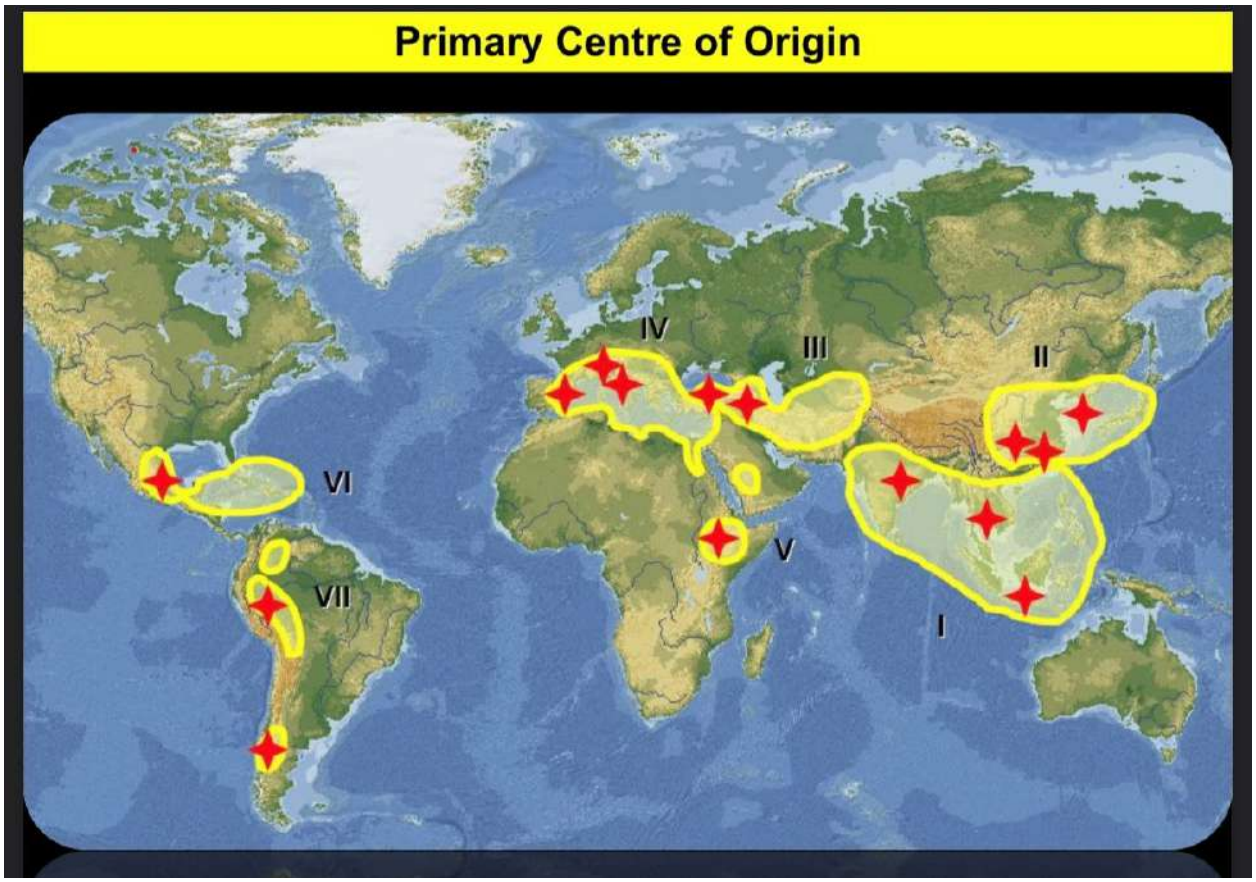
1.China Chinese cabbages, soybean
2. India
   2a. Indo - Burma Cucumbers, eggplant, pigeon pea
   2b. Siam Malaya- Java Coconut, rice, sugar cane
3. Central Asiatic Wheat, barley, oats, figs, pea, vetch
4. Near Eastern
5. Abyssinian
6. Mediterranean Almonds, cabbage, olives

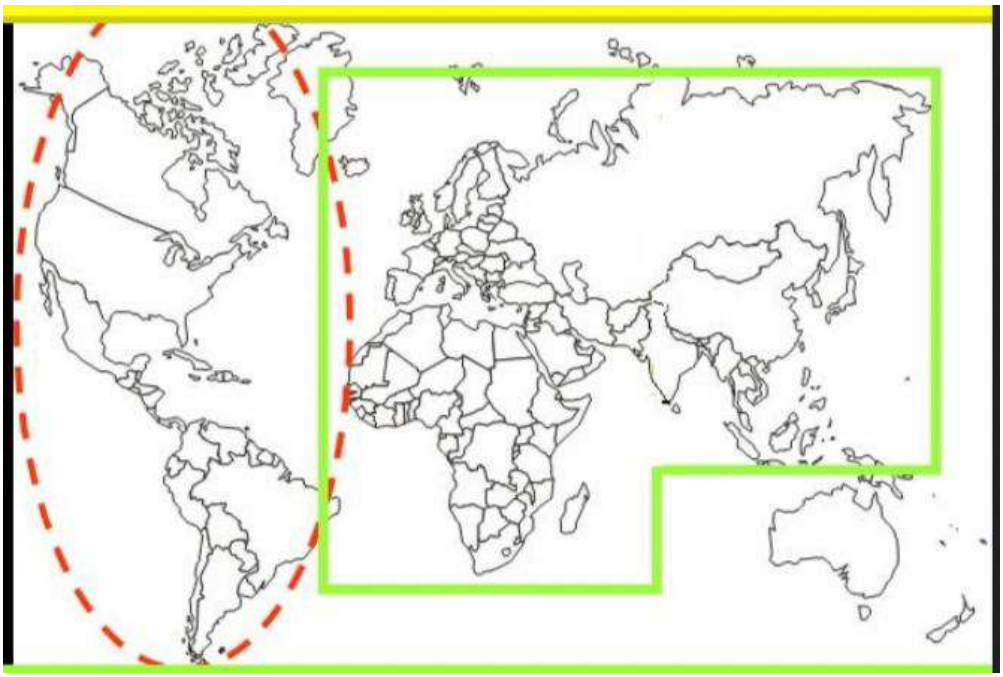
NEW WORLD

7. Central American (Mexico/Central America) - Maize, tomato
8. South American

8a. Peru, Ecuador, Bolivia Peppers, potato, rubber
8b. i. Chile
8b.ii. Brazil, Peraguan

VAVILOV died on 26th January, 1943





NEW WORLD & OLD WORLD

For many years his name was forbidden, His works were forgotten… But His wife and scientists, including foreign scientists, struggled for returning his honest name. Two years after death of Stalin, in 1955 posthumous rehabilitation came to Vavilov In 1968 the Institute was renamed after Vavilov.

Vavilov Institute of Plant Industry (VIR)

Its collection includes 320 000 accessions of cultivated plants and their wild relatives, 2539 botanical varieties of 304 species of 155 botanical families. Herbarium contains more than 250 000 specimens

More than 70% of commercial varieties of modern Russia have been bred using material from the VIR world collection.

In cereals, 95% of all cultivars bred in the recent period were based on germplasm stored in the collection of VIR.

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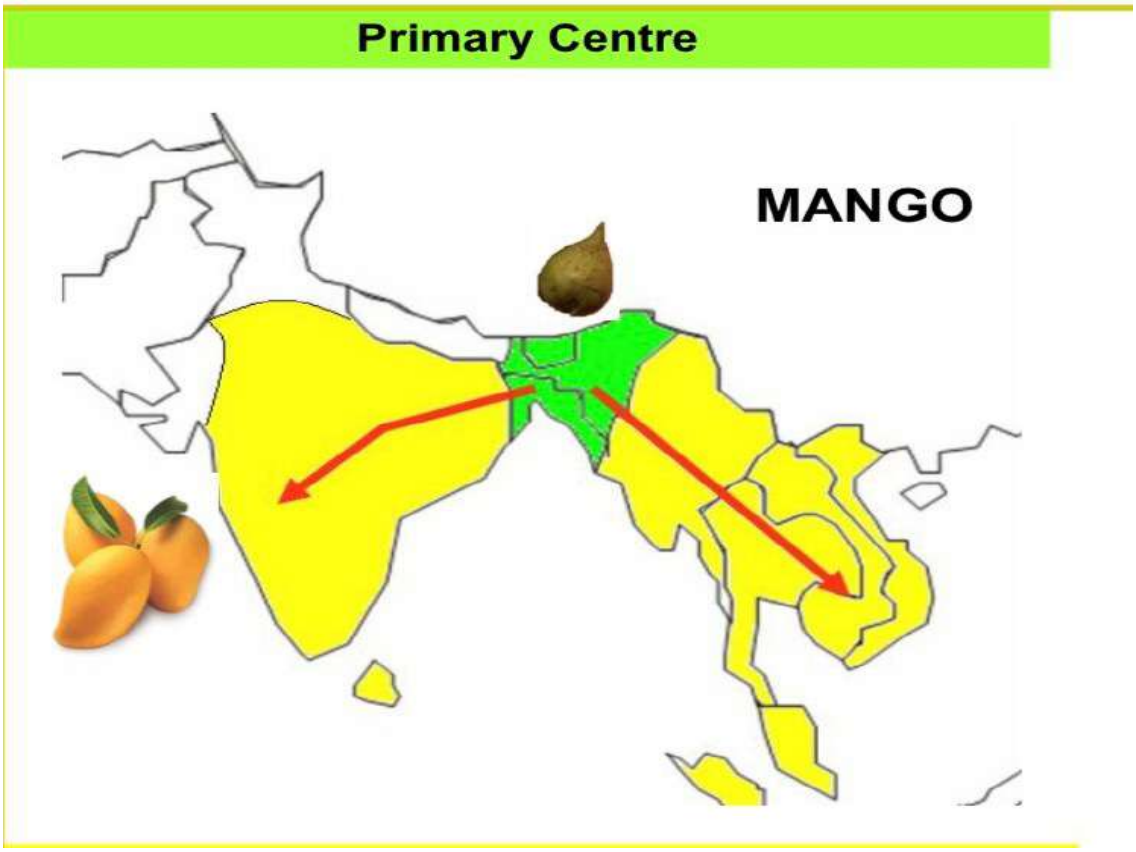
It is better to be extra economical now; than to expose to destruction everything, that had being created by nature during thousands and millions years…»----Vavilov



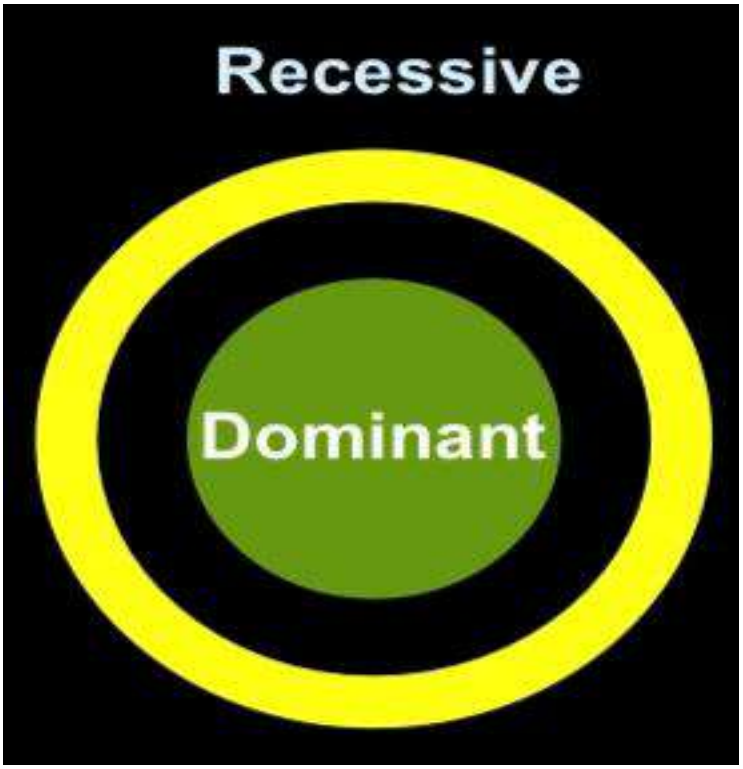
Secondary Centre of Origin

Primary Centre

Rubber

It was originated in Amazon river basin but maximum diversity in cultivated form exist in Malaya

Secondary Centre



Zhukovsky 1965, Mega gene centres

A close associate of Vavilov, proposed 12 megagene centres of crop-plant diversity.

The new areas added to Vavilov's eight were Australia, whole Africa and Siberia followed by revision of the boundaries to make 12 centres.

Microgene centres of wild growing species related to crop plants, were demarcated in the '**Dictionary of cultivated plants and their centres of diversity**', listed species for different megagene centres, and the range and extent of the distribution of genetic/varietal/specific diversity, etc.
Zhukovsky, P.M. 1965. Genetic and botanical irregularities in the evolution of cultivated plants. Genetika Mosc. 1. 41-49

Harlan, 1917-1998

Each crop may have been repeatedly domesticated at different times in different locations or may have been brought into cultivation in several regions simultaneously.

One cannot pin point a single center of origin.

Harlan developed the idea of **'Centre' and 'Non-Centre.**

According to him 'Centre' means places of agricultural origin and 'non-centre' where agriculture has been introduced.

Centre	Non-centre
B.1- North Chinese	**B.2- South-East Asian and South Pacific**
A.1- North East	**A.2-African**
C.1- Meso American	**C.2-South American**

Micro centre (Harlan, 1975)

Harlan also recognized smaller areas/pockets of varietal and/or racial diversity within a Vavilovian Centre, and he termed these as '**Micro centres'.**

Such small areas, as in Turkey and Africa (Harlan, 1975), contain varietal diversity of several crops in the plains and/or mountains.
-Harlan, J.R. 1975. Crops and man. American Society of Agronomy, Madison, Wisconsin. 295 p.

According to Hawkes (1983), Agriculture began not once but several times, more or less simultaneously and in different regions of the world.
He proposed the name **Nuclear centres** and regions of diversity for the centres of agricultural origin from which farming spread into one or more regions. Linked the nuclear centres with the archaeological evidence to provide strong proofs of agricultural origins.
-Hawkes,1983 Hawkes, J.G. 1983. The diversity of crop plants. Harvard University Press, Cambridge, Mass. 184 p.

Nuclear centres	Regions of diversity
A. Northern China	I. China II. India III. South-East Asia IV. Central Asia
B. The Near East	V. The NearEast VI.The Mediterranean VII. Ethiopia
C. Southern Mexico	VIII. West Africa IX. Meso-America
D. Central to Southern Peru	X. Northern Andes (Venezuela to Bolivia)

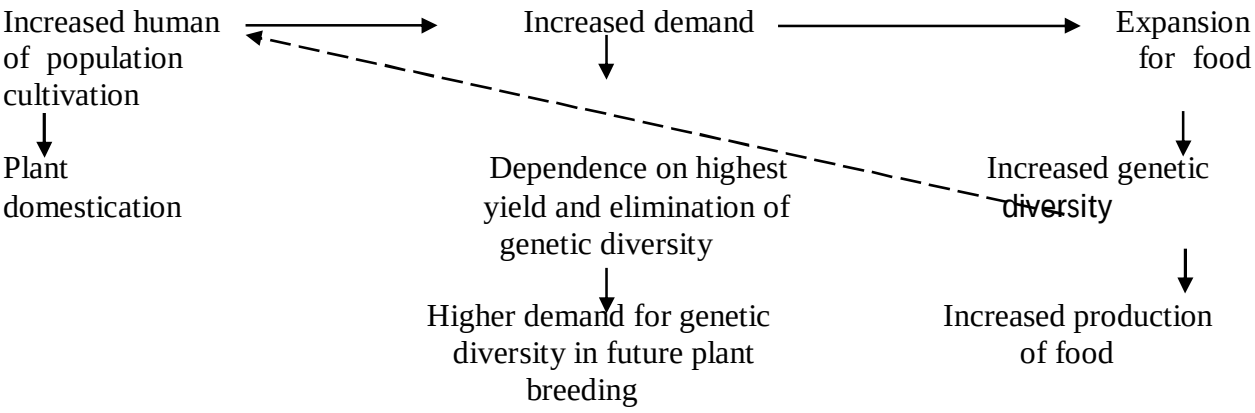
Wilkes, 1984

On the global scene, the human population has enormously increased such that we are held captive by our domesticated food plants, that is we are totally dependent on the high yields of these few selective cultivated plants.

By and large, a dependent, though viable relationship exists among plant domestication, genetic diversity and human population growth.

Wilkes, 1984 Wilkes, G. 1984. Germplasm conservation towards the year 2000. Potential for new crops and enhancement of present crops. In Plant genetic resources: a conservation imperative (Eds., C. Yeatman, D. Kefton and G. Wilkes). American Assoc. for the Advancement of Sciences. Washington D.C., USA.

Wilkes, 1984



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Threat to genetic diversity

Genetic erosion

- It is a gradual persistent loss of plant genetic diversity.
- The technological drawback of improved varieties is that they eliminate the resource upon which they are based.
- Over the past 10,000 years, crop plants have proliferated through an innumerable number of locally adapted genotypes.
- These landraces and folk varieties of indigenous agriculture are the genetic reservoir.
- The genetic diversity is replaced with a relatively small number of varieties bred for high input agriculture.
- The scarcity of land and agricultural practices resulting in the disappearance of habitat which harbour the wild progenitors and weedy forms of our basic food plants.

.....

Threat to (genetic diversity) Genetic vulnerability

- Genetic vulnerability is the use of a narrow genetic base.
- Development of varieties with wider adaptability and resistance against biotic and abiotic stresses with response to management leads to widespread monocultures.
- The narrowness of the genetic base is responsible for greater risk of crop failure.
- The Irish potato famine in the 1840s is a classic example of genetic vulnerability.

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MONOCULTURE- Dense, uniform stands of billions of plants covering thousands of acres, all genetically similar.

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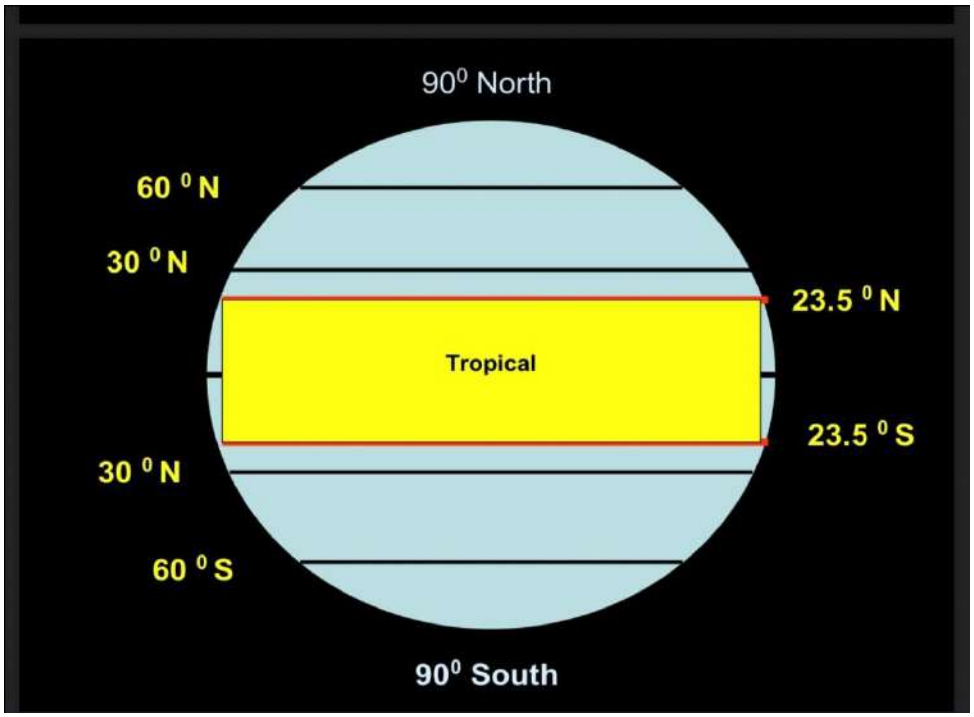
Threat to genetic diversity

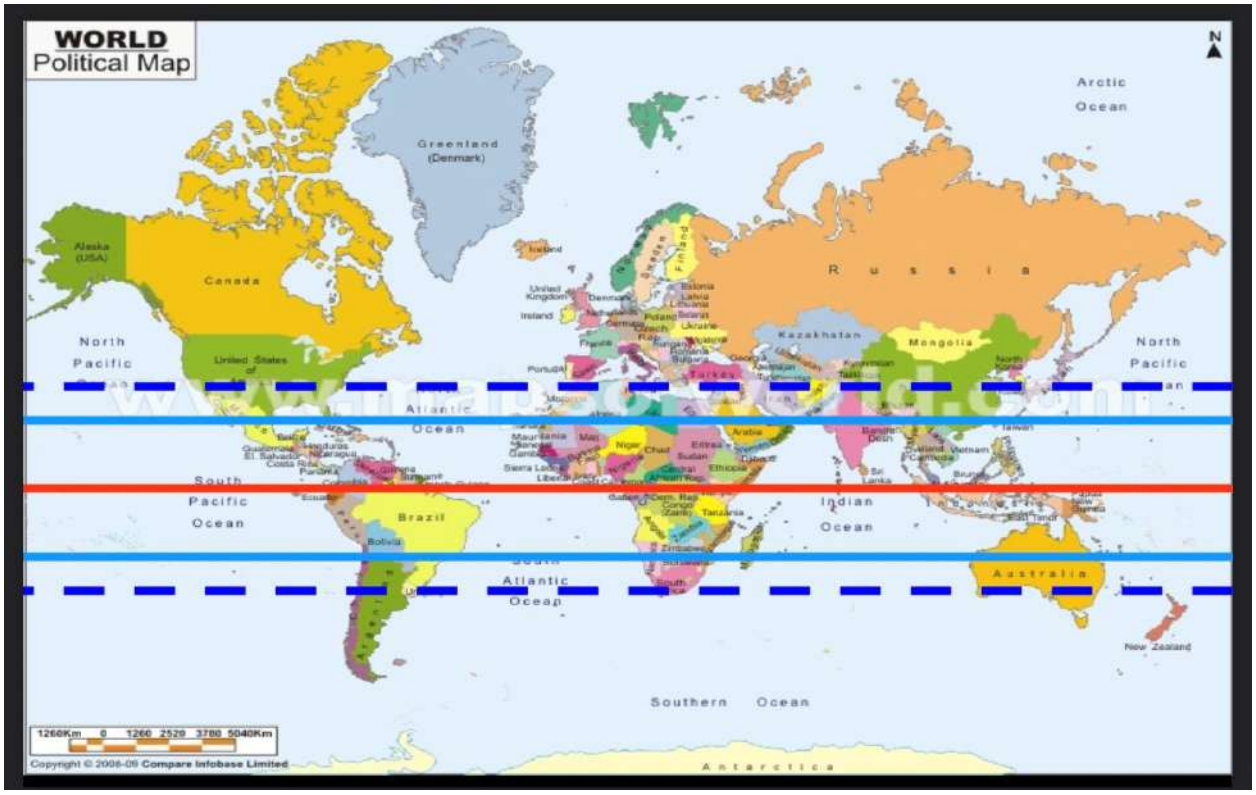
Genetic wipeout

- The rapid and wholesale destruction of a wealth of potential species constituting genetic resources.
- Social disruptions/instability can eliminate such promising diversity.

Quite literally, as Wilkes (1984) points out, the genetic heritage of a millennium in a particular valley can disappear in a single bowl of porridge if the seeds are cooked and eaten instead of saved as seed stock.

EQUALLY DRAMATIC IS THE DISCARDING OF A GENETIC COLLECTION BECAUSE OF THE RETIREMENT/TRANSFER OF CURATOR OR THE COLLECTION IS NO LONGER OF USE TO THE INSTITUTION.


90⁰ North
60 ⁰ N
30 ⁰ N
23.5 ⁰ N
Tropical
23.5 ⁰ S
30 ⁰ N
60 ⁰ S
90⁰ South


WORLD
Political Map
N
Arctic Ocean
Greenland (Denmark)
Alaska (USA)
Canada
R u s s i a
North Pacific
United States of
Kazakhstan
Mongolia
North Pacific
Atlantic Ocean
South Pacific Ocean
Brazil
Bolivia
Indian Ocean
Australia
New Zealand
Southern Ocean
Antarctica
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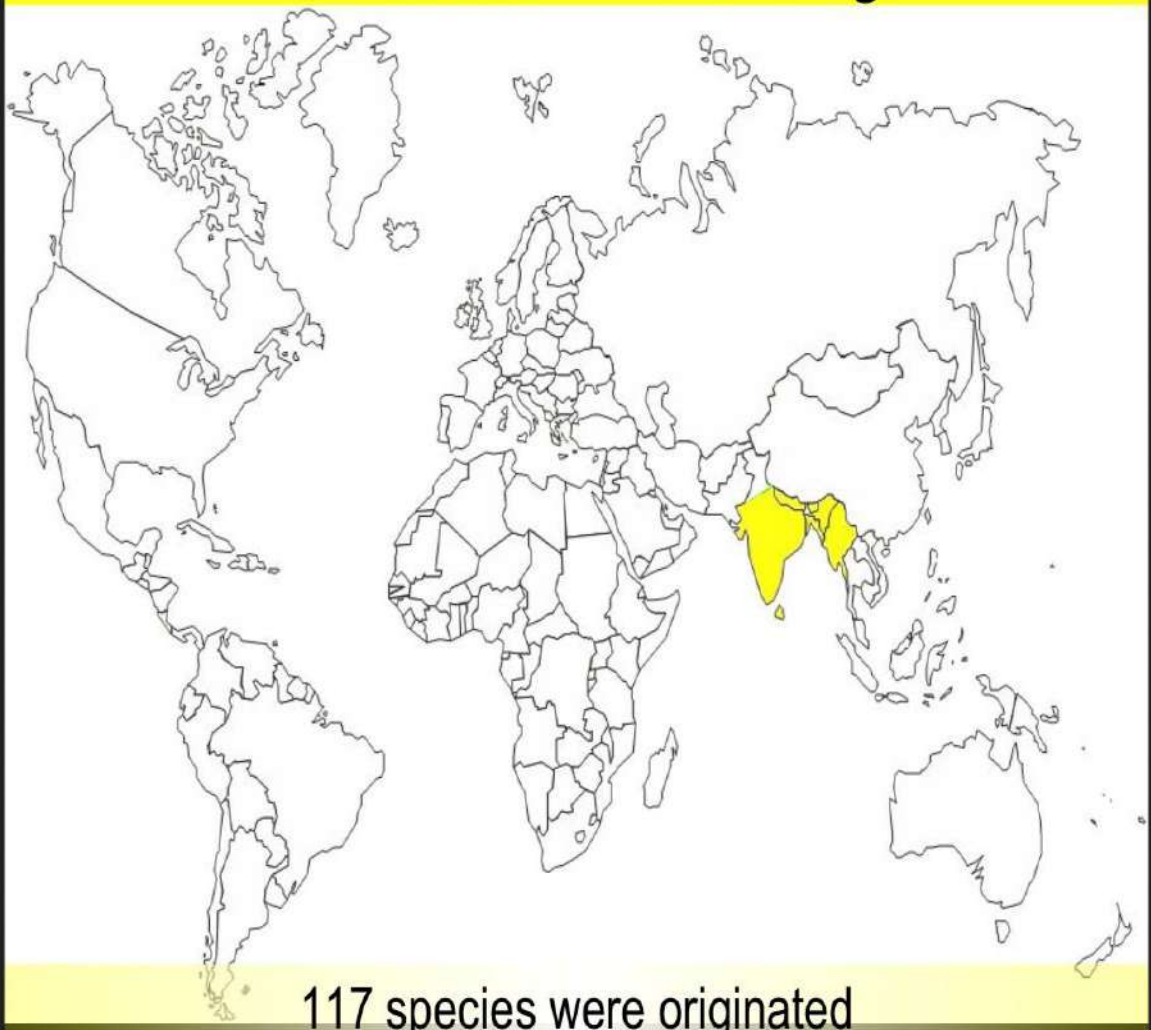
Indo-Burma Centre of Origin



117 species were originated

Indo-Burma Centre of Origin

Fruits	**Mango, orange, tangerine, citron, tamarind, banana, jamun (*Syzygium cumini*), jack fruit (*Artocarpus heterophyllus*), *Citrus* group - lime and others, karonda (*Carissa congesta*), khirni (*Manilkara hexandra*), phalsa (*Grewia sub-inaequalis/G. asiatica*), bael (*Aegle marmelos*), wood apple (*Feronia limonia*), kokam (*Garcinia indica*)**
Sugar	**Sugarcane**
Fiber Plants	**Tree cotton, oriental cotton, jute, kenaf, Sun hemp**
Oil	**Coconut, palm, sesame, safflower, Brassica**
Other	**Croton, bamboo,** betel leaf

Indo-Burma Centre of Origin

Kenaf
Hibiscus cannabinus

Taro
Colocasia esculenta
Family Araceae

Sweet potato
Ipomea batata
Dioscoreaceae

Gum Arabic
Acasia senegal

Rice bean
Vigna umbellata

Tangerine

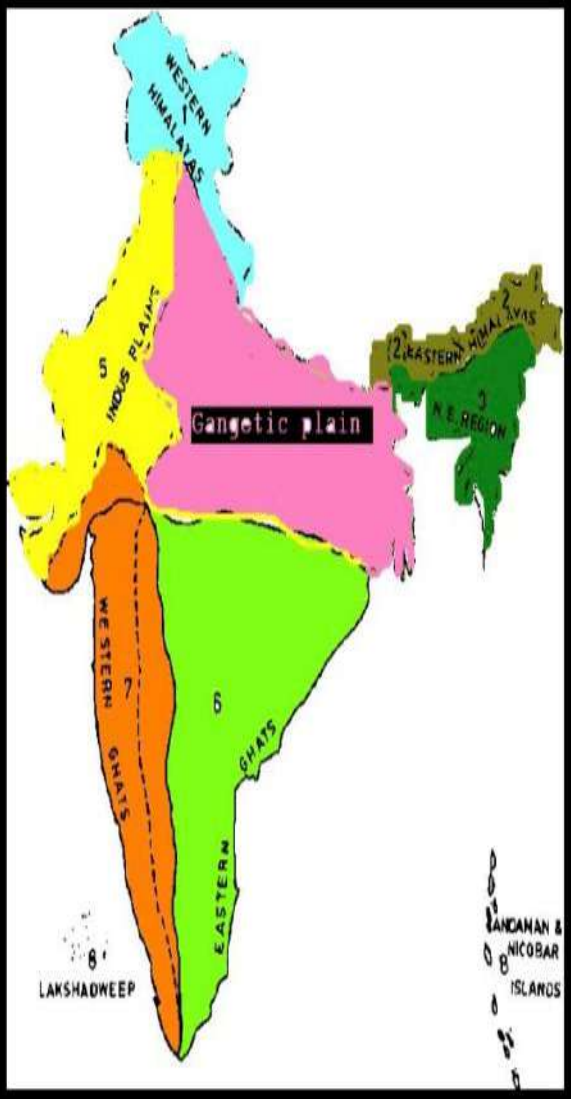
orange-colored citrus fruit

Citron
Citrus medica

Rich floristic wealth of Indian subcontinent

Eight phyto-geographical/ agro-ecological zones

(1) Western Himalayas
(2) Eastern Himalayas
(3) Central Himalayas
(4) Assam
(5) Gangetic plain
(6) Indus plain
(7) Deccan
(8) Malabar



Indo-Malayan Center (Siam-Malaya-Java)

Manila hemp
Musa textilis

Relative of banana

Job's tears
Coix lacryma

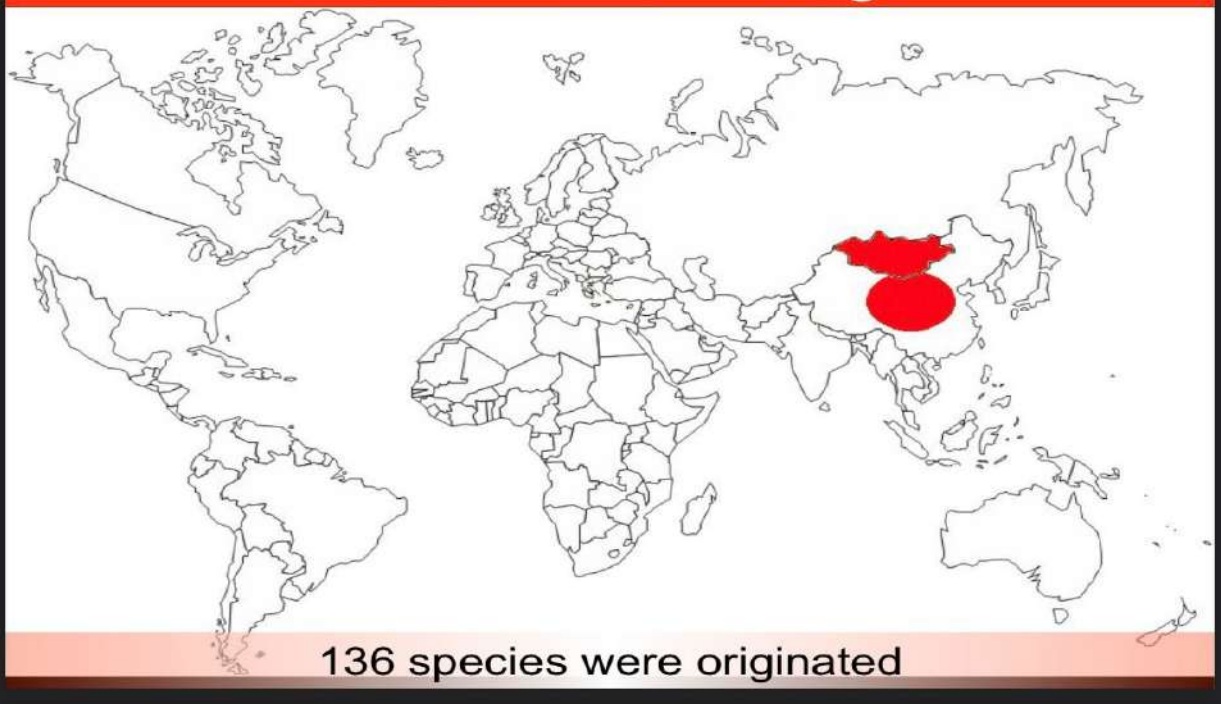
Vyjanti
Seed is used to make necklace

Breadfruit
Artocarpus altilis

When cooked smell like potato

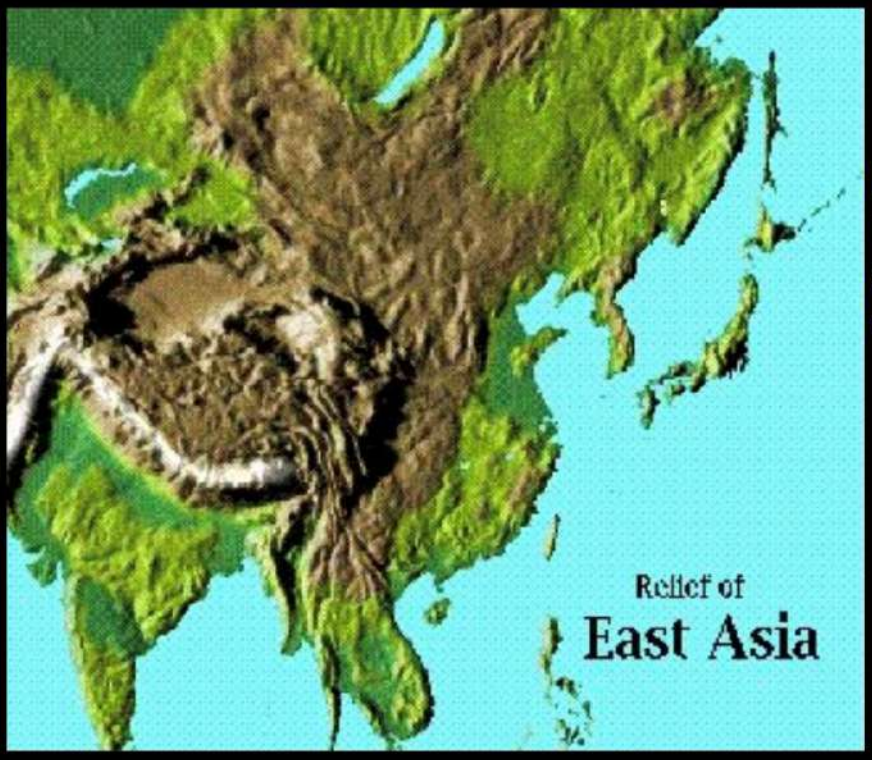
Candlenut
Aleurites moluccana

Chinese Centre of Origin



136 species were originated

Chinese Centre of Origin



Mountainous region of central and western China

Magnolia

Chinese Centre of Origin

Ginseng
Panax ginseng

Velvet bean

Adzuki bean

Chinese Centre of Origin

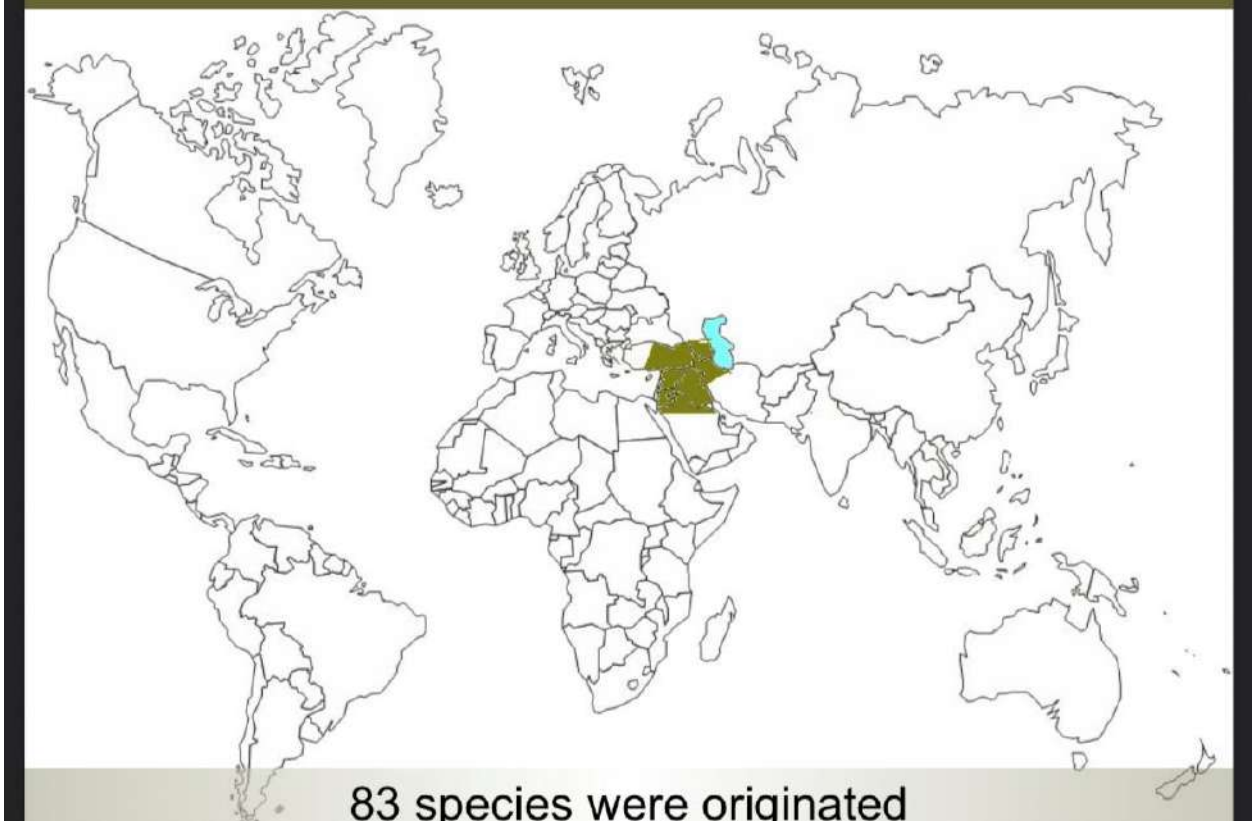
Camphor *Cinnamomum camphora*

Persimmon *Disophyrus kaki (The fruit of the god)*

Quince
Cydonia oblonga

Chinese Centre of Origin

Near Eastern centre



83 species were originated

Mediterranean Center

Anise
Pimpinella anisum

Thyme

Peppermint

Hop
Humuls lupulus

Sage
Salvia apiana

Mediterranean Center

South Mexican and Central American Center

Cacao

Chayote

Henequen (sisal)
Agave fourcroydes

Arrowroot

South Mexican and Central American Center

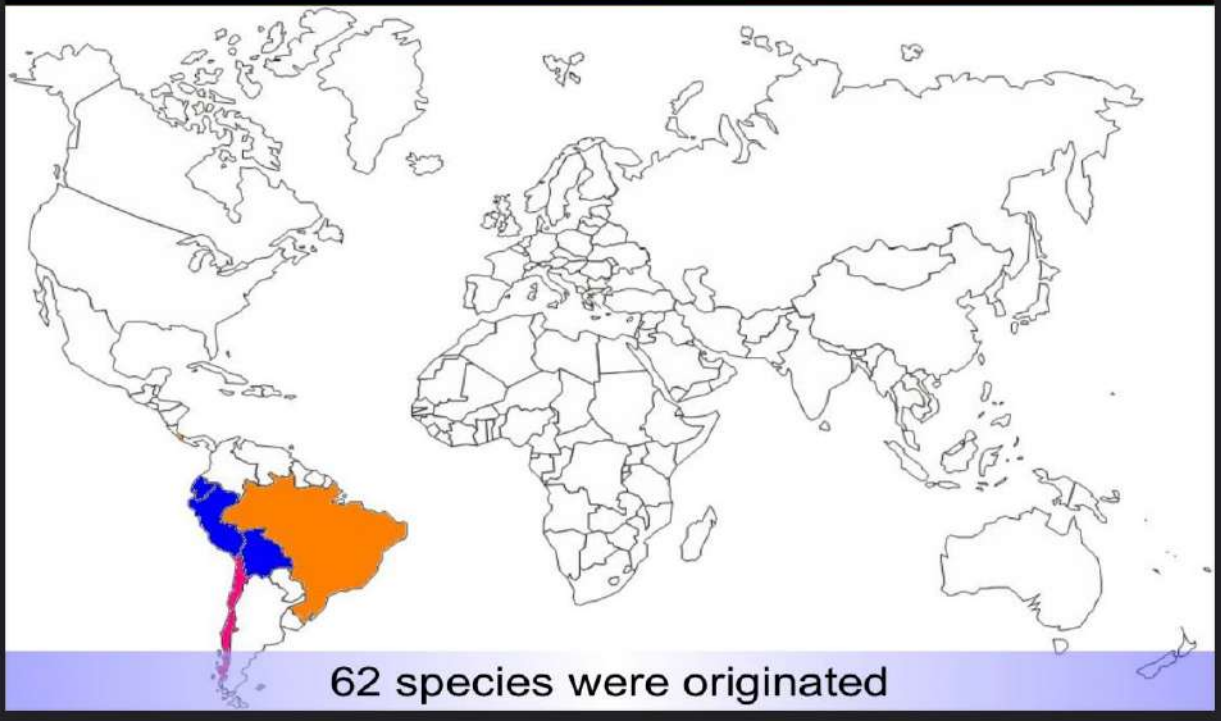
Multiflorus bean

Jack bean

Tepary bean

Lima bean

South American Center



62 species were originated

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2539 botanical varieties of 304 species of 155 botanical families

Herbarium contains more than 250 000 specimens

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