Lecture 1

Bentham and Hooker's classification of plant kingdom — International code of botanical nomenclature and its major guidelines – author citation – Agricultural classification of crops

Angiosperms (flowering plants) exhibit enormous variations that classifying them into different groups is very interesting and as well as tough for taxonomists. The taxonomy of flowering plants originated with the classification of plants into medicinal and food value plants by pre historic people. Later on after civilization, people used to discover more and more useful plants and started classifying them further. Therefore classification is described as the placing of a plant (or group of plants) in groups or categories according to a particular plan or sequence and in conformity with the nomenclatural system. The study of various field crops has been taken up by different workers, classifying them under any of the following groupings namely,

taxonomical,

commercial and

agricultural classification.

I) The Taxonomic Classification

The crop plants are systematically arranged under different orders and families. All the plants referring to one particular family are grouped together. For example, the family graminae comprises the important cereal crops such as rice and wheat, sugarcane, bamboo etc. While the taxonomic classification has certain advantages in understanding the morphological characters of any particular family, it does not bring out the economic importance and other agro-botanical peculiarities of the individual crops.

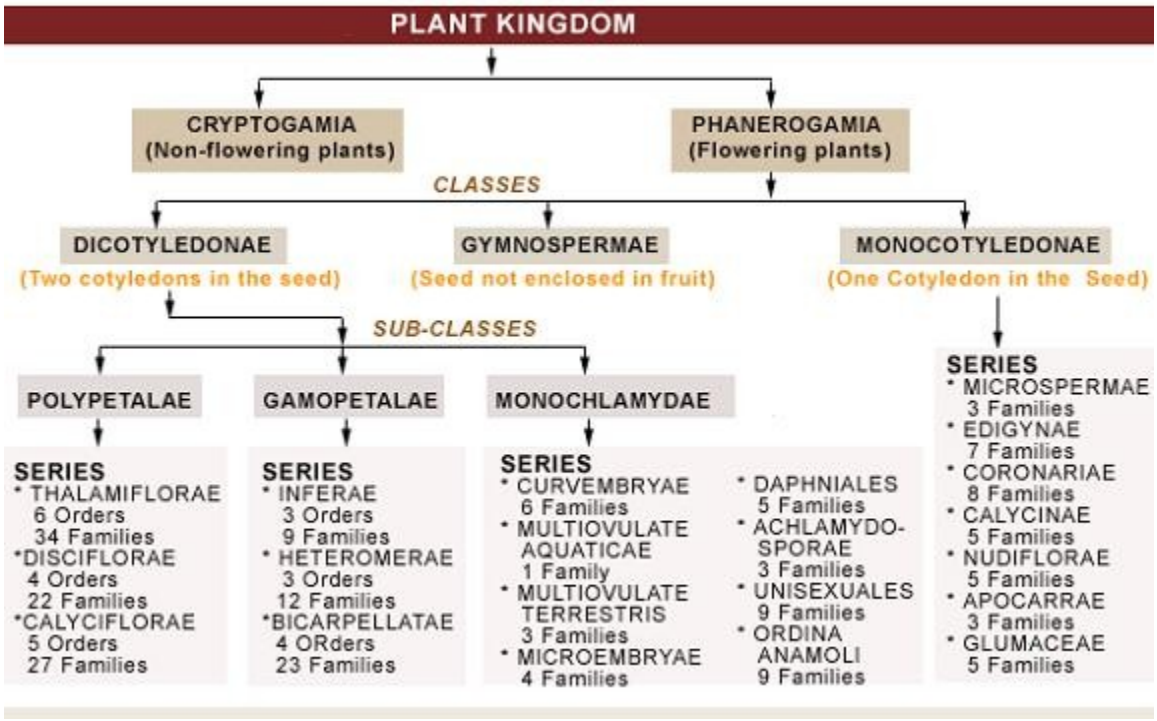
Bentham and Hooker

George Bentham and Joseph Dalton Hooker - Two English taxonomists who were closely associated with the Royal Botanical Garden at Kew, England have given a detailed classification of plant kingdom, particularly the angiosperms. They gave an outstanding system of classification of phanerogams in their Genera Plantarum which was published in three volumes between the years 1862 to 1883. It is a natural system of classification. However, it does not show the evolutionary relationship between different groups of plants, in the strict sense. Nevertheless, it is the most popular system of

classification particularly for angiosperms. The popularity comes from the face that very clear key characters have been listed for each of the families. These key characters enable the students of taxonomy to easily identify and assign any angiosperm plant to its family.

Bentham and Hooker have grouped advanced, seed bearing plants into a major division called Phanerogamia. This division has been divided into three classes namely:

1. Dicotyledonae
2. Gymnospermae and
3. Monocotyledoneae



Class Dicotyledonae

This group includes angiosperms in which the seed bears two cotyledons and leaves exhibit reticulate venation. It is divided into three subclasses - Polypetalae, Gamopetalae and Metachlamydae

Sub-class Polypetalae

The flowers contain distinct non-essential whorls calyx and corolla. In the corolla petals are free. This sub-class includes 8 series Thalamiflorae, Disciflorae and Calyciflorae.

- **Series Thalamiflorae**: Many stamens in the androecium. Flower is hypogynous.

- **Series Disciflorae**: Hypogynous flowers with a cushion-like disc around or below the ovary.
- **Series Calyciflorae**: Flowers epigynous or perigynous. Thalamus is in the form of a cup.

Sub-class Gamopetalae

Flowers with distinct calyx and corolla. In the corolla petals are fused. This sub-class includes 3 series.

- **Series Inferae**: Flowers with inferior ovary.
- **Series Heteromerae**: Flowers with superior ovary. Number of carpels - more than two.
- **Series Bicarpellatae**: Flowers with superior ovary. Number of carpels - two.

Sub-class Monochlamydae

The flowers are with only one non-essential whorl (perianth) or absence of non-essential whorls. It includes 8 series.

- **Series Curvembryae**: Usually single ovule, embryo coiled around the endosperm.
- **Series Multiovulate Aquaticae**: Aquatic plants with syncarpous ovary and many ovules.
- **Series Multiovulate Terrestris**: Terrestrial plants with syncarpous ovary and many ovules.
- **Series Microembryae**: Only one ovule, small, tiny embryo endospermic seed.
- **Series Daphnales**: Only one carpel and single ovule.
- **Series Achlamydosporae**: Ovary inferior, 1 to 3 ovules - unilocular.
- **Series Unisexuales**: Flower unisexual, perianth usually absent.
- **Series Ordines Anomali**: (Anomolous families) Plants with uncertain systematic position but closer to unisexuales.

Class Gymnospermae

This group includes the gymnosperms in which seeds are not enclosed in fruits. This class is divided into three families Gnetaceae, Confiraceae and Cycadaceae.

Class Monocotyledonae

This group includes angiosperms in which the seed bears only one cotyledon. The leaves exhibit parallel venation. It is divided into the following seven series.

- **Series Microspermae**: Ovary is inferior, seeds are minute and non-endospermic.
- **Series Epigynae**: Ovary inferior, seeds are large and endospermic.
- **Series Coronarieae**: Ovary superior, perianth petalloid.
- **Series Calycinae**: Ovary superior, perianth sepalloid.
- **Series Nudiflorae**: Perianth reduced or absent. Seeds are endospermic.
- **Series Apocarpae**: Carpels more than one, free, seeds are endospermic.
- **Series Glumaceae**: Perianth reduced or absent, scaly bracts present.

Each of the series mentioned under dicotyledonae and monocotyledonae have been further divided into orders and families. Bentham and Hooker classified the angiosperms into 202 families. They were able to provide distinct diagnostic key characters to each of these families. This is the reason for the popularity of Bentham and Hooker's classification particularly amongst the taxonomists.

II) The Commercial Classification

The plant products are generally grouped into the following categories based on their commercial purpose.

1) Food crops – cereals such as rice, wheat, maize, sorghum, ragi, oats, pulses (green gram, black gram, red gram, chick pea etc), fruits, vegetables and nuts.
2) Industrial crops – cotton, sugarcane, tobacco, groundnut, castor, gingelly, safflower, tapioca, onion, turmeric, ginger etc.
3) Food adjuncts – It has no distinct demarcation between the food crops and industrial crops and often include spices, condiments, beverages and narcotics.

As seen above, the commercial grouping is on a broad basis. It is possible that one crop which has been included as a food crop may figure also an important industrial crop as in the case of maize and tapioca. A better classification is the agricultural classification.

III) The Agricultural Classification

The agricultural classification of crop plants embraces the salient features of the other two classifications. According to the use of plants and plant products to man, the grouping is made as follows:

1) **Cereals** – The term cereals is derived from "Ceres", the Roman Goddess of harvest and she was worshipped as the 'giver of grain'. It is generally applicable to the grains obtained from the members of the family graminaceae (Poaceae) viz., rice, wheat, maize, sorghum, ragi, barley, pearl millet, fox-tail millet, rye, oats etc. These form the principal sources of food for man and animals.

The term grain crop is also sometimes used for the cereals since the term grain is in a popular way applied to the fruit of the plants belonging to family graminaceae. Botanically the characteristic fruit of the family graminaceae is a caryopsis. The major cereals of India are rice, wheat and millets like sorghum, ragi, maize, and pearl millet.

The term millets are generally used for the number of small grained cereals which are of minor importance as food. Due to adverse soil and climatic conditions the minor cereals have local importance only in regions which come under such stress. However, the minor cereals are of importance as sources of food in many regions especially in drought prone rural areas. The minor cereals (small millets) of India are fox-tail millet (Tenai), little millet (samai), common millet (Panivaragu), Barnyard millet (Kuthiraivali) and Kodo millet (varagu). Some of the temperate zone cereals such as rye, oats and barley also figure as minor cereals under certain regions while they may be major ones in other places.

There are few species of plants other than graminaceae which produce small grains and used for food as in the case of cereals. These are called as 'pseudo cereals'. Buck wheat (*Fagopyrum* spp- Chenopodiaceae), grain amaranthus (*Amaranthus* spp. – Amaranthaceae), Quina (*Chenopodium quinoa* –Chenopodiaceae) and *Zostera marina* (Potamogetonaceae) are considered under pseudo cereals.

Rice is the staple food of nearly half of the population of the world. It contains a larger proportion of starch than all other cereals. Wheat contains a good proportion of proteins besides the starch and comes second in popularity. Sorghum forms another important cereal of the tropical countries like India and Africa. Pearl millet, finger millet,

foxtail millet are important food crops of India. Maize has gained importance in all tropical regions of the world. In the colder regions of Europe and Russia, rye takes the place of wheat. Barley is important as a malt food and oats in a beaten and processed condition form a light food for breakfast

2) **Pulses** – Pulses form an important source of human food next to cereals. The term 'pulse' is used generally for the seeds of leguminous plants (family leguminaceae or fabaceae) which are used as food. Pulses supply proteins and forms chief source in vegetarian food. Though the seeds are generally used, the whole fruit or pods, both young and mature are also utilized. The leguminous plants have nitrogen in root nodules which is produced with the help of nitrogen fixing bacteria (*Rhizobium* spp). Nitrogen is essential for the synthesis of proteins. Hence the seeds, pods, leaves and the shoots also contain high proportion of protein and are useful as food. The average per capita consumption of pulses in India is about one ounce while the minimum requirement is about three ounces according to nutritional experts. The most important pulse crops of India are *Cajanas cajan* (Red gram), *Vigna mungo* (black gram) *Vigna radiata* (green gram), *Cicer arietinum* (Bengal gram) *Vigna unguiculata* (cow pea) and Lablab besides many other minor pulses.

3) **Oils and oil seeds** – These are crops grown for the production of oil from their seeds.Among the agricultural crops, oilseeds are important both for consumption and for industrial purposes. In the human diet, the fat portion is supplied by oils, which give the necessary energy for metabolism besides adding taste to the food. Eg) Sunflower, ground nut, gingelly. mustard etc. Oil is used for medicinal purposes also. In industries oil is used in the preparation of soaps, cosmetics and lubrication. Castor oil and coconut oil are very important industrial oils which figure in the export trade.

4) **Sugars and starches** - Sugar crops are grown for their ability to store sugars in their stems or roots. Sugarcane and sugarbeet grown for sucrose yield; sweet sorghum and sugar cane grown for syrup production, and corn and grain sorghum for dextrose production. The other sources of sugar in the country are the palms namely palmyrah, coconut and date palm. The tapped juice from these palms is generally converted into palm gurs, which form the source of a cheaper sugar to the people. Sugars, besides being used as food sweeteners are rich sources of energy.

Apart from cereals, starchy food is also obtained from sweet potato, tapioca and sago palm. Starch is also an industrial product much needed in confectionery, textile, stationery and cosmetics industries.

5) **Fibres** – Clothing is most important to man next to food. Cotton is the most important fibre crop and has been in cultivation in many countries for centuries. Linen obtained from the flax or linseed plant has been the source of fibre for clothing in temperate regions. Artificial fibres are obtained from wood pulp. For the manufacture of gunny bags, hession cloth and packing material, fibres of jute and mesta are used. Twines, cordages, carpets, mats and brushes are made from coconut fibre.

6) **Bevarages** - Bevarages are drinks which form an essential part of human diet because of their liquid content. Example, Coffee, tea and cocoa are the important bevarages with stimulating effects. Coffee and tea are commercial crops which are grown on plantations and figure in the export market. Cocoa has great potential both as beverage and as confectionery.

7) **Narcotics, fumitories and masticatories** – Narcotics are substances which produce a stimulating or drowsy or numbing effect in moderate doses. These substances relieve pain or produce sleep. The term is often used synonymous with the drugs. Eg) tobacco, ganja, opium and stramonium.

When substances are smoked because of the stimulating effect as in the case of tobacco, they are known as fumitories. Substances which are chewed as the betel leaf and areca nut form the masticatories. Tobacco comes as a narcotic, a fumitory and also as a masticatory. In all the above case the alkaloids present in the plant parts are responsible for creating stimulatory effects.

8) **Spices and Condiments**- Plant products which give aroma and flavor are termed as spices and those which give taste as condiments. The plants under this grouping are pepper, cardamom, cloves, chillies, turmeric, ginger, onion and garlic. These spices and condiments are responsible for the flavor and taste.

9) **Rubber** – The daily consumer use of rubber as well as its industrial consumption is fast increasing especially in the manufacture of tyres. Though latex and rubber are obtained from *Manihot glaziovii*, *Cryptostegia* and *Taraxacum*, the commercial source is mainly from *H.brasiliensis*.

10) **Forages** – The term forages generally include both fodders and pasturages. They are Forage crops grown for hay, silage, or pastures for livestock feed. The cultivated fodders such as the guinea grass, napier grass, lucerne, fodder cholam, fodder maize etc., are harvested and fed to the animals. The grasses and legumes which are grown in arable land and left for animals to graze-on come under the classification of pastures. The straw of paddy, cholam and bhusa of pulse crops and groundnut form important forages. The foliage of a number of trees and shrubs which are edible to animals form another source of forage especially in dry areas and during periods of scarcity.

11) **Green manures and green leaf manures** – The growing of special crops for adding organic matter and nitrogen to the soil and by ploughing them insitu is called green manuring. The plants grown for this purpose of green manuring is called green manure plants. Eg) Daincha, sunhemp, pillipesara, kolinji, indigo, *Sesbania speciosa* and lupins.

The green loppings from shrubs and trees incorporated in fields are called as green leaf manures. Eg) *Ipomea carnea*, *Gliricidia* etc.

12) **Vegetables, fruits and nuts** – Olericulture deals with the study of vegetables. Similarly fruits and nuts which are valuable sources of food are dealt under pomology. The various aspects of horticulture are olericulture, pomology and floriculture (study of ornamental plants).

International code of botanical nomenclature and its major guidelines – author citation

Nomenclature

Nomenclature refers to the naming of things. Botanical nomenclature is (surprise) about naming plants. Bear in mind that plant names refer to abstract entities - the collection of all plants (past, present, and future) that belong to the same group. As you will recall, taxonomy is about grouping. Botanical nomenclature is about applying names to taxonomic groups. Scientific names of plants reflect the taxonomic group to which the plant belongs. One must first decide on the groups to be recognized; only then does one start to be concerned about assigning an appropriate name to the plant. Common names, at least those that are genuinely common names, usually reflect some conspicuous or

valuable characteristic of the plant, not its taxonomic group. The following comments are about scientific names.

Scientific names are never misleading. No matter where you are, every plant has only one correct name. The universality of scientific names means that even English speaking people can find out what species grow in China or Saudi Arabia by reading a technical flora of these countries.

Pronunciation. There is as little point about worrying over the 'correct' pronunciation of scientific names as there is in worrying over which is the correct pronunciation of English words. It may be difficult to recognize a scientific name if it is spoken by someone from another part of the world BUT one can always recognize it when it is written out. In this, scientific names are no different from other words. Think how hard it can be to understand different versions of English. Nevertheless, it is advantageous to use the same pronunciation as the other people you work with. Just be prepared to modify your pronunciation if you move to another part of the world.

Taxonomy refers to forming groups. Plants that belong to the same group have the same name. The taxonomic decisions concerning how a group is to be treated (what goes in the group, what rank it should be recognized as) must be made before it can be assigned a name. It does not matter how you decide what its affinities are (unless, of course, you want others to support and use your treatment), but you must make these decisions before you can decide on an appropriate name for the group. So remember, **taxonomy first**.

If people are going to communicate around the world, there needs to be an internationally accepted system of nomenclature. Creating such a system was not, and is not, an easy task. It was not until 1930 that agreement was reached on an International Code had become standard around 1753. There were, however, many areas where there was widespread agreement in practice, with some of the practices dating back to before Linnaeus. For reasons that you will learn later, Linnaeus is taken as the starting point for botanical nomenlcature. Let's consider for a moment some of the areas of agreement that existed before there was formal agreement on an International Code of Botanical Nomenclature.

Towards an International Code

Pre-Linnaean Practices

1) Names were formed like Latin words. The reason is quite straightforward; Latin was the common language among all European peoples - and plant taxonomy as we know it has its origins in Europe.

2) Once a name had been attached to a plant group, it should not be given another name.

3) When commenting on how a name was to be interpreted, one should list the names of others that had used it.

4) It helps to mention some specimens that one has seen.

The first attempt at developing an international agreement was made in Paris in 1867. At this meeting, it was decided that a) the first edition of Linnaeus' *Species Plantarum*, which was published in 1752, would serve as the starting point of botanical nomenclature and b) if two names had been given to the same plant group, the older name would be the correct name. In addition, various rules were laid down as to what was required to valid publication - a phrase that means "published in such a manner that the name counts". For instance, publication of new names in horticultural catalogs used to be acceptable, but it is not any longer.

Other Codes

In 1892, a group of US botanists held a meeting in Rochester at which they presented some additions and modifications that they considered more objective (a great phrase in science). Among the changes that they proposed were that a) when publishing a new name one should cite at least one herbarium specimen representing the plant group concerned and b) that, when a species was moved from one genus to another it should, if possible, keeps its specific epithet (it is not possible if that epithet has already been used for another species in the new genus). Some of the new rules conflicted with those proposed in Paris, and the modified version being used at Kew, a major taxonomic center in England.

Agreement, at last

In 1930, taxonomists finally agreed on a single International Code of Botanical Nomenclature. This Code is revised every 6 years, but the goals of all the revisions are always to achieve stability in scientific nomenclature and or to clarify problems. The

revisions are published in Taxon, the journal of the International Society of Plant Taxonomists, then voted on at a meeting that is held immediately prior to an International Botanical Congress. The last edition of the Code was published in 2000. There is a copy in the herbarium.

Limitations of the Code

- Before considering what the Code says, it is important to know what it does, and does not, attempt to do.
- It DOES state what to do when you wish to assign a new name to a plant group, how the names of plant groups are to be informed, how to inform people about new names, and how to choose between two (or more) names that have been given to the same plant group.
- It DOES NOT provide any information on how to decide whether a group of plants should be given a scientific name or what rank a group should have. These activities are taxonomic, not nomenclatural.
- Remember: Taxonomy comes before nomenclature.

The International Code of Botanical Nomenclature

Becoming an expert on botanical nomenclature requires several years of study beyond graduate school, plus access to old, and often rare, literature. A knowledge of Latin is also essential because many earlier works are in Latin. What follows is a distillation of some of the keys points of the Code, points that you should endeavor to understand. Some are presented in rather simplified form; be sure to consult the Code itself, plus a nomenclatural expert, before starting a serious argument or proposing a new name.

Principles of Botanical Nomenclature

There are six principles that guide decisions concerning the Code.

1) **Uniqueness Principle (Principle IV).**

The uniqueness principle states that **there is only one correct name for a particular taxonomic group within a given taxonomic treatment.** It is the central principle upon which all the remainder of the code is based. If people disagree on the taxonomic treatment, they will consider different names to be correct but, within any treatment, each taxonomic group has only one correct name.

2) Type Principle (Principle II).

The type principle states, **"The application of names of taxonomic groups is determined by means of nomenclatural types".** For vascular plants such as grasses, a nomenclatural type is a herbarium specimen that has been deposited in a herbarium. A nomenclatural type anchors the meaning of a name. If there is an argument as to what kind of plant the author of a name meant by a particular name, one examines the type specimen. No matter what taxonomic treatment is followed, the name must be used in a sense that includes its type specimen. If, as occasionally happens, the author of a new name provides a description that does not match the type specimen, it is the type specimen, not the description, that determines what kind of plant is called by the name in question.

Adherence to the type principle did not become mandatory until 1958. Prior to that time, when taxonomists published a new name they frequently simply listed several different specimens that exemplified what they meant by the name, without identifying any particular specimen as the 'top dog' among the examples. All the designated specimens, including their duplicates, are referred to as *syntypes*: nomenclatural types of a single name, all of which were equally important. This became a problem if later taxonomists decided that there are two or more taxa among the specimens listed. When this happens, it became necessary to determine which of the specimens listed belongs with the original name.

To prevent such situations arising, the rules for designating a type specimen were made more explicit. Since 1990 it has been necessary to identify the exact specimen that is to be the nomenclatural type of the taxon, and the herbarium in which the specimen is located. Between 1958 and 1990 it was enough to specify who collected the specimen, where it was collected, the date on which it was collected, and the collection number it was given, if any. The problem was that, if the collector made several duplicate specimens, each of the duplicates is a *syntype*. In most instances this is not a problem, but occasionally the supposed duplicates turn out to belong to different species. Requiring that an author state exactly which of the specimens is to be regarded as the nomenclatural type helps prevent even this kind of problem. If possible, the accession

number of the type should be specified as well as the name of the herbarium in which it is located, but many older herbaria do not give their specimens accession numbers.

There are several different kinds of type specimen, but the most important are holotypes, lectotypes, neotypes, and epitypes. The next most important are isotypes, syntypes, and paratypes. The first four kinds of type refer to specimens that are, unequivocally, the nomenclatural type of a name. A *holotype* is a specimen that has been designated the nomenclatural type of a name by the person creating the name. If the person who originally published a particular name did not designate a holotype, a later taxonomist may select a specimen to serve as the nomenclatural type. This specimen then becomes what is called the *lectotype* of the name. If the holotype or lectotype is destroyed or lost, a new type specimen can be selected. Such replacement types are called *neotypes.* An *epitype* is a specimen selected to be the nomenclatural type of name for which there is a holotype, lectotype, or neotype available. Why would it be necessary to select another specimen as a nomenclatural type? Sometimes the holotype, lectotype, or neotype simply does not show the features that are needed to determine, unequivocally, to which of two taxa it belongs. In such a case, it cannot be used to fix the meaning of a name. In such situations, another specimen can be selected as the 'anchoring' specimen; it is this specimen that is the *epitype.*

3) Priority Principle (Principle III).

This principle states**, in essence, that if a taxonomic group has been given two or more names, the correct name is the first name that meets the *Code's* standards for publication.** Basically, this means that the priority of a name dates from the time that it was first published and made known to other botanists. Writing the name in a letter (or Email) to a colleague does not count, nor do notes made on herbarium sheets.

Taxonomic groups may end up with two or more names for several reasons. The most common reason is taxonomic disagreement, about which the *Code* says nothing. Sometimes, the person publishing a later name is simply unaware that the group has already been named. In other cases, two (or more) names were given to different looking specimens of what was later treated as a single group. Whatever the reason, the priority principle states that only the first name validly and legitimately published for a particular taxonomic group is correct.

In determining priority, the date that matters is the date on which the material was actually mailed to other institutions; this is not always the same as the year on the cover of a book or journal.

4) RETROACTIVITY PRINCIPLE (PRINCIPLE VI).

This principle states, **"The Rules of nomenclature are retroactive unless expressly limited". The Retroactivity Principle means that anyone proposing a change in the *Code* needs to consider the effect that the proposed change will have on names published in a wide range of literature and over a considerable period of time.** This is an intimidating requirement. It is why all proposed changes to the Code undergo committee scrutiny before being voted on. If the committee has a problem with a proposed change, one of its members will get in touch with the person proposing the change. The committee member may point out unforeseen consequences of the proposed change. Alternatively, he or she may suggest examples that will make a stronger case for the change, or suggest modifications that will avoid some undesirable consequences.
All proposals to change the *Code* are published in *Taxon*, but they remain proposals until they are voted on at the next International Botanical Congress.

5) PRINCIPLES 1 and V.

The other two principles are straightforward. **Principle I states that botanical nomenclature is independent of zoological and bacteriological nomenclature.** If an organism is considered to be a plant, then it must be named in accordance with the *Botanical Code.* If it is considered a bacterium, it must be named according to the *Bacteriological Code.* **Principle V states that scientific names are to treated as if they were Latin, regardless of their derivation.**

OTHER KEY PROVISIONS OF THE CODE

1. Any changes in the Code should be designed to increase the stability of plant nomenclature. No one likes name changes, not even the taxonomists that propose them.
2. Every plant belongs to a species, every species to a genus, every genus to a family, every family to an order, every order to a class, every class to a division (also called a phylum nowadays - a concession to the greater number of zoologists in the world). This is the taxonomic hierarchy. Note that the Code *assumes* the existence of species. It does

NOT state what constitutes a species, let alone discuss whether species are real. The Code also *requires* that plant diversity be summarized in a hierarchical structure. Again, it is not a question of whether such a structure really exists. The fact that the Code assumes the existence of species and a hierarchical structure does not mean that that the assumptions are correct, merely that, in naming plants (and the zoological code is similar in this regard), one must act as if species are real and nature is hierarchical. Many people object to this, but no one has provided a persuasive argument for dropping the system.

PUBLISHING SCIENTIFIC NAMES.

Before a name, even a name that has a Latin form, can be accepted as a scientific name, it must satisfy several criteria. Some of these have to do with its form, others with how its existence and meaning are made known to others.

Form. Principle V states that a scientific name must be treated as if it were Latin, but the Articles 16-28 of the *Code* also specify what form the name must take. I have summarized them in the table below.

Rank	**Ending**	**Examples**
Division (Phylum)	-phyta	Pinophyta, Magnoliophyta
Class	-opsida	Pinopsida, Liliopsida, Magnoliopsida
Order	-ales	Pinales, Liliales, Magnoliales
Family	-aceae	Pinaceae, Liliaceae, Magnoliaceae
Tribe	-eae	Pineae, Lilieae, Magnolieae
Genus	A noun	*Pinus*, *Lilium*, *Magnolia*
Species	Depends	*Pinus flexilis*,*Lilium grandiflorum, Magnolia grandiflora*
Variety	Depends	*Pinus flexilis* var. *humilus*
Form	Depends	

Family names must be formed by combining a generic name with the suffix –aceae, but there are eight exceptions to this rule. Each of the eight exceptional names was almost universally used, and used in the same sense, throughout the world when the first edition of the *Code* was prepared and so, in accordance with the overriding goal of

achieving nomenclatural stability, it was agreed that they would continue to be used. The eight names are Gramineae (Grass Family, alternative *Poaceae*) *Palmae* (Palm Family, alternatively *Arecaceae*), *Cruciferae* (Mustard Family, alternatively *Brassicaceae*), *Leguminosae* (Pea family, alternatively *Fabaceae*), *Guttiferae* (St. John's Wort Family, alternatively *Clusiaceae*), *Umbelliferae* (Carrot Family, alternatively *Apiaceae*), *Labiatae* (Mint Family, alternatively *Lamiaceae*), and *Compositae* (Daisy Family, alternatively *Asteraceae*).

The name of a species is ALWAYS a binomial. 'Grandiflora' is not the name of a species. It has to be combined with a generic name to form the name of a species, as in *Magnolia grandiflora*. The word 'grandiflora' is what we call the specific epithet. It states which species of *Magnolia* is under discussion. Specific epithets are often adjectives that describe some attribute of the plant (it helps to learn a little Latin - 'grandiflora' means large flowered), but may refer to the habitat of a species (pratensis -of fields, lacustris - of lakes, saxicola - of rocky places), the place where the species occurs (chinensis, europaea, canadensis), or a person that is somehow connected to the species (the connection may be remote) - wrightii (referring a single, male person named Wright), wrightiae (referring to a single female person named Wright), wrightorum (refering to 2 or more people, one of whom - and possibly only 1 out of a 100 - was male) or wrightarum (referring to 2 or more people with not even one male among them - the Romans were sexist).

Technically speaking, subspecies is a higher rank than variety. A subspecies may include several varieties. In practice, most taxonomists nowadays use one rank or the other, but not both. Europeans tend to use subspecies and expect subspecies to occupy somewhat different areas whereas Americans use variety to denote plants that are different from the plants first put in the species. In practice, the two ranks are used almost interchangeably.

Writing Scientific Names

It is customary to write names at the rank of genus and below in italics or some other font that sets them apart from the rest of the text. The names of all ranks from subgenus up MUST be capitalized. In most instances, the specific epithet - and epithets for lower rankings, must NOT be capitalized. There are some exceptions to this rule,

cases where it is permissible, but not required, to capitalize the specific or varietal epithet, but you need to be careful. Personally I recommend always using lower case for epithets (names distinguishing species and lower ranks). That way one is never wrong.

Authorities

You will notice that scientific names are often followed by a word or a capital letter and a period, or one or more unintelligible (to the uninitiated) sets of letters. To join the initiated, read on.The letters and/or words that follow a scientific name (sometimes they may be within a name - more on that later) are a shorthand reference to the name of the person or person that first gave a name to the entity involved and, in some instances, to the person of persons who first treated it at the rank being used. This is probably easier to understand through some examples.

Consider *Oryzopsis exigua* Thurber

Note that only the first two words are italicized. This means you are looking at the name of a species. 'Thurber' is the last name of the person who first gave a name to this species - and the name he gave to it is the one shown.

Consider "*Oryzopsis asperifolia* Michx."

Again, you are looking at the name of a species in the genus *Oryzopsis*. This species was first named by a fellow whose name is abbreviated to Michx. The period tells you that his name has been abbreviated. His full name was Michaux. To whom do you think "L." refers to in "*Triticum aestivum* L."?

"***Dichanthelium lanuginosum* (Elliott) Gould"**

The name is *Dichanthelium lanuginosum.* As you immediately recognize (because the name is a binomial), the entity being named is being treated as a species. The first person to give a name to this species was a chap whose last name was Elliott, but he named it *Panicum lanuginsoum*. An inner circle of initiates could tell you that Elliott refers to Walter Elliott, who lived from 1803 to 1887, in eastern North America (There is a book called Authors of Plant Names that provides such insight). "Gould" stands for Frank W. Gould came along later and decided that, although Elliott was right in describing the species, he should have put it in a different genus, the genus *Dichanthelium.* Elliott's name is in parentheses to show that he was the first person to say "Aha, these plants are different"' Gould's name is outside the parentheses because he said,

yes, Elliott was right - these plants are different - but they should be included in the genus *Dichanthelium*, not *Panicum*

Consider "*Distichlis spicata* (L.) Greene

Linnaeus [L. stands for Linnaeus] first described the entity, but as *Uniola spicata*, not *Distichlis spicata*. Greene was the first person to say no, these plants should be in *Distichlis* and then publish the combination "*Distichlis spicata"*. Linnaeus gets credit for being the first person to describe the entity, Green for being the person to give it the name shown. Most journals, and consequently many professors, ask that you cite the authorities for a name when it is first used. It is a rather meaningless exercise. It is meant to say "I am using this name in the sense that it was used by Greene (in the last example)", but really you are probably using it in the sense that it is used in some flora - or based on what your boss told you. The 1999 Congress encouraged editors to be more rational about when it was useful to cite authorities and when not, but I suspect that most journals will continue to require them for some time to come.

PROPOSING A NEW NAME OR NEW COMBINATION

If you have to publish a new name or combination, the Code requires that you follow certain rules (which it calls articles). The key requirements are that:
1. The new name or combination be published in a normal botanical outlet (not the Herald Journal or Statesman), copies of which are sent to at least two botanical institutions.
2. If the name is for a new taxon, the distinguishing characteristics of the taxon, and preferably a full description, must be given *in Latin* and a holotype specified.
3. If the name is simply a new combination, perhaps reflecting the transfer of a species from one genus to another or its demotion to a subspecies, there must be a clear and complete reference to the place where the original name was first published.

WHY DO SCIENTIFIC NAMES GET CHANGED?

1. Discovery of an older name for the taxon that has been overlooked. In the last decade, it has become possible to conserve the name actually being used if one can show that the earlier name has never become established. This is a *nomenclatural*, not taxonomic reason, for changing a name.

2. Discovery that the name being used for a particular taxon had been applied earlier to some other taxon. This is a *nomenclatural*, not taxonomic reason, for changing the name.

3. A decision that a species belongs in a different genus, or that a taxon needs to be split, or that the rank of the taxon needs to be changed.

These are all *taxonomic* decisions. Most name changes reflect taxonomic decisions, but people that do not agree with the decision may continue to use the existing name. This is what non-taxonomists find frustrating, if not infuriating. Such people often become even more frustrated when told that there is no set of criteria nor any governing board that determines at what rank a taxon should be recognized at, or what its boundaries should be. There are stronger and weaker arguments, but there is not even complete agreement on which are strong arguments and which are weak. Taxonomy is not a field for those that require certainty in their life.

Other Names

Plants are often known by many different names. The names *Convolvulus arvensis*; Bindweed, Field bindweed, Common bindweed, Small bindweed, Morning glory, and Liseron des champs all refer to the same species. The scientific name is *Convolvulus arvensis*. The other names are what are called *common names* or *vernacular names.* I prefer the phrase 'vernacular name' because many so-called common names are simply names constructed to satisfy the demand for a name in a familiar language - they are not names in common use.

Although many people like 'common names', there are many problems associated with them. For instance, Indian ricegrass (*Achnatherum hymenoides)* is not a close relative of either rice or wild rice (two very different species), but it was used for food by Native Americans and looks something like short grain rice. I regard it as a genuine common name - among English speaking people. But the species was an important component of the diet of the Native Americans in Utah and the west. I rather doubt that it is called Indian Ricegrass in any Native American language.

Sometimes, the common name is the same, or partly the same as the scientific name. Many of you probably have no problem understanding Penstemon and Delphinium, but both of these are scientific names. If you grew up in England or

Australia, you would also be familiar with Capsicum as a common name, but in North America the commonly encountered species of Capsicum are called bell peppers or chili peppers. Despite their American names, species of bell peppers and chili peppers are more closely related to potatoes, eggplant, and nightshades than the kind of pepper that we use in pepper grinders.

Problems arise when vernacular names have been created based on scientific names, but the meaning of the scientific name changes. For instance, all species in the genus *Agropyron* were given common names that incorporated the word 'wheatgrass'. The trouble is that most of these species have since been kicked out of *Agropyron*. It is not a huge problem, but it does point up how artificial so many 'common names' are.

Another problem with common names is that they may apply to more than one species. Corn used to the name for the grain most used for flour. In England, corn meant wheat; in Scotland, it meant rye or barley; in these two countries what Americans call corn was known as maize. With the increasing dominance of American English, corn is now generally interpreted as meaning *Zea mays* - otherwise known as maize. Similarly 'Bluebell' forms part, or all, of the name of many different plants. I learned of it as referring to monocots that are sold here as Wood hyacinths. In Scotland, it applies to what I would call a Harebell. but the northern Utah flora refers to as Arctic bellflower. This same work gives Bluebell as the common name for *Mertensia*, a third genus and a third family.

Even in one's own language, common names can be rather obscure. Do you know what plant is meant by Jack-in-the-Pulpit? Actually, that one is not bad. But how about "Welcome home husband no matter how drunk you may be"? Yes, I have seen it listed as a common name. Clearly the people that use it are not bothered by long names. And no, I have never met anyone that uses it.

Official Names

In some countries, one or more government agencies creates plant names in the country's native or official language which they require their employees and contract employees to use. Some of these names are what I would refer to as the *truly* common names, but many are just extensions of a true common name to other species, often by translating the specific epithet. Official names can be useful in talking to non-botanists,

but the result is often a parallel system of nomenclature. The U.S.A. is one such country. Indian rice grass appears to be a genuine common name, that is, one that ordinary people coined and used, for the species that used to be known as *Oryzopsis hymenoides.* Unfortunately, the USDA decided that all species of the genus *Oryzopsis* should be called rice grasses so the official name of *O. kingii* became King Ricegrass and *O. asperifolia* became Roughleaved ricegrass although neither of these species has ever been used as a source food for humans. The problem with this approach to creating official names (which are generally called common names) is that taxonomic study shows that neither *Oryzopsis hymenoides* nor *O. kingii* belongs in *Oryzopsis*. *Oryzopsis hymenoides* is now placed in either *Achnatherum* or *Stipa* (there is taxonomic disagreement) while *O. kingii* is placed in the genus *Ptilagrostis*. Should the official name of *P. kingii* be changed from King Ricegrass? If so, to what?

There are other problems with having official names. For instance, several years ago, the old Soil Conservation Service sent out an updated list of approved common names for Utah's plants. Among other idiocies, it was proposed that people should stop referring to penstemons (unless using a scientific name) and start referring to the species involved as beardtongues even thought the vast majority of the official names (which were called common names) were basically a translation of the binomial. In my opinion, it makes more sense to teach people to refer to Eatons Penstemon rather than Eatons Beardtongue. At least that way they learn half the scientific name.

Author Citation

In botanical nomenclature, **author citation** refers to citing the person or group of people who validly published a botanical name, i.e. who first published the name while fulfilling the formal requirements as specified by the *International Code of Nomenclature.* In cases where a species is no longer in its original generic placement (i.e. a new combination of genus and specific epithet), both the author(s) of the original genus placement and those of the new combination are given (the former in parentheses).

In biological works, particularly those dealing with taxonomy and nomenclature but also in ecological surveys, it has long been the custom that full citations to the place where a scientific name was published are omitted, but a short-hand is used to cite the

author of the name, at least the first time this is mentioned. The author name is frequently not sufficient information, but can help to resolve some difficulties. Problems include:

- The name of a taxon being referred to is ambiguous, as in the case of homonyms such as *Ficus* L., the fig tree genus, vs. *Ficus*.
- The publication of the name may be in a little-known journal or book. The author name may sometimes help to resolve this.
- The name may not have been validly published, but the supposed author name may be helpful to locate the publication or manuscript in which it was listed.

Rules and recommendations for author citations in botany are covered by Articles 46-50 of the *International Code of Nomenclature* (*ICN*). As stated in Article 46 of the botanical Code, in botany it is normal to cite only the author of the taxon name as indicated in the published work, even though this may differ from the stated authorship of the publication itself.

The simplest form of author citation in botany applies when the name is cited in its original rank and its original genus placement (for binomial names and below), where the original author (or authors) are the only name/s cited, and no parentheses are included.

The Latin term "et" or the ampersand symbol "&" can be used when two authors jointly publish a name. In many cases the author citation will consist of two parts, the first in parentheses, e.g.:*Helianthemum coridifolium* (Vill.) Cout.

This form of author citation indicates that the epithet was originally published in another genus (in this case as *Cistus coridifolius*) by the first author, Dominique Villars (indicated by the enclosing parentheses), but moved to the present genus *Helianthemum* by the second (revising) author (António Coutinho). Alternatively, the revising author changed the rank of the taxon, for example raising it from subspecies to species (or vice versa), from subgenus to Section, etc.(Again, the latter is in contrast to the situation in zoology, where no authorship change is recognized within family-group, genus-group, and species-group names, thus a change from subspecies to species, or subgenus to genus, is not associated with any change in cited authorship).

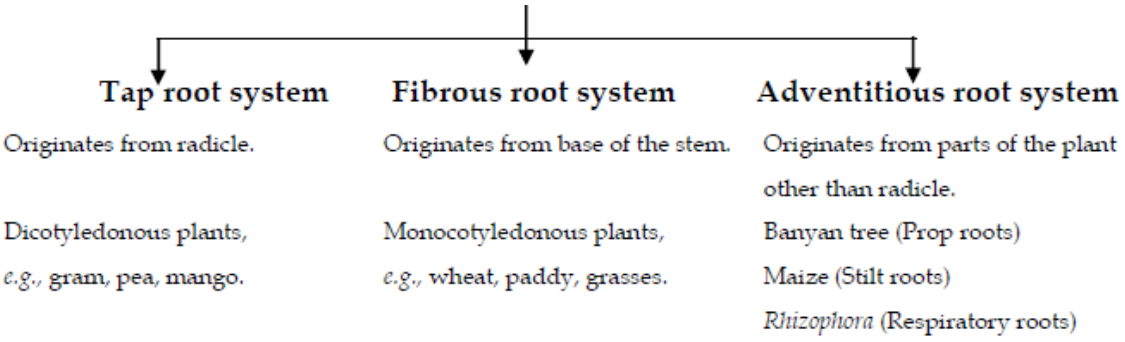
Lecture 2

General morphology: Life span, habit, root, stem, leaf - petiole, leaf margin, leaf apex, leaf shape, venation and phyllotaxy; Modification of roots and leaf.

ROOT

Root is the portion of the plant which grows downward into the soil and develops from the radical part of the embryo.

Types of roots



Roots are the principal water-absorbing organs of a plant. They are present on essentially all vascular plants. In fact, a root, by definition, must have vascular tissues, i.e., water conducts in xylem and sugar conducts in phloem, arranged in a particular way. There are three primary functions of roots: (1) to anchor the plant to a substrate, (2) to absorb water and dissolved minerals, and (3) to store food reserves.

In gymnosperms and dicotyledons, the primary root commonly grows to become a thick central root, the **taproot**, which may or may not have thick **lateral roots** (branches). This structural organization is frequently termed a **taproot system**. The easiest designation of taproot is for something like a carrot (*Daucus carota*), where the lateral (secondary) roots are very thin, so that plant indeed has a single, thick central root. The radicle enlarges to form a prominent taproot that persists throughout the life of the plant. The primary or tap root normally grows vertically downwards to shorter or longer depth, while the branched roots grow obliquely downwards or in many cases spread horizontally outwards. It is a charactrisctic feature of dicotyledonous plants and conifers.

In monocotyledons, the radicle is very short-lived, and before it dies other adventitious roots have already originated from shoot or mesocotyl tissue to become the new root system, called a **fibrous root system**. Fibrous roots are typically thought of as slender, often with few or no lateral roots. It has several to many roots of the same size that develop from the end of the stem, with smaller lateral roots branching off of them. Most monocots

(including grasses and onions) have a fibrous root system. The fibrous root of a few plants is edible eg. sweet potatoes (*Ipomoea batatas*) are the fleshy part of a fibrous root system.

However, many monocotyledons have below-ground **adventitious roots** that are thicker than a pencil. Roots that grow from any part of the plant body other than the radicle are called adventitious roots. They may develop from the base of the stem replacing the primary root or in addition to it, or from any node or internode of the stem or the branch even from the leaf under special circumstances. Adventitious roots are the ones that form from shoot tissues, not from another (parent) root. Most commonly, adventitious roots arise out of stems, originating via cell divisions of the stem cortex or less often from axillary buds hidden in the bark. The adventitious roots of monocots are very extensive and cling tenaciously to soil particles. These plants are excellent for preventing erosion. In some plants, adventitious roots are a primary means of vegetative reproduction.

Root Modification

Typically we see roots in soil, but there are specialized types of **aerial roots** (air roots) that enable climbing plants and epiphytes to become attached to rocks, bark, and other non soil substrates. In addition, parasitic plants may form specialized **haustorial roots** that form an attachment disc to the host during the first stage of colonization. Certain genera of plants have roots that are inoculated with colonies of nitrogen-fixing microorganisms, especially legumes and their associated **nitrogen-fixing bacteria** (rhizobial bacteria). Living in tumor-like **root nodules**, nitrogen-fixing bacteria are able to convert atmosphere nitrogen gas to ammonia, under anaerobic conditions produced by the plant cells, and then use this fixed nitrogen to make amino acids.

A. Modification of tap roots:

i) For storage of food:

1. **Fusiform root:** When the root (hypocotyl) is swollen in the middle and gradually tapering towards apex and base having more or less spindle shaped appearance, it is said to be fusiform (eg) Radish.
2. **Napiform root:** When the root is considerably swollen at the upper part (usually the hypocotyl), becoming almost spherical and sharply tapering at the lower part, it is said to be napiform. (eg) Turnip and beet
3. **Conical root:** When the root is broad at the base and gradually tapers towards the apex like a cone. It is said to be conical. (eg) carrot.

ii) For respiration:

4. **Branched root modification:**

   Pneumatophores: Many plants growing in marshy places develop special kind of roots called respiratory roots or pneumatophores for the purpose of respiration Spongy, aerial roots of marsh or swamps where roots are present in waterlogged soils and cannot obtain enough oxygen for maintaining healthy tissues. Here, pneumatophores are "breathing roots" that are emergent, and they have special air channels (lenticels) for gas exchange in the atmosphere (air enters at zones called "pneumathodes") and there is an internal pathway for getting O2 into the root and to supply submerged roots. Roots grow from the underground roots of the plant but rise vertically upwards and come out of the water like so many conical spikes. Each root is provided towards the upper end with numerous pores or respiratory spaces through which air is taken for respiration. (eg) *Rhizophora*

B. Adventitious root modification:

i. For storage of food:

- **Tuberous or tubercular root:** This is a swollen root without any definite shape as in sweet potato. Tuberous roots are produced singly and not in clusters.
- **Fasciculated roots:** When several tubercular roots occur in a cluster or fascicle at the base of the stem, they are said to be fasciculated (eg) Dhalia, Asperagus.
- **Nodulose roots:** When the slender root becomes suddenly swollen at the apex, it is said to be nodulose (eg) Mangoginger.
- **Moniliform or beaded root:** When there are some swellings in the root at frequent intervals it is said to be moniliform (eg) Mormordica, Portulaca and wild vine.
- **Annulated root :** When the root has a series of ring like swellings on its body, it is said to be annulated (eg) Psychotria, a medicinal plant.

ii. For mechanical support:

- **Prop or stilt root:** In plants like banyan, a number of roots are produced from the main stem and often from the branches. These roots grow vertically downwards and penetrate into the soil. Gradually they get stutter and act as pillars supporting the main stem and the branches or the plant as a whole. Such roots are known as prop or stilt root.
- **Climbing roots:** Plants like betel produce climbing roots from their nodes and often from the internodes to ensure a foothold on neighbouring objects.
- **Buttress roots:** In certain large forest trees, some of the stout roots around the base of

the main trunk show prolific abnormal growth, particularly on the upper side. They at first grow obliquely downwards from the base of the trunk and then spread horizontally outwards at the ground level some times to a considerable length. They are meant to give support to the huge trunk and maintain it in an upright position.

iii. For vital functions:

- **Sucking root or Haustoria:** Parasites develop a kind of roots which penetrate into the tissue of the host plant and suck it, such roots are known as sucking roots (e.g): dodder, broomrape.
- **Respiratory roots:** In Jussiaea, an aquatic plant the floating branches develop adventitious roots which are soft, light, spongy and colourless. They usually develop above the level of water and serve to store up air. Thus they facilitate respiration.
- **Epiphytic roots:** There are certain plants, commonly the orchids which grow perched on branches of trees they never suck the supporting plant as do the parasites. Instead of sucking roots they develop a special kind of aerial roots which hang freely in the air. Each hanging root surrounded by a spongy tissue called velamen. With the help of this, hanging root absorbs moisture from the surrounding air. Vanda, an epiphytic orchid is fairly common example.
- **Assimilatory roots:** Branches of Tinospora climbing on neighbouring trees produce long tender hanging roots which develop chlorophyll and turn green in colour. These green roots are assimilatory roots.

Root Cap: The root is covered at the apex by the thumble-like structure which protects the tender apical part.

Regions of the root:

1. Region of meristematic activity: Cells of this region have the capability to divide.
2. Region of elongation: Cells of this region are elongated and enlarged.
3. Region of Maturation: This region has differentiated and matured cells. Some of the epidermal cells of this region form thread-like root hairs.

STEM

Stem is the aerial part of the plant and develops from plumule of the embryo. It bears nodes and internodes. There is a variety of stem structure adopted to carry out the diverse functions. The nature of stem, height of the plant, duration, mode of life determines the habit. They may be

1. Aerial, 2. Underground.

1. Duration

- **Annuals:** These plans attain the full growth in one season. During this period, they produce flowers and seed and then die at the end of the season. (e.g): Sunflower, rice.
- **Biennials:** These are those plants that live for 2 years. They attain their full vegetative growth in the first year and produce flowers and seeds in the second year. Afterwards, they die off (eg): cabbage, carrot and radish.
- **Perennials:** Perennials are those plants that persist for many years (e.g.): Coconut, Mango, Rubber, Banana .
- **Multiennials :** live for many years like perennials but do not flower every year but flower and give fruits only once during their life cycle (monocarpic) eg. Agave, Palm, Bamboo.

2. Growth Habit

1. **Herbs:** These are small plants with soft stem. According to their duration they are classified as annuals, biennials and perennials. Eg) Coriander.
2. **Shrubs:** They are medium sized plants of hard and woody stem which branches profusely from near the ground so that plant becomes bushy in habit without having a clear trunk. They are larger than herbs and smaller than trees. (e.g.): Garden crotons.
3. **Trees:** They are very tall plants with clear trunk and have hard woody stem and broader. (e.g.): mango tree.
4. **Climbers:** It has thin and long stem with diffused branches. They often develop the special organs by which they cling to the neighbouring objects for support and assist for climbing. Climbers are classified according to their mode of climbing. Eg). Gourds, *Clitoria ternatea*.
   - Rootlet climber
   - Hook climber
   - Tendril climber
   - Leaf climber
   - Stem climber or twiner

Modification of stems:

A. Underground modifications of stems:

For the purpose of perennation, stems develop underground and lodge there permanently lying in a dormant defoliated condition for some time and then giving off aerial

shoots annually under favourable conditions. They are always thick and fleshy, having a heavy deposit of reserve food material in them. This can be readily distinguished by the presence of nodes and internodes, scale leaves and buds. The functions of this modification are a) perennation, b) to store up food material, c) to propagate.

* **Rhizome:** It is a prostate, thickened stem creeping horizontally under the surface of the soil. It is provided with distinct nodes and internodes which bears some scaly leaves at the nodes. It possesses a bud in the axil of the scaly leaf and ends in a terminal bud some slender adventitious roots are given off from its lower side. The rhizome may be unbranched or some times the axillary buds grow out into short, stout branches. It remains dormant underground and with the approach of the vegetative season the terminal bud and axillary buds grow into aerial shoots (e.g): Canna, ginger, turmeric.
* **Tuber:** This is the swollen end of a special underground branch. The underground branch arises from the axil of a lower leaf, grows horizontally outwards and ultimately swells up at the apex. It has on its surface a number of 'eyes' or buds which grow up into new plants. Adventitious roots which are abundantly formed in other underground stems are usually absent from a tuber. A tuber is often very much swollen owing to a heavy deposit of food material, becoming almost spherical (eg): Potato, *Jerusalem artichoke*.
* **Bulb:** This is an underground modified shoot which consists of shortened convex or slightly conical stem, a terminal bud and numerous scale leaves. The scale leaves often simply called scales, grow from upper surface of the stem, while a cluster of adventitious roots are given off from its base. The inner scales are commonly fleshy, the outer ones dry. The scales may occur surrounding the stem in concentric rings, as in onion. The fleshy scales store food. While the dry scales give protection. The bulb is vertical in direction and its terminal bud gives rise to the aerial shoot. Eg). Onion, garlic, fennel. . Some epiphytic orchids (family Orchidaceae) form above-ground storage organs called pseudobulbs that superficially resemble bulbs.
* **Corm:** This is a condensed form of rhizome consisting of a stout, solid, fleshy, underground stem growing in the vertical direction. It is more or less rounded in shape or often somewhat flattened from top to bottom. It contains a heavy deposit of food material and often grows to considerable size. It bears one or more buds in the axils of scale leaves and some of these buds grow up into daughter corms (e.g): Amorphophallus, Gladiolus.

B. Subaerial modification of stems

These are meant for vegetative propagation.

* **Runner**: This is a slender, prostrate branch with long or short internodes, creeping on the

ground and rooting at the nodes. The runner arises as an axillary bud and creeps some distance away from the mother plant, then strikes roots and grows into a new plant. They may break off from the mother plant and grow up as independent daughter plant (e.g): Marsilea, Strawberry.

* **Stolon:** This is a slender lateral branch arising from the base of the plant. At first it grows obliquely upwards to some extent and then it bends down to the ground, striking roots at the tip and producing a bud. The later soon grows into a daughter plant. (e.g): Mint, Strawberry.
* **Offset:** Like runners this originates in the axil of a leaf as short, more or less thickened, horizontal branch. It elongates only to a certain extent and produces at the apex a tuft of leaves above and a cluster of small roots below. The often breaks away from the mother plant. (e.g): Water lettuce, Water hyacinth.
* **Sucker:** Like the stolen, the sucker is also a lateral branch developing from the underground part of the stem. But it grows obliquely upwards and directly gives rise to a leafy shoot or a new plant. Occasionally it grows horizontally outwards only to a certain extent, but soon it turns up as in Chrysanthemum or be shorter and stutter as in banana.
* **Sobole:** the underground runner or creeping stem having no reserve food eg. Agropyron

C. Aerial modifications:

Vegetative and floral buds which would normally develop into branches and flowers often undergo extreme degrees of modification. Metamorphosed organs are stem tendril for climbing, thorn for protection, phylloclade for food manufacture and bulbil for vegetative reproduction.

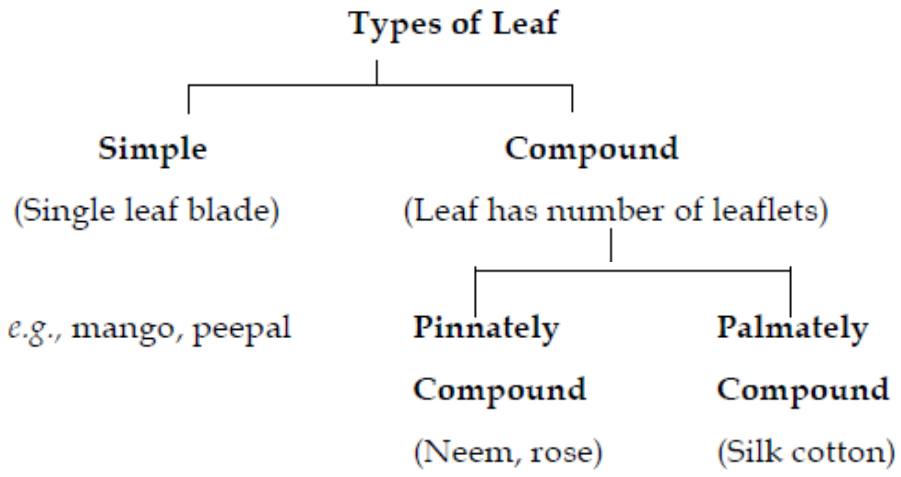
* **Stem tendril:** This is a thin, wiry leafless, spirally curled branch by which climbers attach themselves to neighbouring objects and climb them. Stem tendrils are seen in vitis, passion flower etc.
* **Thorn:** The thorn is a hard often straight and pointed structure. It is regarded as a modified branch because it arises in the axil of a leaf or sometimes at the apex of a branch, which is the normal position of a bud. In lemon. Pomegranate, axillary bud is modified into a thorn. In Carissa the terminal bud is modified into a pair of thorns.
* **Phylloclade:** This is a green, flattened, cylindrical stem or branch of unlimited growth consisting of succession of nodes and internodes at short or long intervals. It develops in many xerophytic plants where the leaves fall off early and modified into spines, evidently reducing the evaporating surfaces. It then takes over all the functions of leaves, particularly photosynthesis. It also functions as a storage tissue retaining plenty of water

and mucilage. Further, because of strong development of cuticle it can reduce transpiration to a considerable extent. (e.g): Cacti – Prickly pear (*Opuntia dilleni*). The phylloclade is otherwise called cladophyll.

* **Cladode:** In some plant, one or more short, green, cylindrical or sometimes flattened branches of limited growth develop from the node of the stem or branch in the axil of a scale leaf. Such a branch is known as the cladode. (e.g): Asparagus.
* **Bulbil:** A bulbil is a small bulb, and may also be called a bulblet, bulbet, or bulbel. It is special multicellular body especially meant for the reproduction of the plant. It may be the modification of a vegetative bud or floral bud. In any case, it detaches itself from the mother plant and grows up into a new independent one (e.g): Onion , *Agave american, Dioscorea bulbifera*.

LEAF

Develops from shoot apical meristem, flattened, green structure, manufacture the food by photosynthesis. It has bud in axil. A typical leaf has leaf base, petiole and lamina.



Parts of leaf:

1. **Leaf base or hypopodium:** It is the part of the leaf attached to the stem. Leaf base usually bears two lateral branches or outgrowths known as stipules.
2. **Petiole or mesopodium :** It is the stalk of the leaf. A long petiole pushes out the leaf blade and thus helps it to secure more sun light. When the petiole is absent, the leaf is said to be sessile and when present, it is said to be petiolate or stalked.
3. **Leaf blade or lamina or epipodium:** It is the green expanded portion. A strong vein known as mid rib runs centrally through the leaf blade from its base to the apex. It is the most important part of the leaf since is the seat of food manufacture for the entire plant.

DURATION OF THE LEAF

The leaf varies in its duration.

i. Caducous: The leaf veins in its duration it may fall off soon after it appears and then it is said to be caducous.

ii. Deciduous or annual : If it losts one season, usually falling off in winter

iii. Persistent or evergreen: If persists for more than one season.

LEAF APEX

Apex of the leaf is said to be

1. Obtuse : It is rounded as in banyan
2. Acute : It is pointed in the form of an acute angle, but not stiff as in China rose.
3. Acuminate or caudate : It is drawn out into a long slender tail as in *Ficus religious*.
4. Cuspidate : It ends in a long rigid shape (spiny) point, as in date palm, pineapple.
5. Truncate : It ends abruptly as if cuts off in a straight line as in Indian sago palm.
6. Retuse : The obtuse or truncate apex is famished with a shallow notch as in water lettuce
7. Emarginate : The apex is pointed with a deep notch as in Bauhinia
8. Mucronate : The rounded apex abruptly ends in a short point as in Ixora.
9. Cirrhose : It ends in a tendril as in glory lily, or in a slender curled, thread like appendage as in banana.

LEAF MARGIN

The margin of leaf may be:

1. Entire : even and smooth as in mango, jack, banyan etc.
2. Repand : shallowly wavy or undulating as in mango.
3. Sinuate : deeply undulating as in polyalthia.
4. Serrate : cut like the teeth of a saw and the teeth directing upwards as in rose.
5. Biserrate : doubly serrate (each tooth serrated again).
6. Serrulate : minutely serrate.
7. Dentate : teeth directled outwards at right angles to the margin of the leaf as in melon and waterlily.
8. Runcinate : serrated with the teeth pointed backwards.
9. Crenate : teeth round as in Bryophyllum.

10. Fimbriate : fringed with fine segments.

11. Ciliate : fringed with hairs.

12. Spinous : provided with spines.

LEAF SURFACE

The leaf is said to be:

1. Glabrous : Surface is smooth and free from hairs or outgrowth of any kind.
2. Rough : Surface is somewhat harsh to touch.
3. Glaucous : Surface is green and shining.
4. Scabrous : Rough surface due to prescence of short rigid points.
5. Gland dotted: glandular surface as in Lemon.
6. Spiny : Provided with spines.
7. Hairy : Covered densely or sparsely with hairs. A hairy surface may be:
    a) Pubescent : Covered with short, soft straight hairs.
    b) Pilose : Thinly covered with long, soft hairs.
    c) Villos : Thickly covered with long soft hairs.
    d) Tomentose : Densely covered with short soft more or less tangled hairs like cotton.
    c) Floccose : Dotting with lot of hairs easily detachable.
    i) Hispid : Beset with rigid or bristly hairs.
    g) Hissute : Covered with long, coarse stiff hairs.

SHAPE OF THE LEAF

1. ***Acicular or Acerose***(Needle-like): Needle shaped leaves like those found in many conifers, including pines, spruce, and firs. The leaves may be grouped in bundles as in pines or singly.
2. ***Linear*** : Long, thin and elongated leaf with parallel sides and no lobes.
3. ***Oblong***: An elongated, non-lobed leaf that is at least twice as long as wide
4. ***Gladiate and Ensiform*** : An elongated, non-lobed leaf that is sword-shaped.
5. ***Falcate*** : Falcate refers to a leaf that is hooked or curled in shape.
6. ***Lanceolate*** : An elongated, non-lobed leaf that is lance-shaped. The widest part of the blade is below the middle of the leaf.
7. ***Spatulate*** : A spoon-shaped leaf that has a rounded top and a tapering base.
8. ***Oblanceolate*** : The inverse of lanceolate(lance-shaped) with the attachment to the petiole being narrower than the tap.
9. ***Oval*** :An oval-shaped leaf with the middle greater than half the length.

10. ***Elliptic*** : A narrow oval the is boarder in the center than the ends. Each end tapers and are approximately the same size.
11. ***Ovate*** :An ovate or egg-shaped leaf blade that is narrower at the top than the base. The inverse of obovate.
12. ***Obovate*** : An egg-shaped leaf blade that is broader at the top than the base. The inverse of obovate.
13. ***Round or Orbicular*** : The leaf blade is a near circle in outline.
14. ***Cordate*** :The blade is heart-shaped with the wide part of the blade attached at the base. The inverse of obcordate.
15. ***Obcordate*** : Heart-shaped but with the narrow part of the leaf at the base. The inverse of cordate.
16. ***Reniform*** : The leaf blade is kidney-shaped .
17. ***Deltoid*** : A triangular-shaped leaf.
18. ***Rhomboid*** : A diamond-shaped leaf.
19. ***Hastate*** :An arrow-shaped leaf with lobes that point outward
20. ***Sagittate*** :An arrow-shaped leaf with lobes that point downward.
21. ***Flabellate*** :A fan-shaped leaf.
22. ***Peltate*** :The petiole is attached within the leaf blade rather than along the blade edge.
23. ***Subulate*** : These are the modified leaves found in some conifers. These are often referred to as awl-shaped or scale-like.
24. ***Oblique:*** two halves of the leaf is unequal as in begonia.
25. ***Cuneate:*** Narrow wedge-shaped with essentially straight sides, tapering to base; the leaf is attached at the narrow end. (or) Cuneate leaves have a small width at base, but then a broad width near the top before the apex
26. ***Lyrate:*** Shape is like that of lyre i.e with a large terminal lobe and some smaller lateral lobes as in radish.
27. ***Pedate:*** leaf is like the claw of a bird with the lobes spreading outwards as in Vitis.

VENATION

The arrangement of veins and veinlets in the leaf blade is known as venation. There are two types of venation.They are reticulate venation and parallel venation

1. Reticulate Venation

When the veins of a leaf show numerous irregular inter-connections giving the appearance of a network, it is called reticulate venation. This is characteristic of dicotyledons. It is of the following types:

a. Pinnate or Unicostate Type

If a leaf shows one vein more prominently than the others, it is described as unicostate condition. This prominent vein runs from the base of the leaf blade to its apex in a median longitudinal position. Hence it is the midrib of the leaf. The midrib produces veins which proceed towards the margin or apex of the leaf. These are then connected by veinlets forming a network. E.g., Mango, Peepul, Guava.

b. Palmate or Multicostate Type

If more than one prominent vein arises from the base of the leaf blade, it is described as multicostate condition. If the major veins converge towards the tip, then it is described as multicostate convergent (e.g. Zizyphus), or if they diverge, the venation is described as multicostate divergent (e.g. Cotton).

2. Parallel Venation

If the veins show a more or less parallel disposition, the condition is described as parallel venation. The parallely running veins are often connected at intervals by short links which are placed at right angles to the prominent parallel veins. Parallel venation is characteristic of leaves of monocotyledons. It is of the following types:

a. Pinnate or Unicostate Type

In this type, the leaf has a central prominent midrib. The midrib gives off lateral veins which proceed parallel to each other towards the margin or apex of the leaf, e.g. Banana.

b. Palmate or Multicostate Type

If more than one prominent vein arises from the base of the leaf blade, it is described as multicostate condition. A multicostate parallel convergent condition is seen in Bambusa arundinacea, whereas a multicostate parallel divergent condition is seen in Borassus.

PHYLLOTAXY

The pattern of arrangement of leaves on the stem is called phyllotaxy. There are three main types of phyllotaxy.

1. Alternate or Spiral

In this type, a single leaf arises at each node. The consecutive leaves are produced in a spiral manner around the stem. e.g. Polyalthia, Hibiscus, etc.

2. Opposite

In this type, the leaves are arranged in pairs at each node. When the opposite leaves arise in the same plane at successive nodes, it is said to be opposite superposed phyllotaxy. e.g., Quisqualis. When each opposite pair of leaves are at right angles to each other, phyllotaxy is said to be opposite decussate. e.g., Calotropis Ixora

3. Whorled Phyllotaxy

If more than two leaves occur at a node, the phyllotaxy is said to be whorled. e.g., Nerium.

Leaf Modification

1) **Leaf tendrils** are coiled structures that attaches a plant for support. A leaf tendril will generally have a bid in its axil or will be a modified leaflet of a compound leaf. Example: pea.

Types of Tendrils

Each type of tendril can be described best by noting its origin from a particular plant part.

- **leaf tendril**: developed from the entire leaf primordium.
- **leaflet tendril**: developed from a single leaflet of a compound leaf (as in many Bignoniaceae) or several of the most distal leaflets (as in sweetpea, *Lathyrus*)
- **stipular tendril**: developed from a stipule attached at the leaf base (Example: *Smilax*, a lianaceous monocotyledon)
- **leaf tip tendril**: developed from the apex of the developing leaf (Examples: glory lily, *Gloriosa* and another lily, *Littonia modesta*). This type of leaf apex is termed **cirrhose**.
- **prophyll tendril**: developed from a prophyll, which is the first leaf on a shoot
- **stem tendril** or **shoot tendril**: developed from a shoot apical meristem, and possibly having minute leaf primordia (Example: evergreen grape, *Rhoicissus capensis*)
- **pedicel tendril** or **peduncle tendril**: developed from the axis that subtends a flower

2) **Spines:** Spines are leaves modified for protection
3) **Stipules:** are small, leaf like structures ate the base of the petioles Stipules have a variety of functions a.) They care photosynthetic b.) They form protective spines c.) They become tendrils that coil around objects that they touch

Kinds of stipules:

According to the shape, portion, colour and size of the stipules they are of the following kinds.

* **The lateral stipules:** These are two free stipules usually small and green in colour borne on the two sides of the leaf base as in china rose, cotton etc.
* **Scaly stipules:** These are small dry scales, usually two in number borne on the two sides of the leaf base as in Desmodium.
* **Adnate stipules:** These are the two lateral stipules that grow along the petiole upto a

certain height adhering to it and making it somewhat winged in appearance as in rose, peanuts and strawberry.

* **Interpetlolar stipules:** These are the two stipules that lie between the petioles of opposite or whorled leaves, thus alternating with the later. They are seen in Ixora.
* **Ochreate stipules:** They form a hollow tube encircling the stem from the node upto a certain height of the internode in front of petiole as in Polygonum.
* **Foliaceous stipules:** These are two large green leafy structures as in pea, *Cassia auriculata.*
* **Bud scales:** These are scaly stipules which enclose and protect the vegetative buds and fall off as soon as the leaves unfold. (e.g.) banyan, jack.
* **Spinous stipules:** In gum tree, Indian plum, Mimosa, the stipules become modified into two wharp pointed structures known as spines one each on each side of the leaf base. Such spinous stipules give protection to the leaf against the attack of herbivorous animals.

4) **Window Leaves:** are shaped like tiny ice cream cones and grow mostly under ground, with only a small, transparent "window" tip protruding above soil level. Their windows allow light to penetrate and illuminate the chlorenchyma tissue, which is below soil level.
5) **Bracts:** are floral leaves that form at the base of a flower or a flower stalk. They are usually small and scale like and protect developing flowers attract pollinators or as a dispersal agent for seeds
6) **Storage Leaves:**

Storage Leaves Storage leaves of plans are fleshy, concentric leaves modified to store food. The leaves of most bulbs store sugar or starch

7) **Insect-Trapping Leaves:** Insect-Trapping Leaves In carnivorous plants, insect-trapping leaves are modified for attracting, trapping and digesting animals. Animals/insect which are caught are digested, and their nutrients are absorbed by the leaf.
8) **Leaves Modified for Reproduction:** Leaves Modified for Reproduction Succulent plants commonly have leaves that are modified for reproduction. Leaves of these plants produce tiny plants to become new individuals when they are shed from the parent leaves.

Lecture 3

Floral morphology: Kinds of Bracts, Inflorescence; Structure of flower, Androecium, Gynoecium, Placentation, Types of Fruits.

Bract

Flower consists of a stalk and is called pedicel. The flower is described as sessile if the pedicel is absent. Flowers are known as ebracteate in the absence of bracts. Bract-like green structures are present on the pedicel and are called bracteoles and the flower with presence of bractiole is called bracteolate and absence of bracteoles is described as ebracteolate.

Bracts are of various types:

- Foliaceous: Leaf-like bracts as in Adhantoda.
- Petaloid: Petal like bracts, peatloids is bracts where they are large and colored as in Bougainvillea.
- Involucre of bracts: Here many bracts form one or more whorled structures called involucres. Example: Head inflorescence of Helianthus.
- Spathe: Special type of bract covering the flowers in spadix inflorescence. Example: Aroids, *Cocos nucifera*.

Inflorescence

In angiosperm plants flowers are reproductive organs. Flower is a modified shoot and is adapted for the purpose of reproduction. Flowers may be single or they may occur in clusters. Clustered flowers are arranged on branches, different from the vegetative branches. Such floral branch is known as inflorescence. Modifications of the inflorescence involve length, nature of the internodes and phyllotaxis. It also considers variation in proportions, reduction, connations, adnations and compressions of the main and the secondary axis.

The stem holding the inflorescence is called a peduncle and the main stem holding the flowers is known as the rachis. The stalk of the flower is called pedicel. A flower in a inflorescence arrangement is known as a floret.

Inflorescence Definition

Inflorescence is defined as a cluster or group of flowers arranged on a stem which composes of a main branch or a complicated arrangement of branches. Inflorescence is basically the part of the shoot of flowering plants where the flowers formed are modified accordingly. An

inflorescence is defined as the reproductive part of a plant which bears a group of flowers in a specific pattern.

Inflorescence Types

Based on the arrangement of the flowers on the main axis or the peduncle and the timing of its flowering; inflorescence can be of two types determinate and indeterminate inflorescence.

Determinate inflorescence

- In determinate inflorescence the terminal axis is with a flower. In this type of inflorescence the youngest flowers are found on the bottom of an elongated axis or on the outside of a truncated axis.
- During the flower time, the apical meristem produces a flowering bud arresting the growth of the peduncle.
- Determinate inflorescence is seen in cymes, cymes are a flat-topped inflorescence in which the central flowers open first flowed by the flowers on the peripheral side.

Example: Onion.

Indeterminate inflorescence

- Here the axis continues to grow. In this type of inflorescence the youngest flowers are present at the top of an elongated axis or on the center of a truncated axis.
- Indeterminate inflorescence may be of many types like raceme, panicle, catkin, spike, carymb, umbel, head or spadix.

Based on branching characteristic inflorescence are of two types:

- **Unbranched** - They are also known as simple inflorescence
- **Branched** - They are also known as compound inflorescence, they are branched.

There are three main types of inflorescence in flowering plants:

I) Simple Inflorescence / Single Terminal Flower Inflorescence

- It is a type of extreme inflorescence where there is no branching, and complete determinacy is seen. Example: Magnolia.

II) *Racemose Inflorescence*

- It is indeterminate and unbranched type of inflorescence. In raceme type, new flowers are generated at the tip of the inflorescence. There is no definite determination and the axis never terminates in a flower. The main axis continues to grow and does not flower terminally. Flowers

laterally in accropetal manner where old flowers are arranged towards base and young flowers are at tip. When peduncle is broad then flowers are centripetally arranged.

The various forms of racemose inflorescence may be described under three heads.

i) those in which the main axis is elongated

ii) those in which the main axis is shortened.

iii) those in which the main axis becomes flattened, concave or convex.

Racemose inflorescence with elongated main axis

***Raceme* :** Simple raceme has long peduncle and bears on a number of pedicellate flowers in acropetal succession. Characteristic feature of Cruciferae family. Eg: Radish. When peduncle is branched and each branch bear pedicellated flowers like racemose and are arranged in acropetal manner known as compound raceme or panicle. Eg: Redgram, Lablab, *Crotalaria.*

Panicle : Panicle is a branched raceme. The peduncle produces a number of branches in acropetal succession. On these branches pedicellate flowers are produced in acropetal succession. Each flower of the spikelet in opposite rows. Spikelets are characteristic feature of the graminae. Eg. Paddy, wheat

***Spike* :** Spike inflorescence has a long peduncle which bears a number of sessile flowers in acropetal succession. Flowers are bisexual. *Example:* Ragi, *Amaranthus.*

***Catkin* :** Catkin is a type of spike inflorescence with a pendulous peduncle. Long, thin and weak peduncle. The flowers in this type of inflorescene are generally sessile and unisexual. *Example: Mulberry,* Betelvine, Pepper.

***Spadix* :** Spadix is a type of spike with a fleshy peduncle. The flowers are usually unisexual. The spadix inflorescence is always accompanied by a green or colourful bracts called spathe, which almost covers the spadix. *Example:* Colocasia, Maize, Palms and Banana

Racemose inflorescence with shortened main axis

Corymb*:* Corymb is a racemose inflorescence with a slightly shortened axis. The older flowers have the longer and the younger flowers have the shorter pedicels. As a result of this flowers the carymb inflorescence are found more or less at the same level of arrangement. *Example: Caesalpinia.*

Umbel : Umbel is also a type of racemose inflorescence whose main axis is shortened and at the tip bears a whorl of bracts. All the flowers are at the same level and they show centripetal arrangement. When the peduncle of this type of inflorescence is unbranched and bears a cluster

of flowers showing centripetal arrangement, this kind of inflorescence is called simple umbel. Compound umbel is where the peduncle is branched from the tip of each branch a luster of flowers is produced in an umbellate manner called a compound umbel. *Example: Coriander, carrot.*

Racemose inflorescence with flattened, concave /convex main axis

Head or capitulum: The main axis or receptacle is suppressed, becoming almost flat and the flowers are also without any stalk so that they become crowded together on the flat surface of the receptacle. In the receptacle, the outer flowers are older and open earlier than the inner ones. Although the inflorescence looks like a single flower, it really consisted of a clustered mass of small sessile flowers (florets) usually of two kinds *viz*., ray florets (marginal strap shaped ones) and disc florets (central tubular ones). The inflorescence is surrounded at the base by one or more whorls of often green bracts forming an involucre. Eg. Sunflower, Safflower.

III) Cymose Inflorescence

In the cymose inflorescence the main axis ends of the flower ends in a flower as the peduncle stops growing. The flowers in cyme show basipetal succession. The oldest flower is the apex and the youngest flower of the inflorescence is at the base of the inflorescence. The flowers are arranged in centrifugal manner, and the oldest flower is at the center and the young flowers are towards the margin.

- Cyme is a determinate and branched type of inflorescence.
- In cymose inflorescence axis terminate in a flower.
- Lateral branches of the flower develop below the terminal flower, each branch ends in a flower, they also produce lateral branches. Every axis terminates in a flower.

1. **Uniparous or monochasial cyme:** (unus: one; paresre: to produce). Here the main axis ends in a flower and it produces only one lateral branch at a time ending in a flower (Simple monochasium). If the lateral and succeeding branches again produce only one branch at a time like the primary one, it is called compound monochasium. There are two forms of uniparous cymes.

   a) Helicoid or one sided cyme: The lateral axes develop successively on the same side, evidently forming a sort of helix. Eg. Begonia.

   b) Scorpioid or alternate sided: The lateral branches develop on alternate sides, evidently forming a zig zag. Eg. Cotton.

2. **Biparous or Dichasial cyme:** (True cyme): Here the main axis ends in a flower and at the same time it produces two lateral younger flowers or two lateral branches. The lateral and succeeding branches in their turn behave in the same manner. Eg. Jasmine, Ixora.
3. **Multiparous or polychasial cyme:** The main axis, as usual ends in a flower and at the same time it again produces a number of lateral flowers around. There being a number of lateral flowers developing more or less simultaneously, the whole inflorescence looks like an umbel, but it is readily distinguished from the latter by the opening of the middle flower first. Eg. Madar, Calotropis.
4. **Compound and mixed forms:** If the main axis of the inflorescence is branched and the branches bear the flowers, the inflorescence is said to be compound. For example, when raceme is branched, it is called a compound raceme or panicle. Eg. Paddy, Sorghum

Flower

Flower is the specialized and modified shoot. Flowers are the reproductive organs of plants. Flower is the modified vegetative shoot and is meant for sexual reproduction. Flower arises from a modified leaf called bract. It consists of a very short axis on which whorls of different parts of the flower are present. The flowers are developed from the axils of the bract**,** these are leaves like structure. Bract protects the flower in the bud condition**.** If the bract is present the flower is called as bracteate**.** If the bract is absent then the flower is called as ebracteate**.** Whereas in bracteoles are also bract like structure present on the pedicel of the flower between the bract and the flower. These are small and thin than the bract**.** It may be one or two in number. If the bracteoles are present the flower is called bracteolate and if the bracteole is absent then the flower is called as ebracteolate.

Peduncle : Peduncle is the stalk of a flower.

Receptacle : Receptacle is the stem portion, it is found at the base in the center of the flower. The internodes are short and the number of leaves is small. Hence, receptacle is not usually a large part of the flower.

Epicalyx: A calyx-like extra whorl of floral appendages, positioned below the calyx. The individual segments resemble sepals and are termed episepals. An epicalyx is found in the members of the family Malvaceae.

Perianth: When there is no distinction between calyx and corolla the whorl is described as **perianth**. Individual perianth segments are called as **Tepals**. Green tepals are called **sepaloid** and coloured tepals are called **petaloid**. Tepals are free (polytepalous) or fused (gamotepalous). Eg: Graminae, Musaceae, Arecaceae family

Calyx

Sepals are collectively known as calyx. It forms the outermost whorl of a flower. They are usually green in color and their typical function is protection for the flower in bud stage and also supports the petals when in bloom. Morphologically sepals are modified leaves. The calyces are described as polysepalous when they are free from each other, example Brassica.

- Calyces are known gamosepalous when the sepals are united or fused; example - crotalaria.
- In plants like sunflower and tridax the sepals are reduced into hair like structures called pappus.
- The calyx is said to be caducous when the sepals fall off as soon as the flower opens. Example: Argemone.
- The calyx is deciduous if the sepals fall off at the same time as the corolla. Example: Mustard.
- In plants like brinjal and tomato, the sepals are persistent as they remain without falling off and are found on the fruit.
- In hibiscus the whorl of bracteoles is attached to calyx cup and is known as epicalyx.

Different types of sepals found in various flowers are given below:

i) **Polysepalous** : The calyces are described as polysepalous when they are free from each other. example Brassica.

ii) **gamosepalous** : Calyces are known gamosepalous when the sepals are united or fused; example - crotalaria.

iii) **pappus**: the sepals are reduced into hair like structures called pappus. Example- sunflower and tridax

iv) **caducous**: The calyx is said to be caducous when the sepals fall off as soon as the flower opens. Example: Argemone.

v) **deciduous** :The calyx is deciduous if the sepals fall off at the same time as the corolla. Example: Mustard.

vi) **persistent**: In plants like brinjal and tomato, the sepals are persistent as they remain without falling off and are found on the fruit.

vii) epicalyx: In hibiscus the whorl of bracteoles is attached to calyx cup and is known as epicalyx.

Corolla

Corolla makes up the second whorl of the flower and it is composed of petals. They are brightly colored, making the corolla conspicuous, and attractive. Petals are also scented in many cases. They help attracting insects for pollination.

- The corolla is described as polypetalous if the petals are free from one another. Example - Crotalaria.
- They are described gamopetalous if the petals are fused or united. Example - Nerium.
- The number of petals in the flower is a feature for classification of plants. In dicot plants, most frequently four or five petals are present. In flowers of monocot plants usually three or six petals are seen.
- The corolla may be either radially or bilaterally symmetrical. If the petals are in radial symmetry, all the petals are identical in size and shape the flower is said to be regular or actinomorphic. Example - Lily, buttercup.
- Many flowers are bilaterally symmetrical, that is they are symmetrical in only one plane, these flowers are said to be irregular or zygomorphic. Example - Orchids and members of pea family.

Forms of corolla:

A Regular and polypetalous:

i. Cruciform: It consists of four free petals each differentiated into a claw and a limb and these are arranged in the form of a cross as in cabbage, cauliflower etc.

ii. Caryophyllaceous: It consists of five petals with comparatively long claws and limbs of the petals are placed at right angles to the claws.

iii. Rosaceous: This form consists off five petals as with the previous case, but these have very short claws or none at all and the limbs spread regularly outwards as in rose, tea.

B. Regular and gamopetalous:

i. Companulate or bell shaped: when the shape of the corolla resembles that of a bell as in gooseberry, it is said to be companulate.

ii. Tubular: When the corolla is cylindrical or tube like, that is more or less equally expanded from base to apex as in the central florets of sunflower, it is said to be tubular.

iii. Funnel shaped or Infundibuliform: The corolla is shaped like a funnel, as in thorn-apple (Datura).

iv. Rotate or wheel shaped: when the tube of the corolla is narrow and short and the limb of it is at a right angle to the tube, the corolla having more or less the appearance of wheel as in jasmine.

v. Hypocrateriform or salver shaped: Sometimes in a rotate type the corolla tube is seen to be comparatively long and the corolla as a whole more or less salva-shaped as in Ixora.

C. Zygomorphic and polypetalous:

Papilionaceous or butterfly like: It is composed of five petals of which the outermost one is the largest and known as the standard or vexillum; the two lateral ones, partially covered by the former are somewhat like two wings of a butterfly are known as the wings or alae and the two inner most ones, apparently united to form a boat shaped cavity are the smallest and are together known as the keel or carina e.g.: papailonaceous family.

D. Zygomorphic and gamopetalous:

i. Bilabiate or two lipped: In this form the limb of the corolla is divided into two portions or lips - the upper and the lower with the mouth gaping wide open (eg.) Leucas, Adhatoda etc.

ii. Personate or masked: This is also two lipped like the previous one but in this case the lips are placed so near each other as to close the mouth of the corolla. The projection of the lower lip closing the mouth of the corolla is known as the palate (eg): snapdragon.

iii. Ligulate or strap shaped: When the corolla forms into a short narrow tube below but it flattened above like a strap as in the outer florets of sunflower, it is said to be ligulate.

Androecium

The stamens in the flower are called androecium. The androecium forms a whorl surrounding the gynoecium and is inside the perianth. Stamens can be free or fused in may

ways, like some stamens be fused but not all. It also can be, the filaments fused and the anthers free and the filaments free and the anthers fused. Usually the anthers have two locules, in some one of the locules may fail to develop or the two locules may merge late in development to give a single locule. Androphore is the term given to a column formed from the fusion of multiple filaments.

The anther can be attached to the filament in two ways basifixed and dorsifiexed.

- Basifixed is where the anther is attached at its base to the filament.
- Dorsifixed, here the anther is attached at its center to the filament, usually versatile.
- Exserted - The stamens extend beyond the corolla.
- Included - Here the stamens are not extending beyond the corolla.

a. Attachment of filament to anther lobe

The attachment of filament to anther lobe is of four types

i. Adnate Filament runs through the whole length of the anther from the base to the apex. Eg: *Verbena*

ii. Basifixed or innate Filament is attached to the base of the anther. Eg. Mustard.

iii. Dorsifixed The filament is attached to the back of the anther. Eg: *Citrus*

iv. Versatile Filament attached to the back of the anther at a point only, thus the anther can swing freely. Eg: Wheat, Maize.

b. Cohesion of stamens

The term 'cohesion', 'connate' and 'coherent' are used to designate the union of members of the same whorl (e.g): stamens with each other, carpels with each other. When stamens are united by their filament only, it is called adelphous. There are five types:

i. Monoadelphous When all the filaments are united into a single bundle but anthers are free from each other. Eg: Malvaceae family

ii. Diadelphous When the filaments are united in two bundles but the anther remains free. Eg: Chickpea, Peas, Redgram**.** In these plants among 10 stamens (9+1), nine stamens are arranged in a bundle while one stamen remains free.

iii. Polyadelphous When filaments are united into more than two bundles. Eg: Castor

iv. Syngenesious The anthers are united in bundle but filaments remain free Eg: Compositae family

v. Synandrous When anthers as well as filaments of stamens are united through their whole length Eg: Cucurbitaceae family.

c. Adhesion of stamens

When the stamens are attached to other parts of flower, then it is called adhesion of stamens.

i. Epipetalous: When stamens are attached to petals. Eg: Sesame and Sunflower.

ii. Epiphyllous: When stamens are attached to tepals. Eg: Liliaceae family.

iii. Gynandrous: When stamens are attached to gynoecium either throughout their whole length or by their anther Eg: *Calotropis*

d. Length of stamens

i. Didynamous : Out of four stamens, if two are long and two are short. Eg: Sesame

ii. Tetradynamous : Out of six stamens, the inner four are long and the outer two are short. Eg: Cruciferae.

e. Dehiscence of the pollen from anther

Dehiscence of the anther refers to the opening of anther to release pollen grains. It may be

1. Longitudinal : Dehiscing along the suture parallel to the long axis of thecae Eg. Cotton, Datura
2. Transverse: Dehiscing at right angle to the long axis of thecae Eg. Basil
3. Porous : Dehiscing by a pore at one end of thecae Eg. Solanum sp.
4. Valvular: Dehiscing through a pore covered by a flap of tissue (anther lobes open like a trap door or shutter). Eg. Cinnamon, Camphor, Bay leaf

Gynoecium

Gynoecium is the collective term used for carpels in a flower. Gynoecium consists of single carpel or multiple unfused carpels or multiple fused carpels. Typically each carpel contains one or more ovules. Post fertilization, ovule develops into seeds and the gynoecium forms the pericarp of the fruit.

- A gynoecium is described as monocarpus if it has a single carpel.
- It is an apocarpus, if the gynoecium has multiple carpels that are distinct, free, or unfused.

- If the multiple carpels of the gynoecium is fused into a single structure then the gynoecium is said to be syncarpous.

The relationship of the gynoecium to the other flower parts is an important systematic and taxonomic character.

- In some flowers the stamens, petals, and sepals are fused to forma a floral tube or hypanthium.
- The flower is said to be hypogynous if the hypanthium is absent. The stamens, petals and sepals are all attached to the receptacle below the gynoecium, they have a superior ovary. This type of arrangement is typical in most flowers.
- A flower is described as epigynous if the hypanthium is present and fused to the gynoecium up to the base of the style. Epigynous flowers often have inferior ovary. Plants with epigynous flowers are orchids, asters.
- Perigynous flowers are those in which a hypanthium is present but it is free from gynoecium or fused partly to the gynoecium . These flowers are referred to have half-inferior ovary. This arrangement is seen plants of rose family and saxifrages.
- Gynophore is the name given, when the gynoecium of the flower is borne on the stalk like in baldder pod.

OVULE

Each ovule is attached to the placenta by a slender stalk known as the funicle. The part of attachment of the body of the ovule to its stalk or funicle is known as the hilum. In the inverted ovule, the funicle continues beyond the hilum forming a sort of ridge, called the raphe. The upper end of the raphe which is the junction of the integuments and the nucellus is called the chalaza. The main body of the ovule is called the nucellus and it is surrounded by two coats termed as the integuments. A small opening left at the apex of the integuments is called the micropyle. Within the nucellus, there is a large oval cell lying embedded towards the micropylar ends, this is the embryosac which bears the embryo, the most important part of the ovule.

FORMS OF OVULE

1. **Orthotropous: (ortho- straight; tropos – a turn):** or **straight:** When the ovule is erect or straight so that the funicle, chalaza and micropyle lie on one and the same vertical line as in Piperaceae, Casuarinaceae. Eg. : Piper, Polygonium

2. **Anatropous: (ana – backwards) or inverted:** When the ovule bends along the funicle so that the micropyle lies close to the hilum, the micropyle and the chalaza, but not the funicle lie on the same straight line. This is the common form of ovule found in 82% of angiosperm families.
3. **Amphitropous: (amphi-on both sides) or transverse:** When the ovule is placed transversely at a right angle to its stalk or funicle. Ovule as well as embryo sac is curved like horse shoe. Eg. Lemna, Poppy, Alisma
4. **Campylotropous (Kampylos – curved) or curved:** When the transverse ovule is bent round like a horse shoe so that the micropyle and the chalaza do not lie on the same straight line as in Leguminosae and Cruciferae. Eg. : Crucifers
5. **Hemianatropous:** Ovule turns at 90^{o} angle upon the funicle or body of ovule and is at right angle to the funicle Eg. Ranunculus.
6. **Circinotropous:** The ovule turns at more than 360^{o} angle, so funicle becomes coiled around the ovule Eg. Opuntia (Cactaceae).

Placentation

Placentation in flowering plants occurs at position where the ovules are attached inside the ovary via the funiculi. The term placentation here refers to the arrangement of placentas inside a flower or fruit. The types of placentation are:

i. Marginal: In marginal placentation, the ovary is one chambered and the placenta develops along the junction of the two margins of the carpel, called the ventral suture as in Leguminaceae. The line or suture corresponding to the midrib of the carpel is known as the dorsal suture. No placenta develops here. Eg. Chickpea, Peas

ii. Axile: In axile placentation, the ovary is two to many chambered usually as many as the number of carpels and the placenta bearing the ovules develop from the central axis corresponding to the congluent margins of carpels and hence the name axile (lying in the axis) Eg. Lemon, Orange, Tomato, Ladiesfinger etc.

iii. Parietal: (parieties: wall): In parietal placentation, the ovary is one chambered and the placentae bearing the ovules develop on the inner wall of the ovary. In Cruciferae family, the placentation is also parietal although the ovary is two chambered. The ovary is at first unilocular but soon a false partition wall develops across the ovary dividing it

into two chamber while the seeds remain attached to a wiry frame work called the replum. Eg. Mustard, Cucumber

iv. Free-central: In free-central placentation, the placenta arises from the base of the ovary, projects far into its cavity as a swollen central axis and bears the ovules all over its surface. Since the placenta lies free in the single chamber of the ovary, the placentation is said to be free central. Eg. Primrose, Dianthus

v. Basal: In basal placentation, the ovary is unilocular and the placentae develops directly on the thalamus and bears a single ovule at the base of the ovary as in Compositae. Eg. Sunflower, Safflower

vi. Superficial: In superficial placentation, the ovary is multilocular, carpels being numerous as in axile placentation but the placenta in this case develop all around the inner surface of the partition walls. Eg. Waterlily (Nymphaea).

Aestivation

Aestivation or aestivation is the positional arrangement of the parts of flower in the flower bud before it is in bloom. Estivation is also sometimes referred to as prefoliation. It is an important taxonomic character.

Classes of aestavation are:

i. Valvate : When the petals of a whorl lie adjacent to each other. The petals slightly touch each other but not overlapping or overlapped. by their margin petal and just touches it. Petals do not overlapping**.**Eg: *Calotropis*, Custard-apple, Mustard.

ii. Twisted or contorted: One part of a petal covers adjacent petals and the other part is covered by posterior petal. One margin of the petal overlaps that of the next one, and the other margin is overlapped by the third one. Eg: Cotton, Ladiesfinger

iii. Imbricate: In aestivation of five parts one being exterior, one interior and rest three having one margin exterior and the other interior**.**

a) **Descending imbricate:** Posterior petal is outermost as in pea. It is otherwise called as vexillary aestivation.
b) **Ascending imbricate:** Posterior petal is innermost as in Cassias.

iv .Quincuncial: It is a modification of imbricate type. Out of the five petals, two are completely internal, two completely external and in the remaining petal, one margin is internal and the other margin is external. Eg: Guava.

Fruits

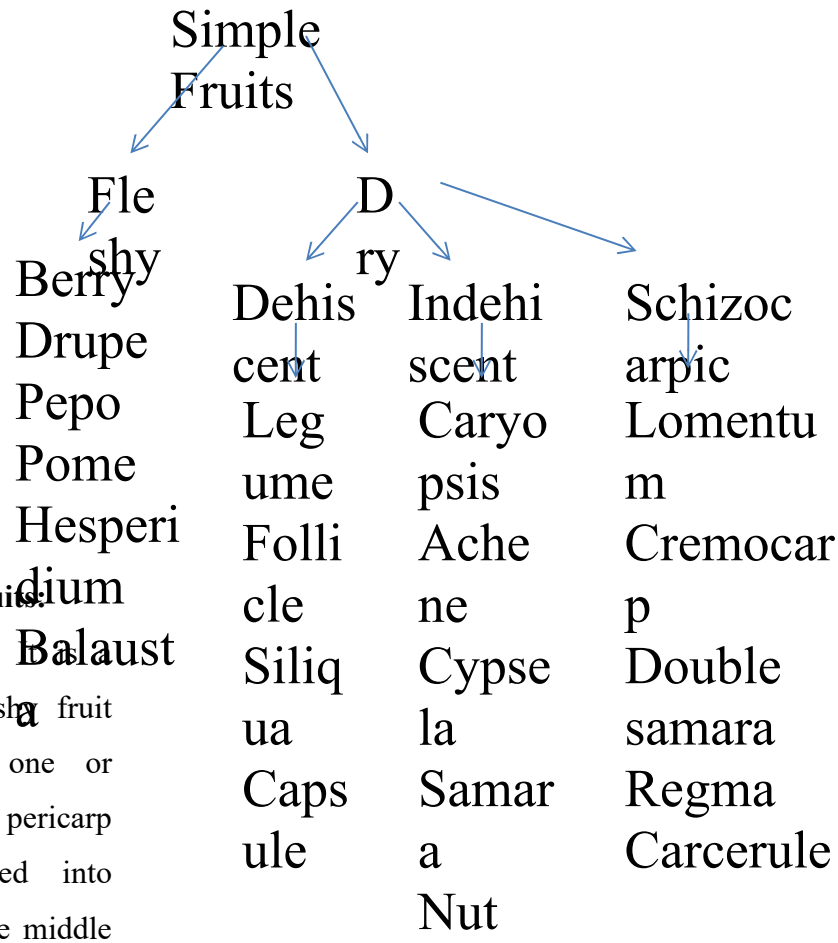
Fruits are nature's way of treating us with sweet and sour foods, that have many health benefits and help keep our mind, body, and skin healthy. One should make it a point of including these abundantly found and healthy foods in their daily diet.

Types of fruits

Fruits are divided in three groups

A) Simple B) Aggregate C) Multiple or Composite

A. SIMPLE FRUITS: The fruit which develops from the syncarpous ovary of a flower with or without accessory parts is called a simple fruit. In simple fruit, the pericarp may be fleshy and juicy or it may be hard and dry. The former are called fleshy fruits and the latter dry fruits.



Fleshy Fruits:

a. Drupe: It is a simple fleshy fruit enclosing one or more seeds. The pericarp is differentiated into outer epicarp, the middle fleshy or sometimes fibrous mesocarp and inner hard and stony endocarp. E.g. Mango, Coconut.

b. Berry: It is a simple fleshy fruit and generally many seeded. The pericarp has an outer thin epicarp and an inner fleshy mesocarp. E.g. Tomato, Brinjal, Grape.

c. Pepo: It is a simple fleshy fruit and generally many-seeded. It develops from an inferior, monolocular ovary, having parietal placentation. E.g. Cucumber, Watermelon.

d. Pome: It is a simple fleshy, false fruit. It develops from a syncarpous inferior ovary having axile placentation. After fertilization, the thalamus becomes fleshy and edible. But the actual fruit lies within. E.g. Apple.

e. Hesperidium: It is a simple fleshy fruit. It develops from a syncarpous inferior ovary having axile placentation. The pericarp is differentiated into outer thick, leathery epicarp having a number of oil glands, the middle white, spongy mesocarp closely attached to the inner side of the epicarp and the inner membranous endocarp projecting inwards forming distinct chambers. From the inner wall of the endocarp grow out numerous, thick, swollen hairs containing a syrupy juice. They are edible. e. g. Orange, Lemon.

f. Balausta: It is a multilocular and multiseeded fruit developed from inferior ovary. Pericarp and endocarp are hard**.** Persistent calyx is arranged in the form of crown. Seeds are irregularly arranged on placenta. Testa is fleshy. This is the edible part of fruit. Eg: Pomegranate

Dry fruits:

Dry dehiscent fruits:

In dry fruits, at maturity the pericarp may split or break open to liberate the seeds. Such fruits are called dry dehiscent fruits. Some of the common types of simple fruits are as follows:

a. Legume or podz: It is a simple, dry, dehiscent fruit developing from the monocarpellary, monolocular ovary having marginal placentation. At maturity, the pericarp splits along both the margins (sutures) to liberate seeds. e.g. Pea, Bean.

b. Follicle: It is a simple, dry, dehiscent fruit developing from the monolocular ovary having marginal placentation. The pericarp dehisces along only the ventral suture~ to liberate seeds. e. g. Calotropis, Asclepias, Michelia.

c. Siliqua: It is a simple, dry, dehiscent fruit developing from the bicarpellary, monolocular ovary having two parietal placentae. The ovary is monolocular in the beginning but becomes bilocular due to the development of a false septum called replum. The pericarp dehisces into two halves from below upwards. The seeds remain attached to the central replum. e.g. Mustard, Radish. But a short, broad and fat siliqua is called silicula, e.g., Capsella, Lepidium.

d. Capsule: It is a simple, dry, dehiscent fruit developing from the syncarpous ovary having axile placentation. The capsules are variously named according to their mode of dehiscence.

Loculicidal capsule

Here, the pericarp dehisces longitudinally along the middle of each loculus into as many valves as there are carpels. e.g., Lady's finger, Cotton

Speticidal capsule

Here, the pericarp splits longitudinally along the Septa and hence the fruit is called septicidal capsule. All the carpels get separated from one another but still the seeds are exposed as in loculicidal capsule. e.g. Aristolochia.

Septifragal capsule

Here, the pericarp breaks away completely from the septa and further the dehiscence may be of septicidal or loculicidal type. e.g. Datura.

Dry indehiscent fruits

These fruits do not dehisce but the seeds are released only after the decay of the pericarp.

a. Achene: It is simple, dry, indehiscent fruit developing from a superior monolocular ovary with a single ovule. The pericarp is dry, membranous and free from the seed coat. e.g. Mirabilis.

b. Caryopsis It is a simple, dry, indehiscent fruit developing from monocarpellary ovary with a single ovule. The pericarp is fused with the seed coat. e.g. Maize, Rice, Wheat.

c. Cypsela: It is a simple, dry, indehiscent fruit developing from inferior, bicarpellary, syncarpous, monolocular ovary with a single ovule. The pericarp is thin and free from the seed coat, e.g. Helianthus.

d. Samara: It is a simple, dry indehiscent fruit. The pericarp produces wings to help in dispersal. e.g. Acer, Dipterocarpus.

v. Nut

This is a single seeded fruit developed from monocarpellary syncarpous superior ovary. Hard pericarp Eg : *Anacardium occidentale* (Cashewnut) and Litchi. In Litchi epicarp and mesocarp are fused and give a leathery appearance. Endocarp is membrane like thin. Outer seed coat grows forward and forms an additional coat around the seed which is called as aril. In mature fruit, this aril is fleshy and is only edible part.

Dry splitting or Dry schizocarpic fruits

Here, the fruit dehisces into units called mericarps. Mericarps in turn split to release the seeds.

a. Cremocarp: It is a simple dry schizocarpic fruit developing from an inferior, syncarpous bilocular ovary. At maturity the fruit splits into two one seeded segments called mericarps. The two mericarps remain attached to a forked axis called carpophore. E.g. Coriander.

b. Regma: It is a simple, dry, schizocarpic fruit developing from superior ovary, having three to many carpels and three to many locules. At maturity it splits into as many parts as there are carpels. Each part encloses one or two seeds. E.g. Castor.

c. Lomentum: It is a simple, dry, schizocarpic fruit. The fruit is constricted or partitioned between seeds into a number of one-seeded compartments. The fruit breaks into one seeded indehiscent segments. E.g. : Mimosa pudica, Acacia.

d. **Double samara:** In maple (Acer), the fruit develops from a superior, bicarpellary ovary and when mature it splits into two samaras each with a wing and a seed.

e. **Carcerule:** This is small, dry indehiscent four chambered fruit developing from a superior bicarpellary pistil. This is the characteristic fruit of labiatae.

B. AGGREGATE FRUITS

A fruit that develops from the apocarpous ovary of a flower is called an aggregate fruit. It is a collection of simple fruits (fruitlets) all of which develop from the apocarpous ovaries of the same flower. After fertilisation, each carpel develops into a fruitlet and hence there will be as many fruitlets as there were carpels in the flower. Such an aggregate of simple fruits is also known as an etaerio. There are different types of aggregate fruits. Some of them are :

a. Etaerio of follicles e.g. Michelia.

b. Etaerio of achenes e.g. Clematis

c. Etaerio of drupes e.g. Rubus

d. Etaerio of berries e.g. Annon

C. MULTIPLE FRUITS

A fruit is said to be a multiple or composite fruit when a number of flowers forming an inflorescence produce a single fruit. Examples of multiple fruits include pineapple , jackfruit, fig, mulberry. Multiple fruit is composed of many inferior ovaries clutched together. Multiple fruits

are actually *multiples of simple fruits* with each simple fruit arising from its own flower with a single pistil.

There are two types of multiple fruits:

(1) Syconium or syconus

It is a type of multiple fruit that develops from hypanthodium type of inflorescence which is a flask-shaped, fleshy structure.

The inflorescence axis develops into a cup like structure or receptacle inside which are produced achene-like fruits (dry, one-seeded, indehiscent fruits), from the female flowers.

Example: fig (*Ficus hispida*), banyan (*Ficus benghalensis*).

(2) Sorosis

It is a type of multiple fruit that develops from spike type of inflorescence where the flowers of each inflorescence fuse with the rachis to form a compact structure. The rachis forms a thick part on which the fleshy edible perianth formed from fertile flowers are arranged. Between these are ribbons formed from sterile flowers. The spiny projections on the outer surface of the fruit represent the stigma. Example: Jackfruit (*Artocarpus heterophyllus*), pineapple (*Ananas comosus*), mulberry (*Morus indica*). The rachis, perianth and the bracts are also fleshy and succulent and form edible part of pine apple.

Lecture 4
Poaceae- Rice and Wheat

The cereals are annual grasses grown primarily for their large seed reserves "grains". In general they provide the main concentrated corbohydrate food for man and for livestock. The cereals grown in a given area depends largely on the climatic conditions. Thus wheat is the cereal mainly grown for human food in temperate climatic, wamer regions maize and in still hoter climates by rice- where irrigation by controlled flooding can be practised and where conditions are unsuitable for rice, millets are grown.

The word cereal is derived from the Roman word Cerealia munera meaning the gift of Goddness Ceres-the Roman Goddess of Agriculture. All cereals are members of grass family Poaceae grown for their edible starchy seeds. Cereals were the first plants to be domesticated. They were first used as food by merely parching or popping the grains. The six great cereals of the world are Wheat, Rice Corn, Barley, Oats and Rye.

With in the cereals there is another group termed Millets, which denotes a variety of small seeds. Originally millets are cultivated by ancient Egyptians, Greeks and Romans. The millets are again sub divided into major millets and minor millets or small millets.

Prominence of Cereals:

The cereals are cultivated in major parts of the world due to the following reasons.

- Greater adaptability
- Easy for cultivation
- Giving more yield per unit area – due to tillering habit
- Grains compact, dry and can be easily handled
- Grains can be easily separated form plants
- Grains has high nutritive value with higher percentage of CHO, sufficient protein (7-10%), fats, vitamins and minerals.

Pseudocereals :

There are certain botanicaly unrelated plants whose seeds are also used in a similar manner as that of cereals. Eg. Buck wheat (Agopyrum esculentum) and Grain amaranthus.

Description of Poaceae family:

- Most of the cereals are herbaceous annuals
- Stem or culm often errect, cylindrical, hollow exept at nodes
- Tillering habit, shallow fibrous root system

- Leaves alternate, distichous with parallel venation and sheathing leaf base
- Presence of ligules, lodicules
- Infloresence is panicle or spike
- Flowers are usually hermaphrodite (maize, monoecious an exception) and pollination is always anemophilous
- Stamens usually three (in rice - six)
- Fruit is a caryopsis

Systematic Position of Family Poaceae:

Division : Phanerogams
Subdivision : Angiosperms
Class : Monocotyledon
Series : Glumaceae
Subclass : Glumiflorae
Family : Poaceae

List of cultivated crops under Poaceae

Sl. No	Crop	Botanical Name	Chromosome number	Economic Part
1.	Rice	*Oryza sativa*	24	Grain
2.	Wheat	*Triticum aestivum*	42	Grain
3.	Maize	*Zea mays*	20	Grain
4.	Sorghum	*Sorghum bicolor*	20	Grain
5.	Pearl millet (Cumbu)	*Pennisetum glaucum*	14	Grain
6.	Finger millet (Ragi)	*Eleusine coracana*	36	Grain
7.	Foxtail millet (Tenai)	*Setaria italic*	18	Grain
8.	Barnyard millet (Kuduraivali)	*Echinochloa frumentacea*	36 & 54	Grain
9.	Proso Millet (Panivaragu)	*Panicum milliaceum*	36 & 72	Grain
10.	Little millet (Samai)	*Panicum sumatrense*	36	Grain
11.	Kodo millet (Varagu)	*Paspalum scrobiculatum*	40	Grain
12.	Sugar cane	*Saccharum officinarum*	80	Stem
13.	Napier grass	*Pennisetum purpureum*	28	Whole plant
14.	Guinea grass	*Panicum maximum*	18, 36 & 48	Whole plant
15.	Buffel grass	*Cenchrus setigerus*	32 to 40	Whole plant
16.	Spear grass	*Heteropogon contortus*	20	Whole plant
17.	Buffalo grass	*Brachiaria mutica*	36	Whole plant
18.	Marvel grass	*Dichanthium annulatum*	40	Whole plant
19.	Kollukottai grass	*Cenchrus ciliaris*	18 to 36	Whole plant
20.	Cumbu- Napier hybid	*Pennisetum glaucum x P. purpureum*	21	Whole plant
21.	Bermuda grass	*Cynodan dactylon*	30, 36 & 40	Whole plant

22.	Johnson grass	*Sorghum halapense*	40	Whole plant
23.	Fodder bajra	*Pennisetum glaucum*	14	Whole plant
24.	Fodder maize	*Zea mays*	20	Whole plant
25.	Sudan grass	*Sorghum arundinaceum var. sudanense*	20	Whole plant

RICE – *Oryza sativa* L. (2n = 24)

Tamil : Arisi / Nellu
Hindi: Chawal

Rice is the staple food of about half of the human race, and of the total area of 100 million hectares, over 90 per cent is grown in Southern and Eastem Asia. It is the most important tropical cereal and, on a world basis production is only slightly bellow that of wheat. Rice is usually cooked by boiling in water or by steaming and is eaten mostly with pulses, vegetables, fish or meat. It is the principal food for many millions of people. The unhusked grain, as well as the growing crop is known as paddy.

Systematic Position:

Division	:	Phanerogams
Sub-Division	:	Angiosperms
Class	:	Monocotyledon
Series	:	Glumacea
Sub class	:	Glumiflorae
Family	:	Poaceae
Sub family	:	Poaideae
Tribe	:	Oryzeae

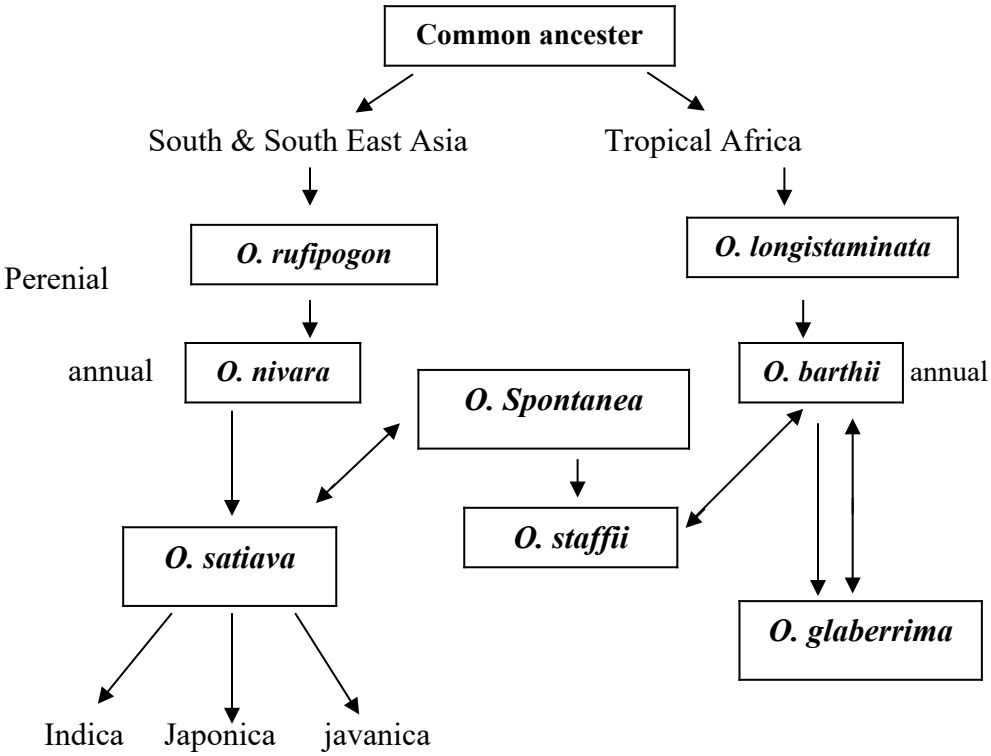
Origin:

Place of origin : S.E.Asia
Distribution : China, India, Bangladesh, Japan, Pakistan, Burma, Vietnam.

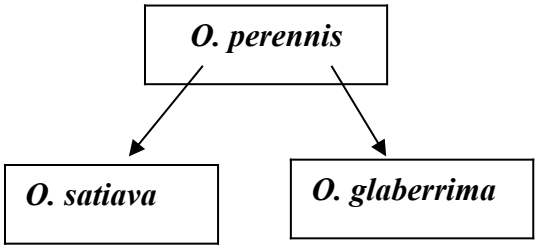
Putative parents and origin of cultivated rice:

There are two divergent views regarding the origin of cultivated rice.

Polyphyletic: Originated from several species. Acording to this theory, the two forms of cultivated rice viz., Asian rice *O. sativa* and African rice *O.glaberrima* have evolved independently in their respective regions from several species.



Monophyletic: According to this theory both Asian rice and African rice arose from a common parent (O.*perennis*). This view is the most accepted one because both Asian rice and African rice are similar except in glume pubescence, ligule size and colour of pericarp which is red in African rice.



Species in the genus oryza

Oryza barthii - Barth's rice
Oryza glaberrima - African rice
Oryza latifolia - broadleaf rice
Oryza longistaminata - longstamen rice
Oryza punctata - red rice
Oryza rufipogon - brownbeard rice
Oryza sativa – rice

The genus *oryza* include 26 species. Out of these two are cultivated diploids viz. *O.sativa* and *O.glaberrima* and rest are wild species which include both diploid and tetraploid forms.

Botanical name	Chromosome No.	Genome	Origin
Cultivated species			
Oryza sativa	24	AA	Asia
Oryza glaberrima	24	AA	Africa
Wild species			
Oryza nivara *(Oryza sativa f. spontanea)*	24	AA	Asia
Oryza meridionalis	24	-	Australia
Oryza longistaminata	24	AA	Africa
Oryza rufipogan	24	AA	Asia
Oryza glumaepatula	24	-	America
Oryza grandiglumis	48	CCDD	America
Oryza barthii	24	AA	Africa
Oryza australiensis	24	EE	Australia
Oryza latifolia	48	CCDD	America
Oryza alata	48	CCDD	America
Oryza eichingeri	24	CC	Africa
	48	BBCC	
Oryza minuta	48	BBCC	Asia
Oryza.punctata	48	BBCC	Asia
Oryza officinalis	24	CC	Asia
Oryza granulata	24	-	Asia
Oryza meyeriane	24	-	Asia
Oryza ridleyi	48	-	Asian
Oryza longiglumis	48	-	New Guninea
Oryza brachantha	24	FF	Africa
Oryza schlechter	-	-	New Guinea

Oryza perennis			
Oryza rhizomatis			
Oryza malampuzhaensis			
Oryza coarctata			

Subspecies in cultivated *Oryza sativa*

Rice has been in cultivation for long period and adapted well under diverse climatic conditions and soils. This has resulted in the evolution of three geographical races which has been given subspecies status. The three subspecies are:

i. **O. sativa** subsp **indica** : Tall spreading, more tillering, awnless
ii. **O. sativa** subsp **japonia** : Short, erect, more tillering, awnless
iii. **O. sativa** subsp **javanica** : Tallest, erect, poor tillering, awned

The morphological and physiological differences between the subspecies

Character	**indica**	**japonica**	**javanica**
Climatic zone	Tropical	Temperate	Equatorial
Photo period	Very sensitive	Not sensitive	Not sensitive
Duration	Long	Short	Very long
Response to Manuring	Low	High	Low
Lodging	Susceptible	Non lodging	Non lodging
Seed dormancy		Present	Absent
Grain shape	Long, narrow	Short, thick	Coarse, broad, thick
Plant colour	Light green	Dark green	Light green
Plant height	Tall	Short	Tall
Tiller number	Many	Moderate	Few
Shedding of grain	Susceptible	Resistant	Resistant
Flag leaf	Long, narrow, drooping	Short, broad, ercet	Long, wide semidrooping
Endosperm	Translucent	Chalky	--
Breaking during milling	High	Low	Low
Yield potential	Medium	High	Low
Market price	High	Low	Medium

Key Botanical features of Rice

Family	:	Poaceae.
Habitat	:	Tropical and Subtropical
Habit	:	Semi aquatic. Free tillering, annual, herbaceous species with fibrous adventitious root system
Roots	:	The young roots are white, thick, short and relatively unbranched. Later they branch freely and become flaccid and brown. The roots can grow under oxygen concentrations. Initially roots are positively geotropic but at panicle initiation, they grow horizontally and upwards to produce a dense surface mat giving more stability to the plant.
Stem	:	The jointed stem of rice called 'culm' is made up of a series of nodes and internodes, erect, cylindrical, hollow at the internodes and solid at the nodes. The node bears a leaf and a bud. Internodes are shorter at the base and becoming progressively longer at top.
Leaves	:	Alternate on the stem in two ranks one at each node. The leaf sheath is continuous with the leaf blade. There may be swelling at the base called pulvinous. The uppermost leaf below the panicle is called the flag leaf. There are two earlike appendages borne on either side of the base of the leaf called **auricles**. At the junction of the blade and sheath, on the inner side is a membranous or glabrous structure called **ligule**. Leaf sheath encircles the whole or part of the internode. Leaf blade long, narrow, pubescent having spiny hairs on the margins.
Inflorescence	:	Loose terminal panicle. Usually 10-30 cm long. It may be erect or drooping; base of the peduncle is enclosed in the sheath of flag leaf.

Spikelet : The spikelet consists of a minute axis (rachilla) on which a single floret is borne in the axils of 2-ranked bracts. The bracts of the lower pair on the rachilla are called as sterile glumes. The upper bracts or the fertile glumes are known as lemma and Palea. The lemma is the larger hardened, 5 nerved bract enveloping the 3 nerved palea. The extended tips of the lemma and palea are the apiculi. At the base of the lemma and palea are a pair of scale like, colourles, transparent lodicules which aid in the opening of the spikelet. At anthesis, the lodicules become turgid and thrust the lemma and palea apart exposing the fertile stamens. There are six fertile stamens in two rows of three each and anthers are versatile. Ovary is hypogynous, monocarpellary, unilocular with a single basal ovule and a pair of feathery stigmas at the top.

Fruit : Grain is caryopsis, the wall of the seed becomes fused with the ripening ovary wall to form the husk. Grains contain nearly 40-50% carbohydrates and 5-10% protein. Seed coat is pigmented and differentiated into epicarp, and mesocarp. Thin membranous pericarp adheres closely to the seed. Endosperm has single aleurone layer of polygonal cells with a central mass of thin walled parenchymatous tissue containing mostly starch.

Grain structure: The seed of the paddy is called "caryopsis". The ovule after fertilisation develops into the seed with its coats (outer cell layer) completely fused together with the developing ovary wall or pericarp. Under this circumstance, the fruit coat or the pericarp is fused with the seed coat.

l. The pericarp or fruit coat: The pericarp is made up of distinct layers of quadrangular cells which form the epicarp. These cells have slight thickening and are followed by cells which are much compressed and form the mesocarp consisting of two to three layers. The endocarp is a single layer of tube cells. The colour in the rice grain is found in the pericarp layer in the mature stage.

2. The seed coats: Due to the pressure brought out by the developing seed on the pericarp, the testa and tegmen become much pressed down and out of shape. A few layers of such cells below the pericarp can be diagnosed as the integuments of seed coats.

3. The aleurone layer: A prominent layer of rectangular cells which contain protein lying next to the seed coats. This layer is known as the aleurone layer. This layer in rice is not coloured unlike in the case of maize. It has been observed that in coloured varieties of rice, the aleurone layer is thicker than in the white rice varieties. The coarse rices generally have a larger aleurone layer than the finer rices. It has also been found that in poor soils, the aleurone layer is thin and improves in thickness with the fertility of the soil

and manure.

4. The endosperm: The entire mass of tissue below the aleurone layer is made up of cells which contain plenty of starch grains and these form the endosperm.

5. The embryo: The scutellum has an upper free part which has a fleshy projection known as the ventral scale. Below this upper ventral scale and almost at the middle of the free part there is another outgrowth which can be called as the 'inner ventral scale' and this inner ventral scale is peculiar to rice embryos only. On the surface of the embryo this outgrowth along with the epiblast forms a continuous covering around the plumule. The structure between the scutellum and the plumule is the mesocotyl.

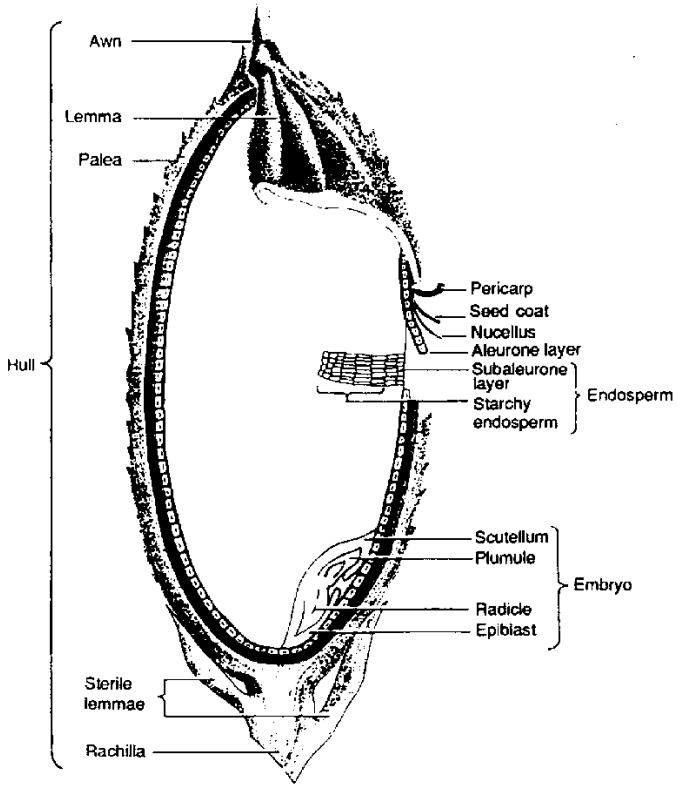


Fig 4.1. Cross sectional structure of rice grain

Classification of cultivated rice:

a) Agronomic classification of cultivated rice:

i. Low land rice – swamp rice; grown on irrigated or flooded lands
ii. Up land rice – hill rice or dry land paddy; grown as rain-fed crop
iii. Floating rice or deep water paddy – grown in areas of deep flooding

b) Classification based on quality characters:

1. **Size:** This classification is to classification is to distinguish trade grades; based on **FAO** recommendations.

   Extra long - over 7 mm

Long - 6-7 mm
Middling - 5-5.9 mm
Short - < 5 mm

2. **Shape:** Based on length breadth ratio (L/B ratio)

Slender or Fine - >3
eg. Basmati. (length 9mm and breadth 3mm then 9/3 = 3)
Medium slender or medium fine: 2.4 to 3.0 Eg. Ponni
Coarse or Bold - 2.0 to 2.39 eg. IR 20
Round - < 2 eg. Kar rice

3. **Endosperm structure**

Glutinous type: Soft endosperm that contains dextrin instead of strach. When cooked will become stricky. Useful for special preparations like "puttu". Used in Japan, china where people use chop sticks, for eating.

Non glutinous type: Contains starchy endosporm when cooked they remain flaky (non sticky). Non glutinous types are cultivated in worlds 90% of area.

Chemical Composition:

The main part used in rice is its grain. The grain or fruit is known as caryopsis the approximate nutrient content of rice is

Carbo hydrate	Protein	Water	Minerals	Others
80%	7%	10%	2%	1%

The caryopsis is also known as paddy or rough rice. The rough rice consists of 20% hull (ummi) i.e. lemma and palea. The process of removing the hull is known as hulling or milling. This can be done by hand pounding also.

After hulling the produce obtained is known as 'brown rice'. Then next step is known as polishing. The brown rice consists of pericap, nucellus, aleurone layer and embryo. All these are collectively known as bran (Thavidu). Which is rich in oils (15 to 20%) proteins, mineral salts and vitamins. During polishing process most of these are lost.

Par boiling of rice:

In this process the paddy is steeped in water for 24 hrs and then steamed under pressure. During steaming process the vitamins and minerals are preserved in the kernel due to absorption. After steaming the grains are dried and milled in the usual manner.

The advantages of parboiling are:

i. the grain under goes less breakage,
ii. it gives high yield of unbroken rice (head rice),
iii. have better keeping quality
iv. Preserves vitamins and minerals.

Comparison of different rice

	Hand pounded	**Milled and polished (Raw)**	**Parboiled**
Water	9.6	9.7	12.5
Protein	7.3	7.0	7.5
Fat	1.2	0.5	0.5
CHO	80.5	79.3	80.0
Ash	1.5	0.5	0.8

Economic uses of rice:

1. **Parched rice- Arisipori**

Parboiled rice is heated to a high temperature in an iron pan containing sand. The rice cracks and swells which is separated from the sand by sieving.

2. **Parched paddy – Nelpori**

The moistened paddy is dried in hotsun and then parched in hot like for parched rice preparation.

3. **Flaked rice- Aval**

Paddy is soaked in water for 2-3 days and then boiled for few minutes. After cooking, thewater is drained off and the paddy is heated in a shallow earthern vessel or iron pan till the husk burst open. Then it is pound in a wooden pestle, which flattens the rice kernel, and the husk is removed. Flaked rice is thin, pappery and half white in colour.

4. **Bran**

By product of rice milling used as cattle feed. Food uses of rice bran have Been explored in other countries in which both full fat and deoiled rice bran have been used in baby foods, breads,muffins, pancakes, cookies,cakes, pies,coatings and crests for finger foods, confectioneries, deep fried preparations, extruded snacks, soups, breakfast cereals and as spice carriers. Processed bran preparations are recently being marketed for use as additives and as a source of fibre in various foods at home. Rice bran has been used with milk to prepare rice bran milk, a nutritional high protein drink.

5. **Rice bran oil**

Rice bran oil is extracted immediately after milling the rice by hydraulic presses or with solvents. Rice Bran Oil has a balanced fatty acid profile close to the World Health Organization (WHO), American heart association's (AHA), the National institute of Nutrition (NIN) and the Indian Council of medical research (ICMR)

recommendation.Rice Bran Oil has more antioxidants (like oryzanol, tocotrienol, tocopherol, squalene) as compared to other cooking oils. This essentially results in health benefits like:-

a. Better Skin: - Squalene softens the skin as it is a natural moisturizer . This effectively helps delay wrinkle formation and protects the skin from sun damage and maintains a healthy skin tone.
b. Enhances the immune system: - Due to its high antioxidant content, it fights the free radicals that harm the immune system thereby protecting the body from disease. Besides benefiting the lipid profile, oryzanol also has anti dandruff and anti ageing properties.
c. Helps prevent cancer: - Rice Bran Oil is rich in tocopherol and tocotrienols (vitamin E) which are powerful antioxidants. These are anti-mutagenic elements that curb the cancer causing free radicals thereby reducing cancer risk. Until recent times the health aspects of Rice bran oil have not been adequately highlighted. It is important for people to know that rice bran oil has not only cholesterol lowering properties but also has anti viral, anti itching and anti cancer effects.
d. Nervous system and endocrine health :-_The antioxidants found in Rice Bran Oil also benefits the nervous system. Vitamin E helps improve neurological functioning and balances the endocrine hormones.

Rice Bran Oil retains antioxidant stability even at high temperatures. It has a high smoking point of 254°C. The usual frying temperatures are between 180°C- 190°C. Rice Bran Oil remains stable upto more than 250°C.

6. **Rice wine**

It is prepared by microbial fermentation of rice in water using yeast. Rice wine typically has a higher alcohol content, 18%–25% than grape wine (9%–16%). It is calles as ‘Santi’ in India, Japanese **Sake** or Chinese **Huangjiu**.

7. **Bran wax**

By product of bran oil extraction contains esters of fatty acid with higher alcohols used in chocolate industry, coating for candy, cosmetics etc.

8. **Husk**

Used as fuel in brick kiln and a substrate for compost making.

9. **Straw**

Used as cattle fee, straw pulp in paper industry, thatching,rope and baskets.

10. **Ground rice meal**

Derived from broken grain is used in confectionery.

11. **Rice starch**

Prepared after removing protein by caustic soda and starch purified by washing and centrifugation, which is used as laundry starch, food and cosmetics. Starch form rice is used in textile industry and also for manufacture of dextrin glucose

Rice and Green revolution

Green revolution in rice was started after the discovery of dwarf mutant Dee-Gee-Woo – Gen by a farmer in Taiwan. Utilising this in Taiwan developed first dwarf variety T (N) –1.

Later of this Dee Gee Woo Gen Was utilised in IRRI and released Wonder Rice IR 8. (Peta x Dee Gee Woo Gen.)

WHEAT – *Triticum sp*. (X = 7)
(Gothumai / Kottampam / Gothi / Godi /Genhu)

Wheat is the most important cereal in the world, giving about one-third of the total production, followed closely by rice. In temperate regions it is the major source of food. The chief use of wheat is the flour for making bread.

Systematic position:

Division	:	Phanerogams
Sub-Division	:	Angeosperms
Class	:	Monocotyledon
Series	:	Glumacea
Sub class	:	Glumiflorae
Family	:	poaceae
Tribe	:	Triticeae
Subfamily	:	Pooideae

Chromosome number:

Diploid (*Triticum monococum)*	:	2n =14
Teraploid (*Triticum dicoccum)*	:	2n = 28
Hexaploid (*Triticum* aestivum)	:	2n = 42

Distribution:

Wheat is basically a temperate crop, but is grown at higher altitudes in the tropics and also extends into the tropical lowlands of USSR, USA, China, India, France and Canada, in India: UP, Punjab, M.P. Haryana, Rajasthan, and Bihar are having major area under wheat.

Place of orgin:

Diploid	**:**	Asia minor
Teraploid	**:**	Abyssinia, North Africa
Hexaploid	**:**	Central Asia

Classification:

Ploidy level	Species	Common name	Genome
Diploid	*T. boeticum (T.aegilopoides)*	Wild einkorn	AA
(2n - 14) 2 species	*T.monococcum*	Einkorn	AA
Teraploid	*T. dicoccoidis*	Wild Emmer	AABB
(2n - 28) 7 species	*T. dicoccum*	Emmer	AABB
	T. durum	Macaroni wheat	AABB
	T. persicum	Persian wheat	AABB

	T. turgidum *T. polonicum* *T. timopheevi*	Rivet wheat Polish wheat --	AABB
Hexaploid (2n = 42) 5 species	*T. aestivum* *T. compactum* *T. sphaerococcum* *T. spelta* *T. macha*	Common or Bread wheat Club wheat Dwarf wheat Spelt what Macha wheat	 AABBDD AABBDD AABBDD AABBDD AABBDD

Origin of diploid wheat:

(Wild einkorn) *T. boeoticum* (*T.aegilopoidus*)

↓ (natural mutation and selection)

T. monoccocum Cultivated diploid AA (2n = 14)

T. boeoticum is probabley the ancester for all the cultivated wheats:

Origin of tetraploid wheats

T.boeoticum x *Aegilops speiltoides*

AA BB

2n = 14 ↓ 2n 14

F1 Sterile **(AB)** (2n= 14)

↓ (mutation and doubling)

T. dicoccoides 2n = 28 Wild emmer AABB

↓ By natural selection

T. dicoccum (Emmer wheat) AABB

(2n = 28) Cultivated

Related species of Triticum:

1. ***T. boeoticum*:**

Forms with one to two seeded spikelets occur. The brittle ears shatter at maturity into individual spikelets armed with awns which provide an effective means of seed dispersal.

2. ***T. monococcum*:**

Primitive diploid form domesticated, evolved from T. boeoticum by mutation and selection.

3. ***Aegilops speitoides*:** (2n = 14 : B genome)

It is naturally cross - polinating. It is the recognised donor of the B genome.

4. ***T. dicoccoides*:**

It is naturally cross-polinating. It is the recognised donor of the B genome.

5 ***T. dicoccum*:**

The spikes are dense, bearded and laterally compressed, the spikelets are two grained and the grains are retained within the glumes after threshing (speltoid). It is the oldest of the cultivated wheat.

6. ***T.durum*:**

Free threshing wheat with naked grains important of the tetraploid wheats. Grains contain high glutien.

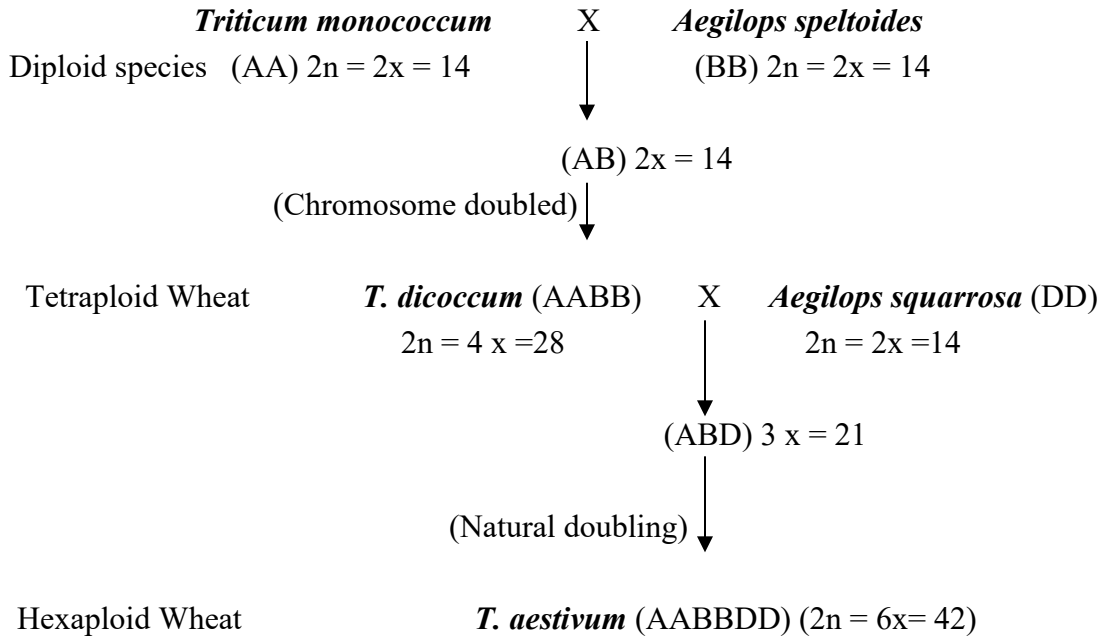
7. ***Ae. squarrosa*:**

It is the sourse of D genome in the cultivated hexaploid wheat, high adaptabiligy. (2n= 14: D genome).

8. ***T. spelta*:**

Hexaploid species, considered an amphidiploid from hybridization between T. dicoccoides and *Ae. squarrosa*.

The evolution of hexaploid bread wheat from its wild relatives.



The most important important of all the hexaploid wheat is the common bread wheat, *T.aestivum* grown in all parts of the tropics and sub tropics. From hexaploid wheat most modern wheats have been developed. It exhibits and extremely wide range of morphological and physiological variation and ecological adaptation.

Family description of Wheat

Habitat : Subtropical, temperate

Habit : Erect, annual which grows from 30 to 120 cm.

Roots : Mostly adventitious and fibrous

Stem : Cylindrical with distinct nodes and internodes. Usually there are six internodes and the sixth is the spike bearing one.

Leaves : Simple, alternate in distichous arrangement, long, linear lamina with leaf sheath covering the internodes, ligule membranous, auricles prominent.

Inflorescence: Terminal distichous spike, with tough rachis, awned or awnless, glabrous or hairy.

Spikelets : Sessile, distichous, single at each node of the rachis. Each spikelet has varying number of florets on a short jointed rachilla and the florets are also sessile on the rachilla and alternately arranged. A spikelet has two glumes. Lemma broad with an acute tip or awn, palea thin and membranous. Lodicules 2, stamens three with thin filaments and large anthers. Superior ovary, unilocular with a single ovule attached laterally to the ventral side of the loculus, styles two, each with a feathery stigma.

Fruit : Dry one seeded indehiscent fruit known as caryopsis containing 70% carbohydrate and 11% protein.

Structure of Wheat Grain

Fruit is a dry, one seeded indehisent fruit known as caryopsis. The grain may be either hard or soft in texture with a creamy white, amber, red or purple colour depending upon variety. It contains a protein called gluten which makes ideal for bread making.

i) The dorsal (back side) convex surface of kernal is smooth except at the base where the fruit coat is wrinkled indicating the position of embryo, the ventral surface (front side) is flat and characterised by a deep furrow or groove.

ii) The naked caryopsis has a prominent crease on the central side and is hairy at the apex.

iii) The fused pericarp and testa surrounds both endosperm and the embryo with scutellum in direct contct with the surface of endosperm.

iv) The axis of the primary root (radical) which is enclosed by the coleorhizae and the plumule with the perfeting sheath of the coleoptiles enclosing the primordial of two or three foliage leaves and the short apex.

v) The part of the axis between the point of attachment of the scutellum and the plumule is the mesocotyl which is the internode between the scutellum representing the cotyledon and the coleoptiles representing the next leaf.

The following 4 structures are recognised in wheat grain

i. Grain coat
ii. Nucellar epidermis
iii. Endosperm
v. Embryo.

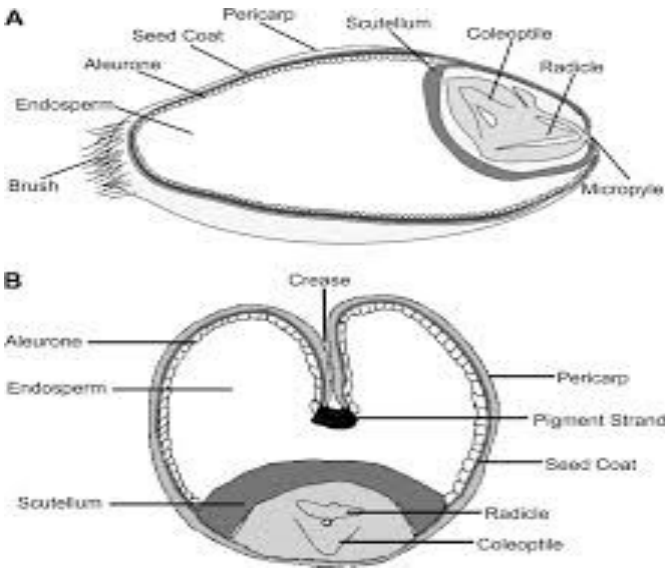


Fig. 4.2. Structure of wheat grain

Composition of The Grain

Bran coat	:	19-10 %
Embryo	:	2.5 %
Starchy endosperm	:	85-86 %
Aleurone layer	:	3 -4 %

Chemical Composition

	Grain	**Flour**
Water	13.0%	12.4%

Protein	11.5%	10.0%
Fat	2.0%	1.0%
Carbohydrate	70.0%	76.0%
Fibre	2.0 %	0.3%
Ash	1.5 %	0.3 %

Types of Wheat

In temperate countries cultivated wheat is classified into two categories.

Spring Wheat - short duration: March - May to August - September

Winter Wheat - long duration: October - November to May - July

Quality oF Wheat:

Depends mainly on the milling and baking qualities. Baking quality is assessed based on gluten content and are classified in to

a) Soft wheat and b) Hard wheat.

Soft wheat:

Pale, having a white starchy interior. Lower in gluten content and make a "weak" Flour. Suitable for making cakes and cookies. Protein 8 to 11%.

Hard wheat :

Dark and vitreous. Show no white starchy area. Higher in gluten content make a strong flour suitable for bread making. Protein 13 to 14 %.

Economic Importance of wheat

1. Wheat is the staple food of north Indian people.

2. Wheat grains are grounded into flour (atta) and consumed in the form of chapatee

3. Soft wheat is used for making chapathi, bread, cake, biscuits, pastry and other bakery products.

4. Hard wheat is used for manufacturing rawa, suji and sewaya.

5. In areas where rice is a staple food grain, wheat is eaten in the form of puri and uppumav.

6. It is also used for making flakes and sweet meats like kheer, shira, etc.

7. Wheat straw is used as fooder, padding material and mulching material.

8. *T. durum* paste is used for making macaroni, spaghetii, vermicelli and noodles.

9. Industrially starch, gluten, malt, distilled spirit.

10. Wheat bran is rich in proteins, valuable live stock feed.

11. Used as roughage in human food.

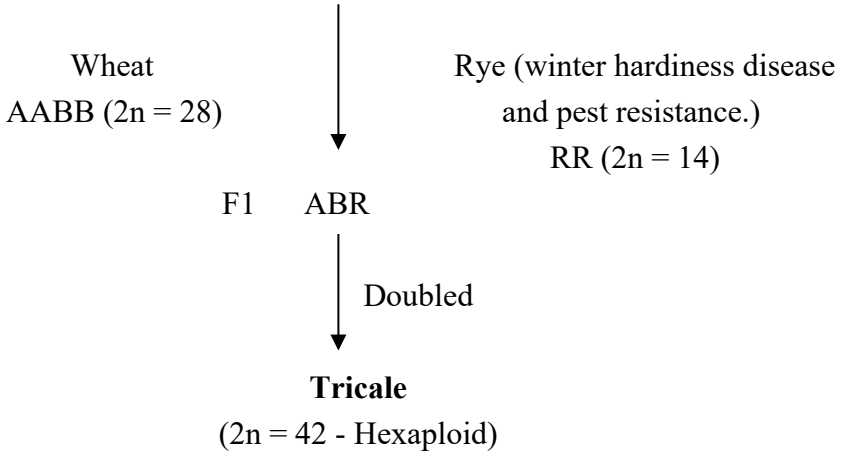
12. Wheat straw as livestock feed.
13. Corrugated board from straw.

Green Revolution in Wheat:

Started by Norman Borlaug in Mexico. He identified three dwarfing genes in the wheat variety NORIN - 10. Using this Mexican dwarf wheat, wheats with high yield potential were evolved. Wheat revolution in India was started by M.S. Swaminathan. Eg. Sharbathi Sonara, sonara 65, Kalyan Sona.

Man made cereal - Triticale

Triticum dicocum x ***Secale cereale***



Lecture 5

MAIZE - Zea mays (2n - 20)

(Corn/ Makka cholam / Konda cholam / Makka jonna / Makka)

Maize is the most important cereal in the world after wheat and rice; it was also most widely distributed. The genus Zea is considered to be monotypic previously. Recently Teosinte the related genera of Zea has been included as Zea mexicana.

Centre of origin	**:**	Southern Mexico.
Distribution	**:**	USA, China, Africa, Argentina, France, Mexico, Hungary.
In India	**:**	Uttar Pradesh, Bihar, Punjab, Himachal Pradesh, Karnataka, Tamil Nadu.

Systematic position

Division	:	Phanerogams
Sub – Division	:	Anageosperms
Class	:	Monocotyledon
Series	:	Glumacea
Sub class	:	Glumiflorae
Family	:	Poaceae
Sub family	:	Poaideae
Tribe	:	Maydeae

Closely related species and genera of zea:

Zea mexicana (Euchlaena mexicana) Teosinte (2n = 20): An annual grass which resembles maize in habit, but produces number of basal tillers. Distributed in Mexico as weed of maize. It corsses readily with maize and the hybrids are fertile with normal meiosis. Used as fodder.

Putative parents and origin of cultivated Maize

- The genus Zea was previously considered as monotypic.
- Later on *Teosinte* has been included *Euchlaena mexicana* has been changed as *Zea mexicana*
- Another wild relative is *Tripsacum dactyloide* (gamma grass) a perennial grass which is used as fodder

  All the three are inter crossable

There are three different views about the origin of maize.

1. It originated from Teosinte (Euchlaena mexicana) (Zea maxicana) by direct selection, mutation or hybridization with other grasses. Teosinte is having cob and tassel and easily crossable. This theory was not accepted based on cytological studies.

2. Another theory is that maize originated from a wild pod corn. Zea mays var. *tunicata* through natural mutation. This view is the most accepted one. But origin of pod corn is not known.
3. Another theory is that teosinte, tripsacum and maize, all descended from a common ancestor by divergent evolution but this common ancestor lost during evolution.

Classification:

Maize which is a cross polinated crop is classified in to seven varieties.

1. Dent corn:

Zea mays var. indentata - Characterised by a depression or dent at the tip of the kernel. The kernel consists of soft starch at the centre. The soft starch is surrounded by hard starch. Dent corn may be yellow, white or red in colour.

2. Flint corn:

Zea mays var. indurata - Central part of endosperm consists of soft starch surrounded by hard starch. Flint corn shrinks uniformly as it matures. The kernels are of various colours ranging from white to yellow, red and purple. The maize cultivated in Tamil Nadu is flint corn.

3. Sweet corn:

Zea mays var. saccharata - the kernels have a relatively large proportion of sugar. The corn is characterised by its translucent, horny appearance when immature and wrinkled at maturity. Baby corn is obtained from the sweet corn. Green cobs on 40^{th} day after sowing can be harvested and used as salad.

4. Flour corn or soft corn:

Zea mays var. amylacea - The kernels are filled with soft starch surrounded by a thin layer of hard starch. Because of soft starch it is ;easily ground and made into flour.

5. Wax corn:

Zea mays var. ceratina: The endosperm contains waxy starch which takes up red stain, when treated with iodine. Waxy starch is useful in manufacture of adhesives. Also useful in textile sizing and finishing.

6. Pop corn:

Zea mays var. everta- Contains higher percentage of hard starch with a little soft starch in the centre. The kernels are smaller. When exposed to high temperature they explode and grain turns inside out. The popping is due to formation of steam in the central part of the endosperm, where water is present. Due to steam pressure popping takes place.

7. Pod corn:

Zea mays var. tunicata: It is of less interest. It is a primitive tupe. The kernel is enclosed by tusk. It is mainly grown for breeding experiments.

Xenia

Xenia effect occurs in maize kemal, due to the effect of foreign pollen on the triploid endosperm. The expression of colour of endosperm is decided by the second nucleus of the

pollen uniting with the pollar nuclei of the embryo sac. (dominant gene Y is for yellow; recessive y for white).

Nutritive value of maize:

Moisture	Starch	Protein	Fat	Sugar	Pentosan	Ash	In the available protein zein predominates and deficient in tryptophan and lysine: this can be increased by the gene **Opaqyue-2**
20%	77%	9%	5%	2%	5%	2%	

Protein in corn is composed of two fractions:

a) Protein found in the embryo which is nutritionally balanced but it is 20 percent of the total protein present.

b) Protein found in the endosperm known as **Zein** which have inadequate amounts of two essential amino acide lysine and tryptophan. Here 80 percent of total protein is present.

Botanical features of MAIZE

Habitat : Tropical and subtropical.

Habit : Tall herbaceous annual, growing upto four meters, often single stalked, rarely tillering

Roots : Adventitious, generally thick and fibrous, stilt roots from the bottom nodes thick and often pigmented

Stem : Robust, erect, solid and cylindrical. Succulent nodes. Short at base and thick, progressively become longer and thicker

Leaves : Distichous, each with leaf sheath, ligule, auricle and lamina, sheath entire below and split above. Ligule is membranous, auricles broad, lamina long ribbon like with a strong mid rib and wavy.

Inflorescence : Unisexual and monoecious. Staminate inflorescence (tassel) terminal and the pistilate inflorescence (cob) axillary.

Tassel : Lax panicle, spikelets borne on the central axis in four to eleven rows and in the lateral branches in two rows, each row of spikelets occur in pairs, one sessile and another pedicellate but identical. The glumes G1 and G2 are long and membranous. Within the glumes there are two flowers, both staminate. Both the florets possess lemma, palea and two fleshy lodicules, stamens are three in number, versatile, pistil is rudimentary.

Cob : The ear bearing branch is much like main shoot. It is covered by husk or modified leaves. Spikelets are arranged regularly in longitudinal rows around a thick fleshy, central axis. The spikelets are in pairs, sessile and identical, each having two glumes and two lemmas. The glumes are much shorter than the spikelet, broad and fleshy at the base, thin and membranous above and fringed on the edges. Lemma I is thin hyaline, paleate, often lodiculate and sterile. Palea is thin and hyaline and the lodicules are present as minute scales. Lemma is short and broad, hyaline, lodicules generally absent. The staminodes may be present. The ovary is superior, unilocular with a single ovule. Style long reaching even up to forty five to fifty cm, its tip divided into two unequal lobes.

Fruit : Kernel or grain is a caryopsis which contains 79% strach and 9% protein.

Economic uses:

As human food : Corn flake, Corn meal, Corn puff, Pop corn, corn syrup, Corn oil, corn rice

As cattle feed : Grain as feed for poultry, piggery and cattle. Green fodder for silage and dry fodder

Industrial use :

Corn starch	-	Textile
Corn Grits	-	Corn flakes and starch
Brewer's grits	-	In breweries and distilleries.
Corn maida	-	Bread, biscuit, vermicelli, bajji, pakoda etc. Also used in gum manufacturing industry.
Corn oil	-	Cosmetic, edible oil - improves blood circulation, reduce fat etc., used as salad oil.
Corn syrup	-	Shoe polish, paper making
Corn sugar	-	Chemicals and leather industry
Glucose	-	Fermented liquor
Zein	-	Utilised for making artificial fibres with good tensile strength and wool - like qualities.
Corn cake	-	Cattle and poultry feed.

SORGHUM -Sorghum bicolor (L) Moench (2n = 20)
(Great millet / Indian millet / Milo / Cholam/ Jola / Jowar)

Sorghum is the fourth important world cereal, following wheat, rice and maize. It is the staple food in the drier parts of tropical Africa, India and China. The threshed grain is ground into a wholemeal flour, and used for making thin porridge or a thick paste or dough by boiling in water.

Systematic position:

Division	:	Phanerogams
Sub - Division	:	Anageosperms
Class	:	Monocotyledon
Series	:	Glumacea
Sub class	:	Glumiflorae
Family	:	Poaceae
Sub family	:	Poaideae
Tribe	:	Andropoganae
Sub tribe	:	Sorgasturm

Place of origin : Africa in the primary centre. India is the secondary centre of origin.

Distribution : India, Africa, China, Iran, Japan, Korea, USA, Australia.

In India : Maharastra, Gujarat, Andhra Pradesh, Madhya Pradesh, Karnataka,

Tamil Nadu and Rajasthan.

Classification:

Right from 16th century there were number of classification for the genus sorghum. The famous among them is Snowde's classification (1963) later refined by Garber (1950) and Dogged (1970).

Sorghum

Section I
Sorghum (True Sorghum)

Section II
Para sorghum (Other Sorghum)
S. versicolor
S. introns
S. purpureosericeum
S. nitidum
S. plumosum

Section I
Sorghum (True Sorghum)

Sub section
Arundinaceae (2n = 20)

Series
Spontanea (grass)
S. sudanense
S. aethiopicum
S. virgatum
S. verticicifolium
S.stapfii

Series
Sativa (grain)
S. vulgare
S. subglabaesence
S.dochna

Sub section
Halepensia (2n = 20, 40)
S. halepense
S. miliaceum
S. almum
S. Propinquum
S. radolphianum

The latest classification was done by **Harlan and de Wed** (1972). According to them, the cultivated sorghum ***Sorghum bicolor*** is divided in to five basic races based on the coverage of glume of the grain

1. Bicolor (B) Grain elongate, glumes, Clasping the grain which May be completely covered Or 1/4 exposed.	Bicolor	Guinea
2. Guinea (G): Grains flattened dorso -ventrally.		

3. Caudatum (C) Grains asymmetrical, glumes ½ the length of the grain	Caudatum	
4. Kaffir (K) Grains symmetrical (spherical), glumes clasping in varying length	Kafir	Durra
5. Durra (D) Grains rounded obovate, wedge shaped at the base and broadest slightly above the middle; glumes very wide		

Hybrid Races:

This consists of all combinations of the basic races.

1.	Guniea	biocolor	(GB)	6.	Guinea	Kaffir	(GK)
2.	Caudatum	biocolor	(CB)	7.	Guinea	durra	(GD)
3.	Kaffir	biocolor	(KB)	8.	Kaffir	caudatum	(KC)
4.	Durra	biocolor	(DB)	9.	Kaffir	durra	(KD)
5.	Guniea	caudatum	(GC)	10.	Durra	caudatum	(DC)

Wild sorghum sp. of Tamil Nadu:

S. halapense : Both 2n = 20 and 2n =40 forms are available and utilized for forage sorghum improvement

S. sudanense: Utilized for improvement of forage sorghum.

S. nitidum : Found in Kodai Hills. Pocesses shoot fly resistance and dormancy.

S. staffii : Found in Southern districts, used for inducing dormancy.

Land races Of Sorghum:

i. Peria manjal cholam
ii. Chinna manjal cholam
iii. Thalai virichan cholam
iv. Makkattai cholam
v. Sen cholam
vi. Irungu cholam
vii. Vellai cholam

Chemical composition:

	Whole grain	**Fresh plant (fodder)**
Water	8-16%	78-86%
Protein	8-15%	12%
Carbohydrate	70-74%	40-50%
Fibre	1-3%	20-30%
Fat	2-3%	

Ash	1.5-2%

Sorghum Poisoning

The aerial shoot of sorghum contain the cynogenic glycoside dhurrin, which by enzyme action hydrolizes to give hyrocyanic acid, (HCN). As little as 0.5g HCN is sufficient to kill a cow. Nitrogenous manuring increase HCN content. The poison is destroyed when the fodder is made into hay. HCN is more in dry land sorghum. It gets reduced after flowering.

Botanical features of Sorghum

Habitat	:	Tropical and subtropical
Habit	:	Annual, herbaceous, erect, single stalked or with tillers
Stem	:	Erect, solid, 50 to 180 cm in height, slightly furrowed on alternate sides, pithy, dry or juicy with light green thickened nodes. Internodes are short at the base and longer above
Leaves	:	Simple, alternate, glabrous, long, lanceolate, leaf blade is ribbon like with an acute apex, midrib prominent, ligule is short, membranous and fringed, present at the junction of leaf sheath and leaf blade.
Inflorescence	:	Usually compact panicle or semi compact or loose (lax) panicle. Terminal peduncle erect or recurved to give a pendent or goose neck appearance. Spikelets occur in pairs on the lateral branches of the panicle. One is sessile while the other spikelet is pedicelled. Sessile spikelet is bisexual or hermophrodite, pedicelled one is male or sterile. Sessile fertile spikelet is comparatively larger than staminate spikelet.
Fertile (perfect) spikelet	:	It has two glumes of approximately equal length (G_1 and G_2) having two flowers inside, lower is sterile with empty lemma (L) and no palea (P_1X) upper floret is perfect, bisexual, consists of membraneous lemma (L2). Two lodicules present adjacent to fertile lemma, lodicules are fleshy and truncate. Stamens three and versatile, pistil with roundish single celled ovary and two long styles ending in a feathery stigma.
Staminate (or) pedicelled spikelet	:	Spikelets are with long or short pedicel, two leathery boat shaped glumes encloses two florets. The lower floret is represented by the lemma only and the upper floret is staminate with short an awend lemma, palea absent, two lodicules, three stamens, pistil absent.
Fruit	:	Caryopsis, vary in shape and colour usually white or pale contains 70% carbohydrate and 12% protein.

Economic uses:

- Flour of sorghum is used for making porridge, biscuits or unleavened bread.
- Prop sorghums with horny endosperm used for popcorn making.
- Sorghum is also widely used for brewing beer which is a valuable dietary supplement because of its high vitamin B content.
- Sorghum with sweet stems containing up to 10 per cent sucrose, is used for chewing and manufacture of syrup.
- Sugar varieties containing 18 per cent Total Soluble Sugar (TSS), the juice is extracted, sterilized, fermented with yeast for 48 hrs. Distillation is done and 45% ethanol extracted. The grain is also used as valuable stock feed.

- Fodder sorghum principally used as fodder, hay and silage making.

PERALMILLET - Pennisetum glaucum L. (2n = 14)
(Bulrush millet / Spiked millet / Cat-tail millet / Cumbu / Sajja / Bajra)

Pearl millet is the staple food in the drier parts of Tropical Africa and in India, where it is the fourth most important cereal after rice, sorghum and wheat. The grains are also fed to poultry and other livestock. The green plants provide a useful fodder and it is sometimes grown for this purpose. It also plays a major role in fodder improvement by crossing with Napier grass.

SYSTEMATIC POSITION :

DIVISION : Phanerogams
Sub – Division: Anageosperms
Class : Monocotyledon
Series : Glumacea
Sub class : Glumiflorae
Family : Poaceae
Tribe : Paniceae

ORIGIN :

Place of origin :Africa
Distribution :Africa India, Pakistan, Bangladesh,
In India :Uttar pradesh, Punjab, Andhra Pradesh, Tamil Nadu and Rajasthan Gujarat, Maharastra,

CLASSIFICATION:

Stapf (1934) has classified the genus Pennisetum into five sections,

The cultivated Pennisetum glaucum belongs to the section Pennicillarea. This section consists of 32 species. Among this six are considered as wild and probable ancestors for the cultivated bajra. All these are found in Africa.

		SECTIONS		I.	P.perrottetti
1.	**Gymnothrix**			ii.	P.mollissimum
2.	**Eupennisetum**			iii.	P.violaceum
3.	**Pennicillarea**			iv.	P.versicolor
4.	**Heterostachya**			v.	P.adonense
5.	**Brevivalvula**			vi.	P.gymnothrix

ORIGIN OF PENNISETUM GLAUCUM:

The various sub species of pearl millet are Polyphyletic in origin, some being derived from one or several wild species, some of which occur as weeds in the cultivated crop, other races being derived by hybridisation. Pearl millet is a product of **multiple domestication.**

WILD SPECIES UTILISED:

P. purpureum - tetraploid, crosses freely with diploid P.glaucum and utilised extensively in forage crop improvement. The triplod sterile hybrids produced by these crosses are named as bajra napier hybrids or napier bajra hybrids.

E.g. NB 21, BN 2

CHARACTERISTICS FEATURES OF BAJRA :

1. Spikelet subtended by involucre of bristles.
2. Lodicules are absent (flower opening does not occur, only androecium and gynoecium protrude out).
3. Pennicillate anthers (anther tip cilliated - charecteristic of the genus Pennisetum)
4. Fused style with bifid stigma.
5. Protogynous nature.

CHEMICAL COMPOSITION OF GRAIN :

Water	Carbohydrate	Protein	Fat	Fibre	Ash
12%	67%	11%	5%	1.2%	2.7%

Botanical features of CUMBU

Family	:	Poaceae
Habitat	:	Tropical and subtropical
Habit	:	Erect, annual, tillering habit and growing up to three metres
Stem	:	Solid, slender or stout, round. Nodes slightly swollen with ring of silky hairs while internodes are cylindrical and glabrous. The inter nodal length increases from the base of the culm upwards.
Leaves	:	Linear, usually with sparse hairs or very hairy or glabrous. The base of the blade is slightly auricled. The ligule is narrow membranous with a fringe of hairs. It closely surrounds the stem. The leaf sheath completely encircles the stem
Inflorescence	:	Terminal panicle, spiciform (or) cylindrical, peduncle is thin, cylindrical, clothed with soft, more or less woolly hairs below the base of the spikelets. Central rachis cylindrical bearing densely packed clusters of spikelets arranged spirally on the rachis, rachillae small bearing involucre of bristles and a cluster of one to two spikelets. Each spikelet has two glumes. The lower glume short and broad, membranous. The upper glume is about the half the length the spikelet. Inside the glume, there are two flowers, the lower one staminate, sterile and the upper flower

perfect. Lower floret contains L1 (broadly oblong to ovate and cuspidate) and P1 is membranous. Stamens three with characteristic penicillate anthers, no ovary, lodicules absent.

In the upper perfect floret, L_2 is long and oblong and P2 is tougher than P1, Stamens three, penicillte anthers. Ovary with single style, flowering protogynous. Stigma bifid at the top and non plumose.

Seed : Caryopsis is grey rarely yellow contain 12% protein and 67% carbohydrate.

USES:

Flour	-	Preparation of cakes or unleavened bread
Grain	-	Malted seed is an important source of beer. Feed for poultry and other livestock
Green plant	-	Fodder
Straw	-	Feed for livestock, bedding, thatching, fencing and fuel

RAGI - Eleusine coracana Gaertn. (2n = 36)
(Finger millet / Kezhvaragu / Mutthair/ Thamida / Nacheni / Mandal)

Finger millet is an important staple food in parts of East and Central Africa. And India, particularly in Karnataka. It is used for malting and brewing.

SYSTEMATIC POSITION :

DIVISION	**:**	Phanerogams
Sub - Division	:	Anageosperms
Class	**:**	Monocotyledon
Series	**:**	Glumacea
Sub class	**:**	Glumiflorae
Family	**:**	Poaceae
Tribe	**:**	Eragrostideae

ORIGIN :

Place of origin:		India
Distribution	**:**	India, Africa Srilanka japan,
In India	**:**	Karnataka, Tamil Nadu, Maharastra, Andhra Pradesh Bihar, and Uttar Pradesh.

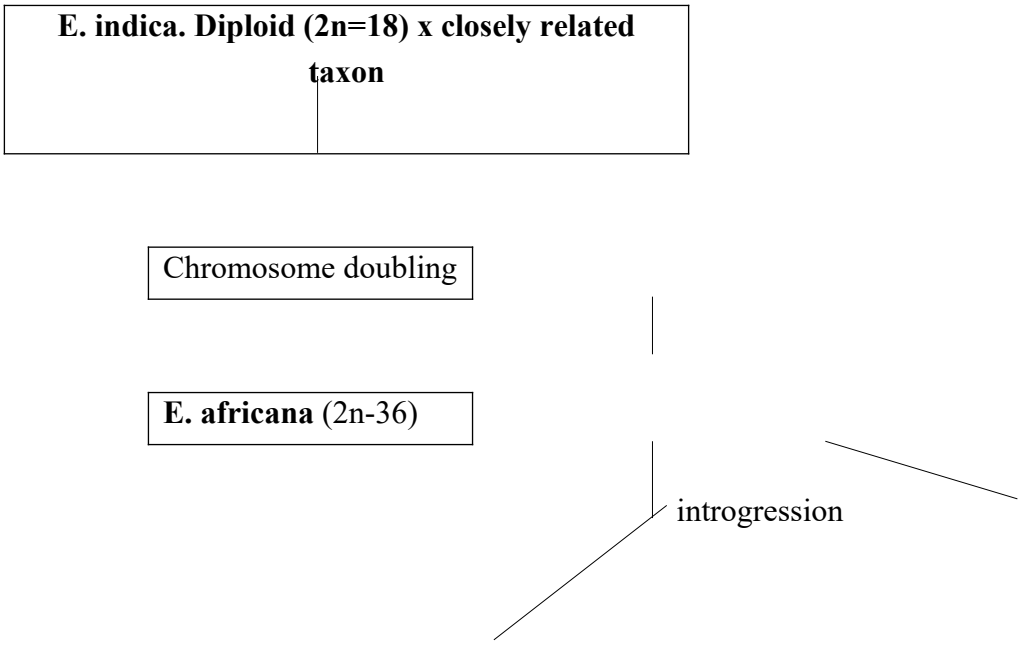
CLASSIFICATION :

The genus Eleusine consists of eleven species. Of these six are diploids and five are tetraploids.

Eleusine indica is a diploid with 2n - 18. **Eleusine coracana** and **E. africana** are tetraploids (2n = 36).

ORIGIN OF CULTIVATED SPECIES:

E. indica is considered as one of the parent for the tetraploid E.africana E. coracana is mutant selected from of E. africana.



mutant

E.coracana (2n = 36)Tetraploid

Hybridisation and introgression between E.coracana and E.africana continued and still continues in the highlands of Tropical Africa.

CHARACTERS OF ELEUSINE:

Infloresence is contracted into a number of digitate spikes of spikelet. Spikelet consists of more than two florets subtended by two glumes.

CULTIVATED TYPES OF RAGI :

There are two cultivated types of rigi.

1. Indian ragi, E.Coracana and **2. African ragi, E.africana.**

African ragi.

It has long fingers, bold grain, stiff straw, photo sensitive and uneven grain maturity phase.

Indian ragi:

Short fingers, small grains, photo insensitive.

TYPES OF RAGI BASED ON EARHEAD SHAPE :

Fisty	:	Incurving so deep that gives a fisty appearance
Incurved	:	Practically closes the central cavity
Top curved	:	The top of each finger is curved towards the inner cavity
Open	:	The fingers are errect
Cock's comb	:	Just like comb of a cock.

FRUIT:

Utricle, pericarp forms a thin, wrinkled, papery covering not fused with seed and break away easily from the seed. Colour of seed coat may be white or brown.

CHEMICAL COMPOSITION :

Water	Protein	Fat	Carbohydrates	Fibre	Ash	Calcium
13%	8%	1.3%	72%	3%	2.7%	0.33%
The grain is also rich in phosphorous and iron						

Botanical features of Ragi (Finger millet)

Family	:	Poaceae
Habitat	:	Tropical and subtropical
Habit	:	Annual, herbaceous, tillers well and branches freely
Stem	:	Compressed, elliptic, bearing many distichous leaves
Leaves	:	Linear with distinct midrib and ligule with fringe of hairs
Inflorescence	:	Terminal digitate panicle borne on a long peduncle from the end of which four to five spike radiate in a whorl called finger with an odd one, a little lower down the whorl and called the thumb. Rachis of the spikes is flat. Spikelets are sessile arranged on two rows alternately attached to one side of the rachis. Each spikelet is having 3-7 flowers enclosed by common glumes (G1 and G2).
	:	Florets are hermaphrodites with boat shaped lemma and a small palea with two styles with plumose stigma. The terminal floret sterile.
Fruit	:	Blader shaped utricle. Grain contains 72% carbohydrates and 8% protein. The grain is a rich source of calcium (0.33%) and also rich in phosphorus and iron.

USES:

Grain:

Grain is usually converted into flour and used for a variety of preparations – cakes, pudding, porridge etc.

Ragi is recommended as a wholesome food for diabetic patients

Grain is used in malting and brewing

Straw is a nutrition fodder for cattle and may be fed green or hay

Grains can be stored for long periods upto ten years or more without deterioration or weevil damage. It is an important famine food.

Ragi malt:

Food for the aged and children.

Straw:

Cattle feed.

Lecture- 6

Guinea grass, Napier grass, *Cenchrus* and Sugarcane

GUINEA GRASS

Panicum maximum (2n=18, 36, 48)

Place of Origin : Africa
Distribution : West Indies, Jamaica, Tamil Nadu, Karnataka, Andhra Pradesh, Maharastra, Gujarat.
Propagation : Root slips.

Botanical features of Guinea grass

Habitat : Tropical.

Habit : A dense, erect, perennial, rhizomatous grass, culms with big internodes, slender and glabrous nodes and leaf sheath pubescent.

Leaves : Leaf blade long, upto 60 cm, and 2-2.5 cm broad, little rough and succulent, linear, non droopy.

Inflorescence : Open terminal panicle with stiff branches in whorls. Spikelets small, glumes two, small, first lemma paleate sterile, second lemma fertile, paleate, stamens three, ovary with two styles and plumose stigmas.

Grains : Small, enclosed by the rigose lemma and palea and deciduous.

Economic uses:

Highly palatable grass, with high dry matter content (15-20%) It is a very good grass for grazing, green fodder and silage making, grown in many sewage farms. It is free from all known toxic principles. It contains 5-8% protein with well balanced calcium and phosphorus. It is useful as a soil binder to protect against soil erosion. .

NAPIER GRASS (Elephant grass)

Pennisetum purpureum* (*2n=28)

Place of Origin : Africa
Distribution : West Indies, Jamaica, Tamil Nadu, Karnataka, Andhra Pradesh, Maharastra, Gujarat.
Propagation : Root slips.

Botanical features of Napier grass

Habitat : Tropical

Habit : Perennial, tall, profuse tillering with creeping rhizomes

Leaves : Linear, long, dull green with hairy ligules

Inflorescence : Terminal, dense, spiciform panicle. Yellow or tinged with brown or purple. Spikelets lanceolate, one or two flowered, G1, G2 minute. Lemma one paleate, staminate, lemma two paleate, bisexual, stamens three, penicillate anthers, style long, connate, bifid stigma.

Grains : Small, oblong

Economic uses

Leaf contains 5-7% protein with balanced proportion of calcium and phosphorus. It is coarse for hay making

CUMBU NAPIER HYBRID

(Bajra x Napier) – **BN hybrids** (Napier x Bajra) **– NB hybrids**

Pennisetum glaucum* x *P. purpureum

2 n = 14 | 1n = 28

2n = 21

Sterile but vigorous

It appears like *P. Purpurcum* with greenish bristle. Hybrid is high yielding. Perennial grass, protein 6-8%, good for hay making, comes up well in sewage water. Propagated by root slips or stem cuttings are very vigorous in their growth and highly adaptable. High yielders, Nutritious, palatable, succulent, juicy, less fibrous fodder. Protein 8-10% hay making. Rich in calcium, phosphorus and high carotene (vit A) and vit. D Lucerne meal used in cattle and poultry feed. Good as a green fodder and as well as for silage.

KOLUKATTAI GRASS

Cenchrus spp. **(*2n=18, 36)***

- White kolukattai : *C. ciliaris*
- Neela kolukattai : *C. glaucus*
- Black kolukatti : *C. setigerus*

Place of Origin : Africa

Distribution : West Indies, Jamaica, Tamil Nadu, Karnataka, Andhra Pradesh, Maharastra, Gujarat.

Propagation : Root slips

Botanical features of *Cenchrus* (Kolukattai grass) *Cenchrus* **spp.**

Habitat : Tropical

Habit : Perennial grass with underground rhizomes

Stem : Aerial branches, tufted, erect or decumbent, tillering

Leaves : Leaf sheath slightly compressed, shorter than the internodes with

scattered hairs, ligule short, thin, membrane fringed with hairs, the leaf blade is linear with hairs scattered above and sparse at the lower surface.

Inflorescence : A raceme of spikes, floral axis flattened and grooved, one to three spikelets subtended by involucre of bristles, connate at the base, spikelets sessile, oblong lanceolate, first glume is small, hyaline, ovate-lanceolate, second glume ovate, acute, hyaline and one-third to half the length of the lemma, first lemma paleate, staminate or sessile, second lemma paleate with hermophrodite flower, stamens three, ovary with two plumose stigmas, lodicules absent, grain small, oblong .

Economic uses:

Suited for grazing as well as a cut fodder. It makes a good hay as it retains its mutative value even when ape. It is suited to grow under leucacna as silvipastute .

SUGARCANE

Saccharum officinarum. (2n = 80)

Origin : South Pacific

Distribution : Tropical countries of the world. India, Brazil, China, Mexico, Srilanka, Pakistan, Africa, South America.

In India : Uttra Pradesh, Maharastra, Tamil Nadu, Andhra Pradesh, Karnataka, Haryana, Punjab, Orissa, Gujarat, Rajasthan, highest yield is obtained in Tamil Nadu.

Classification:

Three cultivated and two wild species were recognized by Barber.

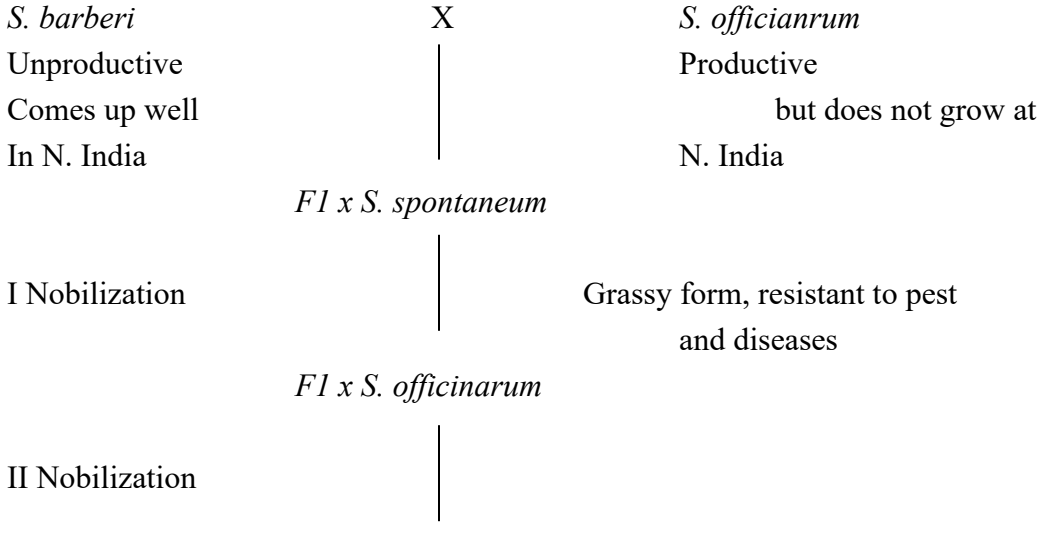
1. *Saccharum officinarum – noble cane* (2n = 80)
    - Large barreled,
    - Low fibre.
    - High sucrose content
    - Susceptible to diseases and pests.
2. S. *barberi – Indian cane* (2n = 82 - 124)
    - Intermediate between noble cane and wild cane, internodes cylindrical.
    - Small barelled, Internodes spindle shaped.
    - High fibre content.
    - Resistant to disease.

3. *S. sinense – chinese cane* (2n = 118)
    - Hard, small barelled.
    - Mainly used as fodder.
    - Resistant to diseases.
    - Fair amount of sucrose.
4. *S. spontaneum – Wild cane* (2n = 40 - 128)
    - Vigorous, thin, grassy forms.
    - Virtually no sucrose.
    - Resistant to drought, pest and diseases.
5. *S. robustum – Wild cane* (2n = 60-194)
    - Thick stalks.
    - Low sucrose content
    - Disease resistant.

The above five species are important for the improvement of sugar cane. All these species intercross freely.

Nobilization of sugarcane:

Nobilization process in sugarcane was started by C.A. Barber and T. S. Venkataraman at Coimbatore . Crosses were made between unproductive canes of North India, *S. barberi* and Tropical Noble Cane. *S. officinarum* (susceptible to diseases) which is productive but susceptible to diseases. The hybrids then crossed to S. spontaneum thus transfering the vigour and disease resistance from *S. spontaneum* and evolved varieties suitable for North Indian conditions.

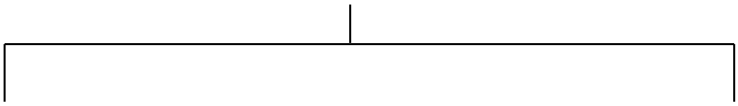


Noble canes suitable for Cultivation in N. India

Classification of Saccharum according to Jesweit:

Jesweit's Classification of Saccharum

A) Main axis of inflorescence with long hairs, glumes always 4 (Lodicules.2 present) Pedicellate spikelet blooms first. Culms green, greyish green, or white.

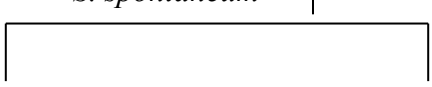


Lodicules ciliate
Long subterranean present
Runners present
Growing wild

Lodicules not ciliate Runners short

Cultivated

S. spontaneum



Leaves broad Long canes

Internodes Spindle shaped

S. sinense

Leaves narrow Short
Canes Ligular proess prominent
Internodes cylindrical *S. barberi*

B) Main axis of inflorescence glabrous, Lodicules 2 usually absent. Sessile spikelet opens first. Culms dark green, dark red, violet, dark yellow. Lodicules not ciliate. Cultivated: *S. officinarum.*

Manufacture of cane sugar:

The following process is involved in the manufacture of Cane Sugar.

1. Extraction of the Juice:

Cleaned pieces of canes are passed through four roller crushers After major quantity of the juice has been extracted by the crushers in the first two mills. Cold or hot water is sprinkled over the baggasse, where by residual juice gets diluted and can be easily extracted by further milling. About 90-95 per cent of the juice is extracted and sent for clarification.

2. Clarification of juice:

The dark juice is opaque liquid containing about 15 per cent sucrose and small quantities of glucose, fructose, vegetable proteins, mineral salts, organic acids, colouring matter, gums and fine particle of baggasse suspended it.

Clarification involves sulphitation i.e., adding milk of lime and treating with sulpur dioxide and Carbonation i.e., adding milk of lime and treating with carbondioxide. Combination of both this methods gets better results.

A current of carbondioxide followedly sulphurdioxide is passed through the detecated juice (juice treated with 2-3 per cent lime til pH value reach a 7.2) to remove excess lime and to bleach the juice. Sulphitation prevents formation of brown mass by oxidation.

3. Concentration and crystallization:

The clear juice in concentrated in a multiple effect evaporator. Purified juice led to evaporators and converted in to syrup. This syrup is cooled and crystallised in open tank. The left over is mother liquor called molasses.

4. Refining and drying of crystals:

The raw sugar is redisolved in hot water and the suspended inpurities removed by filtration. Concentration under reduced pressure and crystallization as usual.The solution in decoloured by treating with carbon black. Then the clear liquid is centrifuged to get pure sugar crystals.

Botanical features of Sugar Cane

Habitat	:	Tropical and subtropical.
Habit	:	Perennial grass, growing erect and tall, upto 6-8 metres, also called as ‘giant grass’
Stem	:	More or less cylindrical, solid, jointed with distinct nodes and internodes, the nodes are provided with root primordia and intercalary meristematic tissue.
Leaves	:	Alternate, distichous, enclosing a bud in the axil, lamina linear with a distinet midrib, margins and surface quite rought. Ligules simple.
Inflorescence	:	Silky panicle called ‘arrow’. The main axis carries a number of lateral branches repeatedly branched and ultimately ending in rachii which bear the pair of spikelets. Of the paired, one is sessile and the other pedicellate. Both are identical in size, shape and structure. Each spikelet is subtended by soft silky hairs called the ‘callus hairs’. The spikelets are deciduous. Glumes 1 and 2 are epaleate, sterile and as long as the spikelets and these glumes enclose in florat parts. Lemma 1 epaleate and sterile, lemma II is absent but its palea alone is present and faces glume II and

encloses the bisexual flower. Lodicules two, truncate at top, stamens three, ovary superior with two styles and plumose stigmas.

Fruit : A caryopsis and very small and used as seed only in breeding work.

Economic uses:

The stem yields the sucrose on crushing, the left out, after crushing is the bagasse, the molasses and press mud.

- Sugar- Alcoholic beverages, Soft drinks, Confectionery, Ice cream, Chocolate, Sweetening agent other industrial uses like drug industry and for preservation.
  Neera contains 14 per cent sucrose

Toddy	-	Fermented neera.
Palm jaggery	-	By boiling neera.
Leaf	-	For brushes and brooms, baskets, mat etc.
Timber	-	Rafters, pillar, posts fuel.

- By products:

  There are five by products of sugar industry:

  i. *Mollases:*

  Mainly for preparation of chemicals, like vinegar, glycerol, lactic and citric acid, aconitic acid, power alchohol, chloroform, plastics etc. also for biogas plant, live stock feed, alcoholic drinks etc.

  ii. *Bagasse:*

  Mainly as boiler fuel, manufacture of paper, insulating wall board, plastics etc.

  iii. *Cane wax:*

  After extraction with solvents, wax is used for making polishers.

  iv. *Press mud:*

  Used as fertilizer because (filter cake) it contains more calcium, nitrogen and phosphorus. Basic organic manure

  v. *Trash:*

  Treated with fungi and used as organic manure.

Lecture 7

Fabaceae - Red gram, Bengal gram and Soybean

The Fabaceae are mostly herbs but include also shrubs and trees found in both temperate and tropical areas. They comprise one of the largest families of flowering plants, numbering some 400 genera and 10,000 species. Previously Fabaceae was under the family Leguminosae as the sub-family Papilionaceae. Now it has been given to the family rank. So the sub-family Papilionaceae becomes the family Fabaceae.

Systematic Position:

Division – Phanerogams
Sub-division - Angiosperms
Class - Dicotyledonae
Subclass - Polypetalae
Series - Calyciflorae
Order - Leguminales
Family - Fabaceae

Description of the family Fabaceae

Habit: Fabaceae shows a wide variety of habits. They may be herbs, shrubs and trees. Some members are tendril climbers.

Stem: Herbaceous, weak or woody branched cylindrical or angular.

Leaves: May be simple or compound. Alternate and stipulate leaf base is swollen (pulvinus). Leaves are pinnately or palmately compound. In *Pisum sativum* the upper leaflets are modified to tendril.

Inflorescence: Raceme or panicle raceme sometimes solitary axillary.

Flowers: Flowers are bracteates, bracteolate, pedicillate, complete, bisexual, zygomorphic, irregular papilionaceous, usually Hypogynous or slightly perigynous.

Calyx: Usually 5 sepals, gamosepalous, aestivation is valvate or imbricate, odd sepal is anterior.

Corolla: Usually 5 petals, polypetalous, corolla is papilionaceous. The odd posterior petal is called standard or vexillum is the largest petal. The two lateral ones, called wing, two innermost (anterior) are smallest and united to form a boat-shaped structure called Keel (carina) in which essential organs are closed.

Androeceium: Stamens 10, usually diadelphous 9 + 1 , sometimes monadelphous, rarely polyandrous, anthers are 2 celled, dehiscence by longitudinal, dithecous, dorsifixed and introrse .

Gynoecium: Monocarpellary, ovary superior, unilocular with many ovules at ventral sutures. Placentation is marginal. The style is long flattened and hairy, stigma capitate.

Fruit: It is a legume (pod) or lomentum. It develops from a monocarpellary superior ovary with marginal Placentation. It dehisces along both the sutures.

Seeds: Usually non-endospermic

Economic Importance of the Leguminosae

The family Leguminosae consists of 3 sub families. viz., Papilionidae, mimosidae and Caesalpinioideae. At present the sub family Papilionidae has been given family status and termed as Family Fabaceae. In terms of economic importance the Leguminosae is the most important family in the Dicotyledonae. Legumes are second only to the Grasses (cereals) in providing food crops for world agriculture.

- ❖ In comparison to cereal grains the seeds of Legumes are rich in high quality protein, providing man with a highly nutritional food resource.
- ❖ The total world value for leguminous crops is thought to be approximately two billion US dollars per annum. Many more legumes are local food plants.
- ❖ In addition to those legumes cultivated for human consumption many yield important fodders, green manures and forages, e.g. *Lupinus* (Lupin), *Medicago* (Alfalfa) and *Trifolium* (Clover).
- ❖ Legumes are utilised for a variety of other purposes including timber, medicine, tannins and gums. Various species of *Lonchocarpus* and *Derris* are the source of rotenone, which is used as an insecticide, fish poison or molluscicide. Some Legume trees yield valuable resins, used in varnishes, paints and lacquers, e.g. *Copaifera* and others are the source of dyes, e.g. *Indigofera* which is cultivated for a blue dye.
- ❖ Many Legume species are characteristic of open and disturbed places and are thus well adapted to grow under marginal land in poor conditions.

Nitrogen Fixation by legumes

Many Legumes are able to convert atmospheric nitrogen into nitrogenous compounds useful to plants. This is achieved by the presence of root nodules containing bacteria of the genus *Rhizobium*. These bacteria have a symbiotic relationship with Legumes, fixing free nitrogen for the plants. In return legumes supply the bacteria with a source of fixed carbon produced by photosynthesis. This enables many Legumes to survive and compete effectively in nitrogen poor conditions. Root nodules are general in the Mimosoideae and Papilionoideae, but rarely formed in the Caesalpinioideae.

Characteristics of Pulses

The pulses or legume seeds forms and important source of protein to vegetarian population. The characteristic features of pulses are:

a. They contain 17 to 40 per cent protein, the highest being in soybean (40%).
b. They contain 50 per cent a carbohydrate
c. The fat content is very low 1 to 2 per cent.
d. Rich in lysine, tryptophan and threonine but low in sulphur containing amino acids like methionine, cystine, and cystene. Hence the protein available in pulses is not a balanced one. To over come this we eat cereals along with pulses.
e. Many grain legumes contain toxic substances like trypsin inhibitors which are removed by cooking.
f. The pulse crops are having root nodules which fix up atmospheric nitrogen in to the soil. Hence useful for crop rotation.

g. *Lathyrus sativus* (kesari dhal) contains toxic amino acid which is removed by boiling and removing water. It causes lathyrus disease in human being.
h. Some crops like lima bean contain HCN, which is dissipated by boiling and changing water.

List of cultivated crops under Fabaceae

Sl. No	Crop	Botanical Name	Chromosome number	Economic Part
1.	Red gram	*Cajanus cajan*	22	Seed
2.	Bengal gram	*Cicer arietinum*	16	Seed
3.	Black gram	*Vigna munga*	22 & 24	Seed
4.	Green gram	*Vigna radiate*	22	Seed
5.	Cowpea	*Vigna unguiculata*	22 & 24	Seed
6.	Soybean	*Glycine max*	40	Seed
7.	Horse gram	*Macrotyloma uniflorum*	24	Seed
8.	Lab lab	*Lablab purpureus*	22 &24	Seed
9.	Lima bean (Butter bean)	*Phaseolus lunatus*	22	Seed
10.	French bean	*Phaseolus vulgaris*	22	Seed
11.	Groundnut	*Arachis hypogaea*	40	Seed
12.	Sunnhemp	*Crotalaia juncea*	16	Stem & Whole plant
13.	Sesbania	*Sesbania bispinosa*	12	Stem as fibre flowers as vegetable
14.	Lucerne	*Medicago sativa*	16, 32 & 64	Leaves and Toppings
15.	Stylosanthes	*Stylosanthes hamata*	40	Leaves and Toppings
16.	Clitoria (Butterfly pea)	*Clitoria ternatea*	16	Leaves and Toppings
17.	Cow pea	*Vigna unguiculata*	22 & 24	Leaves and Toppings
18.	Siratro	*Macroptilum atropurpureum*	32	Leaves and Toppings
19.	Agathi	*Sesbania grandiflora*	24	Leaves and Toppings
20.	Chithagathi	*Sesbania aegyptica*	12	Leaves and Toppings
21.	Kalyanamurungai (Indian coral)	*Erythrina indica*	42&44	Leaves and Toppings
22.	Daincha	*Sesbania aculeate*	12 & 24	Whole plant
23.	Manila Agathi	*Sesbania rostrata*	24	Whole plant

RED GRAM- *Cajanus cajan* (L.) (2n=22)

(Pigeon pea / Thuvarai / Thuvara./ Kandi/Togari Arhar / Toor / Dhal)

Red gram ranks highest among the pulse crops of India and consumed by large population of the country. Cajanus cajan was introduced into India by the ancient traders on the route between Zanzibar, India and Sri Lanka .

Systematic Position

Class **:** Dicotyledonae
Subclass **:** Polypetalae
Series **:** Calyciflorae
Order : Leguminales
Family **:** Fabaceae
Subfamily **:** Papilionoideae

Place of origin **:** Africa
Distribution **:** Africa, India, Egypt, Burma, Ceylon.
In India **:** Uttra Predesh, Bihar, Madhya Predesh, Maharastra, Gujarat, Andhra Pradesh, Tamil Nadu.
Wild species **:***Cajanus Kerstingii*
Putative parents **:** *Cajanus lieata* may be the progenitor for *Cajanus cajan*. Related crossable genera is *Rhynchosia*

Classification:

Two botanical varieties were described

a) ***Cajanus canaj var. bicolor* (Arhar):** These cultivars are extensively cultivated in North India. The plant is woody perennial in habit.
b) ***C. Cajan var. flavus (Tur):*** Cultivated in peninsular India. Annual in habit.

Characters	**Arhar (bicolor)**	**Tur (flavus)**
Habit	Tall growing, 140-175cm, large bushy	Medium tall to dwarf types Two types of plant habit (a) determinate with terminal cluster of flowers. (b) indeterminate with axillary clusters.
Duration	Perennial , late maturing	Annual, early maturing ranging from 105 days to 180 days.
Flowering	Twice a year	In case of non season bound varieties throughout the year.
Pod	Pods dark red or purple hairy large containing 5 to 6 seeds, bold. Green seeds used as	Pods green, glabrous, medium to small containing 3 to 4 seeds per pod. Seeds medium bold.

	vegetable	
Standard petal color	purple streaked yellow flowers	standard or vexillum coloured plain yellow
Inflorescence	Axillary raceme	May be terminal or axillary raceme

Key botanical features of Red gram

Habitat

Tropical, widely adaptable with regard to climate and soils; drought resistant; can tolerate water logging but sensitive to frost; being short day plant, the crop shows photoperiodic effect.

Habit

Woody, annual, biennial or perennial, erect and branching

Root

Tall, upright dense root systems. Large clusters of nodules are produced under favourable condition

Stem

Woody, cylindrical, hairy and striated

Leaves

Trifoliately compound, spiral phyllotaxy, petiole grooved, central leaflet longer than lateral ones, stipules small, lamina hairy with the under surface greyish due to dense hairs, along with the hairs, long stalked, there are yellow glands which are prominent

Inflorescence

Terminal or axillary raceme on long peduncle. Flowers are clustered at the top of the peduncle.

Flowers

Flowers are bisexual, irregular, zygomorphic, pentamerous, bracteate and bracteolate, yellow in colour.

Calyx

Calyx five gamosepalous, four lobed, two lobes being united.

Corolla

papilionaceous corolla, standard petal auricled, yellow or dorsal side purple or red or yellow with red or purple veins; wings and keel petals yellow of equal length; keel incurved at the apex.

Androecium

Stamens ten (9+1), diadelphous, lies within the two keel petals; nine unequal stamens (didynamous) unite to make up the tube and the tenth stamen is free vexillary, anthers uniform, small oblong, yellow dorsifixed.

Gynoecium

Monocarpellary, ovary superior with many ovules in marginal placentation; lying within the staminal column with style emerging and curving upwards between the anthers; ovary and base of style hairy; stigma knob shaped.

Fruit

Pod which is variable in shape and size, constriction, texture and pubescence. Pods with deep constrictions are known as beaded while others are flattish with diagonal depressions between seeds; 2-8 seeded; beaked, usually hairy, green or dark maroon or blotched with maroon; do not shatter in the field.

Seed

Round or oval; about 8 mm in diameter; Colour ranges from cream to black with different shades of yellow, red and brown. A dark chocolate colour is the most common colour with a white hilum. Cotyledons elliptical and deep to light yellow in colour

Chemical composition

Contents	**Dry ripe Pigeon pea (%)**	**Split dhal**
Water	10	15%
Protein	19	22.3%
Fat	8	1.7%
CHO	57	57.2%
Fibre	1.5	3.5%
Ash	3.8	3.6
Rich in vitamin B, calcium and phosphorus		

Economic uses of Red gram:

- The young green pods and green seeds are eaten as vegetable.
- The ripe dry seeds are boiled and eaten as pulse.

  Two different ways of making split pulse (Dhal)

a. Wet method: By soaking seeds in water for 6-10 hours, smearing them with red earth (2 2.5 Kg per 45 kg of seeds), heaped up overnight; drying them in sun, sieved and winnowed to remove the earth and splitting them in the mill. The dhal recovery is 80 per cent but fetches lower price..

b. Dry method: Seeds are well dried in sun for 3-4 days and are directly split in the mill. The dehusking process is repeated 3-4 times by separating the unsplit seeds, treated with oil, dried in sun and milled again. In this method the recovery percentage is 66 per cent.

- Dried husk and broken pieces of seed are used as cattle feed
- Green leaf and tops of the plant are used as fodder and for making silage.
- Dried stake is used as fuel and as thatching material
- Used as temporary shade in young cocoa and other crops.
- Used as windbreaks and for anti erosion work.

BENGAL GRAM - *Cicer arietinum* L. (2n = 16)
(Chick Pea/Gram/Kondai kadalai/Senaga / Channa)

Bengal gram is a much branched herb, one of the most important pulse of India, it is highly drought resistant and requires a cool dry climate and light well-aerated soils. In India it is grown as a winter crop.

Systematic Position

Class **:** Dicotyledonae
Subclass **:** Polypetalae
Series **:** Calyciflorae
Order : Leguminales
Family **:** Fabaceae
Subfamily **:** Papilionoideae

Place of Origin **:** South West Asia
Putative parent **:** ***Cicer reticulatum*** crosses freely with ***C. arietinum***
Classification:

The genus *Cicer* consists of 40 species of both annual and perennial herbs. The only cultivated species in this genus is ***Cicer. arietinum.*** Other related species are *C. chorossanicum, C. montbrelli, C. bijugum, C. anatolicum, C. cuneatum, C. pinnatifidum*.

C. soongaricum is cultivated in Afghanistan, Western Himalayas and Tibet.

C. microphyllum is grown in higher elevations for food as well as for forages.

Vander Maesen has *described* two cultivated types:

Microsperma - *Desi*
Macrosperma - *Kabuli*

Distribution : India, Pakistan, Ethiopia, Turkey, Burma and Moracco.
In India : Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, Punjab, Maharastra and Bihar.

Types of Bengal Gram:

Desi	Kabuli
Small, irregular shape seeds of varying colours	Bold seeds, smooth, cream to white in colour
Seed coat wrinked	Seed coat somewhat smooth
Plant short with small leaflet and pale green	Plants tall, leaflet bigger in size.

Dark green leaves, Purple (or White) flowers	Light green leaves, flowers white in colour

Distinguishing Features:

1. Imparipinnate leaves
2. Serrated leaf margin
3. Presence of oil glands throught out plant body
4. Flowers axillary, solitary cyme
5. Inflated pods having one to two seeds only
6. Branching from base or the stem.(inverted umberalla shape)

Chemical Composition

Protein	Fat	CHO	Ash	Fibre	Water
17.0%	5.3%	61.2%	2.7%	3.9%	9.8%

Key botanical features of Bengal gram

Plant Habit

Chickpea is a herbaceous annual plant which branches from the base. It is almost a small bush with diffused, spreading branches. The plant is mostly covered with glandular or nonglandular hairs but some genotypes do not possess hair. Based on seed size and color, cultivated chickpeas are of two types.

1. **Macrosperma *(kabuli* type).** The seeds of this type are large (100-seed mass >25 g), round or ramhead, and cream-colored. The plant is medium to tall in height, with large leaflets and white flowers, and contain no anthocyanin.

2. **Microsperma *(desi* type).** The seeds of this type are small and angular in shape. The seed color varies from cream, black, brown, yellow to green. There are 2-3 ovules pod^{-1} but on an average 1-2 seeds pod^{-1} are produced. The plants are short with small leaflets and purplish flowers, and contain anthocyanin.

Seed and Germination

Chickpea seeds have a seed coat, two cotyledons, and an embryo. The seed coat consists of two layers, the outer testa and the inner tegmen, and a hilum. The hilum is the point of attachment of the seed to the pod. There is a minute opening above the hilum called the micropyle, and a ridge formed by the funicle called the raphe. The embryo consists of an axis and two fleshy cotyledons. The pointed end of the axis is the radicle and the feathery end the plumule.

Chickpea seeds germinate at an optimum temperature (28-33°C) and moisture level in about 5-6 days. Germination begins with absorption of moisture and swelling of the seed. The radicle emerges first followed by the plumule. The portion of the axis above the cotyledon called the epicotyl, elongates and pushes the plumule upward. The growth of the plumule produces an erect shoot and leaves, and the radicle grows to produce the roots. The first true

leaf has 2 or 3 pairs of leaflets plus a terminal one. The plumular shoot and lateral branches grow continuously to develop into a plant.

Root

Chickpea plants have a strong taproot system with 3 or 4 rows of lateral roots. The parenchymatous tissues of the root are rich in starch. All the peripheral tissues disappear at plant maturity, and are substituted by a layer of cork. The roots grow 1.5-2.0 m deep. Chickpea roots bear *Rhizobium* nodules. They are of the carotenoid type, branched with laterally flattened ramifications, sometimes forming a fanlike lobe.

Stem

The chickpea stem is erect, branched, viscous, hairy, terete, herbaceous, green, and solid. Thebranches are usually quadrangular, ribbed, and green. There are primary, secondary, and tertiary branches.

Primary branches arise from the ground level as they develop from the plumular shoot as well as the lateral branches of the seedling. They are thick, strong, and woody, and may range from one to eight in number.

Secondary branches develop at buds located on the primary branches. They are less vigorous than the primary branches. Their number ranges from 2 to 12. The number of secondary branches determines the total number of leaves, and hence the total photosynthetic area.

Tertiary branches arise from the secondary branches.

The primary branches form an angle with a vertical axis, ranging from almost a right angle (prostrate habit) to an acute angle (erect). Generally stems are incurved at the top, forming a spreading canopy.

Leaves

Chickpea leaves are petiolate, compound, and uniimparipinnate (pseudoimparipinnate). Some lines have simple leaves. The rachis is 3-7 cm long with grooves on its upper surface. Each rachis supports 10-15 leaflets each with a small pedicel. The leaflets do not end at the true terminal position (the central vein continuing the rachis) but at the subterminal position (the central vein oblique to the rachis). This indicates the presence of two terminal leaflet buds, one of them being aborted or transformed into a mucro or foliar shoot which is sometimes quite large. The leaflets are 8-17 mm long and 5-14 mm wide, opposite or alternate with a terminal leaflet. They are serrated, the teeth covering about two-thirds of the foliar blade. The shape of the leaflets is obovate to elliptical with the basal and top portions cuneate or rounded. Leaves are pubescent.

Stipules

The stipules are ovate to triangular in shape and serrated (2-6 teeth). They are 3-5 mm long and 2-4 mm wide. The longest margin is toothed and the smaller one entire.

Pubescence

The external surface of the chickpea plant, except the corolla, is densely covered with glandular or nonglandular hairs. The hairs vary in form and dimension: short stalked, multicellular stalked (both glandular and nonglandular), and unicellular. Some genotypes, however, do not possess any hair.

Inflorescence

The solitary flowers are borne in an axillary raceme. Sometimes there are 2 or 3 flowers on the same node. Such flowers possess both a peduncle and a pedicel. The racemose peduncle is 6-30 mm in length. At flowering, the floral and racemal portions of the peduncle form a straight line, giving the appearance that the flowers are placed on the leafy axil by a single peduncle. After fecundation the raceme is incurved. The bracts are 1-5 mm in length.

Flowers

Chickpea flowers are complete and bisexual, and have papilionaceous corolla. They are white, pink, purple or blue in color. In colored flowers, the peduncles may be of different colors, the floral part purplish and the racemal green. The axillary inflorescence is shorter than the subtending leaf.

Calyx

The calyx is dorsally gibbous at the base. There are five sepals with deep lanceolate teeth. The teeth are longer (5-6 mm) than the tube (3-4 mm) and have prominent midribs. The five sepals are subequal. The two dorsal (vexillar) sepals are closer to each other than they are to the two lateral ones in the ventral position. The fifth calyx tooth is separate from the others. The peduncles and the calyx are glabrous. The calyx tube is oblique.

Corolla

Chickpea flowers have five petals which are generally celeste and purplish red or light pink in color. The petals are polypetalous i.e., consisting of standard (vexillum), wings, and keel. The vexillum is obovate, 8-11 mm long, 7-10 mm wide, and either glabrous or pubescent with no glandular hair on its external surface. The wings are also obovate with short pedicels (nails). They are 6-9 mm long and about 4 mm wide with an auriculate base. The auricula are over the pedicel and form a pocket in the basal upper part, which is covered by the vexillum. The keel is 6-8 mm long, rhomboid, with a pedicel 2-3 mm long. Two-thirds of the frontal side of its ventral face is adnate. The wings do not show concrescence with the keel.

Androecium

There are 10 stamens in diadelphous (9)+1 condition. The filaments of nine of the stamens are fused, forming an androecial sheath; the tenth stamen is free. The staminal column is persistent. The fused part of the filament is 4-5 mm long and the free part 2-3 mm, upturned, and dilated at the top. The apex of the sheath is oblique. The stamens facing the petals are a little longer than the others. The anthers of these stamens are bicelled, basifixed, and round. The other anthers are dorsifixed, ovate, and longer than the basifixed ones at flowering. The anthers burst longitudinally. The pollen grains are orange.

Gynoecium

The ovary is monocarpellary, unilocular, and superior, with marginal placentation. It is ovate with a pubescent (glandular hairs predominate) surface. The ovary is 2-3 mm long and 1-15 mm wide. There are 1-3 ovules, rarely 4. The style is 3-4 mm long, linear, upturned, and glabrous except at the bottom. The stigma is globose and capitate. Sometimes it may be of the same size as the style.

Economic uses of Bengal gram

- Dried seeds soaked in water, cooked and eaten.
- Dhal used in various food preparations. Dahal prared by splitting the seeds in a mill and separating the husk; Out turn 80%
  Popped grain- "Pottu kaddali
  Broken seed as dhall "kadalai paruppu
- Flour (basin) used in various food preparations.
- Roasted seeds are taken as food and also used in preparation of various dishes.
- Green pods and tender shoots used as vegetable.
- Dried plant as cattle feed.
- An acid liquid from glandular hairs is collected by spreading a thin cloth over night. The liquid collected contain 94 per cent malic acid and 6 per cent oxalic acid. It is used as vinegar and also as medicine.

SOY BEAN - *Glycine max* (L) Merr. (2n = 40)
(Soya been / Soya mochai /Bhat/Ramkurthi)

Soya bean are one of the world's most important sources of oil (20 per cent) and protein (40 per cent). It is also an important food crop, where the dried seeds are eaten as whole, split or sprouted: the unripe seeds as vegetable: they are processed to give to give soya milk, which is a valuable protein etable: they are processed to give soya milk, which is a valuable protein supplement in infant feeding: they are made into curds and cheese.

Systematic Position

Class : Dicotyledonae
Subclass : Polypetalae
Series : Calyciflorae
Order : Leguminales
Family : Fabaceae
Subfamily : Papilionoideae

Place of origin : China

Distribution : USA, China, Brazil, Indonesia, Argentina, Canada, Thailand, Japan, India.

In India **:** Uttar Pradesh and Madhya Pradesh

Putative Parents/Wild relatives:

There are two views about origin of soybean.

G. max arose from ***Glycine usuriensis*** which is a slender, twining ;plant with small seeds. Grown as a wild species in **Japan, Korea.**

By natural corssing of ***G. usuriensis x G. tomentella*** (wild sp. of China)

Distinguishing Features

- Both determinate and indeterminate types are available.
- Presence of pubescence throughout the plant body.
- Inflorescence a highly condensed raceme. Flowers small.
- Style curved. Glabrous with capitate stigma.
- Monodelphous stamens.
- Yellow seeded types contain high oil and less protein black seeded types contain high protein and low oil.

Key botanical features of Soybean

Habitat:

Grown in areas where summer is hot. With stand excessive heat or severe winter. Grown in wide range of soils.

Habit:

Erect, bushy pubescent annual with grey hairs on all parts of the plant. Determinate cultivars and indeterminate cultivars are present.

Stem:

Suberect or climbing, branched

Leaves:

Trifoliate, alternate long petiole, leaflets ovate, acute, 5 to 10 cm long, subtended with short stipulate, small pointed stipules.

Inflorescence:

Flowers small, numerous up to twenty on short racemes arising in the axils of the leaves, white or purple. Determinate cultivars develop terminal inflorescence and indeterminate cultivars develop axillary inflorescence.

Calyx:

Hairy, persistant

Corolla:

Standard ovate, emarginated (notched), wings narrow, obovate, keel shorter than wing petals, whitish or light purple with deep purple veins at its base,

Androecium:

Stamens ten often monoadelphous,vexillary stamens free at the base; anthers uniform, globose.

Gynoecium: sessile, ovary short, hairy, ovules few with short curved style and apical stigma

Fruit :

Pods borne in cluster on short stalks; pale yellow, grey or black; slightly curved.

Seed:

Linear to oblong, recurved, densely pubescent, 3 to 5 cm long, three to seven seeded, slightly constricted between the seeds, seeds small, globose, smooth varying in size.

Cultivated types of soyabean

1. Yellow seeded forms – for oil production
2. Green seeded forms - for vegetable purpose
3. Brown or black seeded forms – Hay and fodder purpose
4. Black seeded forms – Rich in proteins

Economic uses of Soybean:

- Most important source of oil (20%) and protein (43%)
- Unripe seeds are used as vegetable.
- Dried seed are eaten whole, split or sprouted and used.
- Substitute for black gram in preparation of flour for idly.
- Soya milk, Soya sauce, Soya oil is used for edible purpose.
- Soya curd and cheese also made
- Soya milk is used in the preparation of infant foods who are having lactose intolerance (eg. Isomil, Nusobee, Simyl etc).
- The whole plant as fodder and seed as cattle feed.
- Soya meal or protein used to manufacture synthetic fiber, adhesive, fire fighting foam.
- Soya flour used in bakery.
- In Indonesia, boiled beans are fermented by *Aspergillus* and made into cakes (tempe).

Lecture 8

Fabaceae – Black gram, Green gram, Cow pea, Lab lab, Horse gram and Groundnut

BLACK GRAM - *Vigna mungo* L. (2n = 24)
(Uzhunthu/ Uddulu / Urad / Urd)

Division	:Phanerogams
Sub-division	:Angiosperms
Class	:Dicotyledon
Series	:Calyciflorae
Order	:Rosales/Leguminales
Family	:Fabaceae
Sub-family	: Papilionidae

Place of origin **:** India

Distribution **:** India, Africa, Iran, Malaysia, Sri lanka, USA and West Indies.

In India **:** Uttar Predesh, Madhya Predesh, Punjab, Maharastra West Bengal, Andhra Predesh, Karnataka, Tamil Nadu

Putative parent **:** *Vigna radiata var, sublobatus or Vigna trinervius.*

Botany of Black gram:

Habitat	:	Tropical, grown in areas with rainfall not more than 35 inches per year, suited to clay soils and is often grown on black cotton soils in India, drought resistant.
Habit	:	Annual, diffusely branched herbaceous, 30-100 cm in height, erect, semi erect to trailing or spreading types, plant densely hairy
Root	:	Tap root and branched
Stem	:	Slightly ridged, covered with brown hairs, hairs pointing downwards and grows upto 1.5 m height.
Leaves	:	Trifoliate, alternate, stipulate, stipules falcate (sickle shaped) and foliaceous, petiolate, pulvinate, stipellate, stipel small and flat, leaflets ovate to lanceolate, entire, acute, sparsely hairy on both surfaces, plamately reticulate.
Inflorescence	:	Axillary raceme with the flowers congested at the top of the peduncle,2-3 branched, flowers five to six, bracteate, bracteolate, bracteoles 2, pedicillate, bisexual, hypogynous, zygomorphic, complete, pentamerous
Calyx	:	Sepals 5, gamosepalous, imbricate
Corolla	:	Papilonaceous, petals 5, polypetalous, keel in the form of a spiral beak, descendingly imbricate
Androceium	:	Stamens 10, diadelphous (9+1), filaments alternatively long and short, anthers uniform, dithecous, introse, dorsifixed.

Gynoceium : Superior ovary, hairy, monocarpellary, unilocular with few ovules on marginal placentation. Style terminal, filiform, densely bearded beneath the stigma, stigma oblique.

Fruit : Pod; erect or sub erect, hairy, bright to dark brown colour, 6 to 8 cm long 4-10 seeded with short hooked beak.
Seeds generally black, oblong with white hilum, hilum concave. Seed coat surface is smooth. Cotyledons are white.

Pollination : Self-pollination is the rule; pollen shed in the previous day evening and the flower open in the morning.=

Cultivated types of black gram

Early cultivars : large black seeded.

Late cultivars : small olive green seeds usuallygrown as green manures in West Indies.

Chemical composition:

Protein	Fat	CHO	Ash	Water	Fibre
23.4%	1.05	57.3%	4.8%	9.7%	3.8%

The cotyledon of black gram contains batter (amino acid related sub-stance). This makes the wet flour to swell up *i.e.* doughiness. Because of this batter it is suitable for making iddlis, dosai, etc.

Economic uses:

- Seeds used as a source of protein (23%).
- Dried grain used in preparation of *idli, dosai, vadai* etc,.
- Flour used in bakery for preparation of bread and biscuit.
- Green seed and pod are eaten as vegetable.
- Dried or green plants are used as fodder.
- Broken grain, seed coat and bhusa *(potto)* are excellent fodder.
- Used as green manure and cover crop and as a short lived forage
- Green pods used as vegetable.

GREEN GRAM – *Vigna radiata* L . (2n = 22)
(Sirupaiaru/ Passiparuppu / Mung / Moong bean)

Division :Phanerogams
Sub-division :Angiosperms
Class :Dicotyledon
Series :Calyciflorae
Order :Rosales/Leguminales
Family :Fabaceae

Sub family : Papilionidae

Place of Origin **:** India

Distribution **:** India, Africa, Iran, Malaysia, Sri Lanka, USA and West Indies.

In India : Uttra Predesh, Mathya Predesh, Punjab, Maharastra, West Bengal, Andhra Predesh, Karnataka, Tamil Nadu.

Putative parent **:** *Vigna radiata var. Sublobatus* and *Vigna trinervius.*

Cultivated types of Green gram

1. Golden gram : yellow seeds, not a prolific seed producer and with a tendency to shatter, used mainly for pasture, hay, silage and as a cover crop.
2. Green gram : dark or bright green seeds, cultivars produce seed prolifically and the pods ripen more uniformly and have lesser tendency to shatter, mostly used as a pulse crop.

Botany of Green gram:

Habitat	:	Tropical, dry land crop, grows on good loamy soil, requires well distributed rainfall, drought resistant, susceptible to water logging.
Habit	:	Herbaceous, annual, erect or semi erect with slight tendency for twining in the upper branches.
Root	:	Tap root
Stem	:	Erect or semi erect, sparsely hairy, branched, 0.5 to 1.3 m tall.
Leaves	:	Trifoliate with long petioles, stipules with basal appendages, stipels minute, leaflets entire, ovate.
Flowers	:	ten to twenty crowded in axillary racemes on long pedicels, bisexual, hypogynous, zygomorphic, complete, pentamerous, bracts ovate
Calyx	:	Sepals 5, gamosepalous
Corolla	:	Yellow, Papilonaceous, petals 5, polypetalous, keel in the form of a spiral beak, descendingly imbricate
Androceium	:	Stamens 10 (9+1), diadelphous, filaments alternatively long and short, anthers uniform, dithecous, introse, dorsifixed.
Gynoceium	:	Superior ovary, hairy, monocarpellary, unilocular with few ovules on marginal placentation. Style terminal, filiform, densely bearded beneath the stigma, stigma oblique and introse.
Fruit	:	Pod, hairy, bright to dark brown colour, 6 to 8 cm long with 4-10 seeds, generally green, oblong with white testa and fine wavy ridges, hilum concave. Seed coat surface is smooth. Cotyledons are white.
Pollination	:	Self-pollination

Chemical composition

Protein	Fat	CHO	Ash	Water	Fibre
23.6%	1.2%	58.2%	4.0%	9.7%	3.3%

According to the US Department of Agriculture's (USDA) nutritional facts and analysis records, mung beans contain between nineteen to twenty-five percent protein, sixty percent carbohydrate and four percent fiber and are an excellent source of B vitamins. Vitamin B1, present in mung bean, is required for critical neuronal functions. Vitamin B2 or riboflavin is vital for healthy eyes and skin. Vitamin B3 or niacin regulates cholesterol and blood sugar levels in the body. Vitamin B6 is necessary for the production of the neurotransmitter serotonin, which is active in mood regulation. Vitamin B9, also known as folate or folic acid, is required for production of red blood cells and is thus important for regulating the oxygen carrying-capacity of the blood and also reduces the risk of heart disease. When sprouted, mung beans develop good amounts of Vitamin C which needed by the immune system for healing and fending off infections.

Mung beans are also a treasure house of minerals including calcium, iron, magnesium, potassium, phosphorus and copper. These mineral, are vital for everyday functions of the body and maintaining homeostasis or equilibrium and help prevent heart disease, anemia, diabetes and renal (kidney) problems. Iron and copper are required for production of hemoglobin and zinc is required for regulating insulin production. Calcium is needed to strengthen the bones, magnesium for nerve and muscle function and potassium is necessary for normal heart function. The concentration of potassium, copper, zinc and magnesium are higher in mung as compared to the levels in other known vegetables and fruits. It's no wonder that mung bean is considered the royal bean or queen of beans.

Economic uses:

- Mung bean has highest digestibility among the grain legumes.
- It is free from causing flatulence.
- Mostly used as sprouts.
- Flour used in various Indian and Chinese dishes.
- Green pods used as vegetable
- Seed as food for human beings
- Green and dry plant as fodder.
- Husk of split grain utilized as livestock feed
- Grown for hay green manure and as a cover crop.

Difference between Black gram and Green gram

Characters	**Black gram (*vigna mungo*)**	**Green gram (*vigna radiata*)**
Stem	Mostly purple coloured;	Mostly green coloured
Leaf colour	Dark green	Pale green (yellowish green)

Hairiness	Densely hairy; reddish brown hairs on the stem and leaves.	Sparsely hairy on stem and leaves.
Pods	Short in length, erect with long hairs. less shattering	Long, radiating, small hairs present, highly shattering.
Seeds	Large oblong with square ends	Small in size, round
Seed coat	Normally black in colour, Testa with no ridges	Normally green in colour, fine, wavy ridges
Cotyledons	White pasty when chewed	Cream, not pasty, broken in to hits
Hilum	Concave	Flat

LAB LAB *lablab purpureus* (2n = 22, 24)

(Hyacinth bean/Pandal avarai / Mochai / Field bean/Sem)

Lab lab is commonly cultivated for pulse as well as vegetable purpose. It is also called poor man's bean because it can be grown in marginal lands also.

Systematic position:

Division :Phanerogams
Sub-division :Angiosperms
Class :Dicotyledon
Series :Calyciflorae
Order :Rosales/Leguminales
Family :Fabaceae
Sub family : Papilionidae

Place of Origin - India
Distribution - India, Central America, China and Aftica.
In India - Karnataka, Andhra Pradesh.

Botanical features of lablab:

Habitat : Tropical; grown widely in summer,can tolerate short period of flooding, but intolerant to poor drainage and prolonged inundation.

Habit : Branching and twining herb, annual, erect, occasionally short lived perennial.

Root : Tap root

Stem : Slender, round, internodes elongated, trailing to 3-6 m in length.

Leaves	:	Alternate, petiolate, pulvinate, stupilate, petioles long and slender, pinnately trifoliate leaflets, entire, acute, sparesly hairy, lateral leaflets oblique,ovate, pubescent.
Inflorescence	:	Axillary raceme, flowers congested at nodes in a long peduncle. Bracteate, Bracteolate, pedicillate (short pedicel)
Flowers	:	Flowers medium sized, papilionaceous, white or blue or purple on short pedicels.
calyx	:	Companulate, sepals five, gamosepalous.
Corolla	:	papilionaceous. Polypetalous descendingly imbricate
Androecium	:	10 stamens- diadelphous, filaments alternately long and short, anthers dithecous, introse
Gynoecium	:	Ovary monocarpellary and superior. ovules - unilocular with few ovules.
Fruits	:	Legume or pod Pods are variable in size, 5-6 seeds/pod, 4-5 cm long, broadly, smooth, often curved and flattened.
Seed	:	Non - endospermous, large thick, ovoid, slightly flattened. Seeds are variable in size and colour, white hilum, along 1/3 of the edge. Seed color vary from white or cream through light to dark brown to red or mottled.
Pollination	: Selfpollination	

Botanical Varieties of Lab Lab

There are two cultivated varieties:

Lablab purpureus var.typicus - Garden bean "Pandal avarai"

Lablab purpureus var. lignosus - Field bean "avarai"

The distinguishing features of Avarai (***Lab lab purpureus var. typicus***) and ***Mochai (Lab lab purpureus var. lignosus***) are given below:

Difference between Garden Bean and Field Bean

Character	Garden bean	Field bean
Habit	Perennial, cultivated as an annual twiner	Semi erect, bushy perennial, cultivated as annual
odour	No pungent smell	Has a characteristic smell due to an oily secretion.
Flower	White or purple	Usually white
Pod	The pods are long, tapering	The pods are relatively shorter, oblong and fibrous seeds, 4-6 almost round seeded.

Pericarp	Slender or soft	Tough, firm and parchment like.
Seeds	Long axes of seeds are parallel to the length of the fruit	Long axes of seeds are at right angles to the length of fruit.
Edible part.	Whole immatured pod used as vegetable. Matured green seeds are also used as vegetable	Green immature seeds alone as vegetable, Dried seed as pulse Ripe seeds of lignosus contain Protein 24.9 per cent, Fat 0.8 per cent, Carbohydrates 60 per cent Fibre 1.4 per cent and Ash 3.2 per cent

Chemical composition:

Crude protein 20-28%, vitamins A, B and C. Grain has tannins, phytate and trypsin inhibitors. Soaking or cooking can reduce the activity of these compounds.

Economic uses:

- Seed of motchi are used as pulse/protein purpose
- Tender pods of avarai used as vegetabe
- Also used as legume fodder
- As green manure crop, cover crop and to enrich soil fertility.

COWPEA – *Vigna unguiculata* (L.) Walp. Aggreg. (2n =22)
(Thattaai payaru/kaaraamani/Maampayaru/Labia/Chowli)

Cowpea is grown in warm parts of the world especially in the tropics. The dried pulse may be ground into meal which is used in number of ways. The fresh seed and immature pods are eaten as vegetable. The young shoot and leaves are eaten as spinach.

Systematic classification:

Division :Phanerogams
Sub-division :Angiosperms
Class :Dicotyledon
Series :Calyciflorae
Order :Rosales/Leguminales
Family :Fabaceae
Sub family : Papilionidae

Place or origin : Africa
Distribution : Africa, USA, India, Australia
In India : Kerala, Tamil Nadu, Karnataka, Andhra Pradesh
Putative parent : *Vigna unguiculata subsp menensis*

Classification:

According to Faris 1965 three subspecies are recognised.

1. *Vigna unguiculata subsp. Unguiculata* (*syn.V.u.subsp. catjang)*- grain Cowpea:

The common cowpea more highly specialized in Africa. Pods 8 to 13 cm long. Neither flabby nor inflated. Pods remain erect at maturity.

2. *V. unguiculata subsp. Sinensis*- Catjung type cowpea*:*

Pod length 20 to 30 cm Pods are not inflated. Pods fibrous when green. The stature of pods are pendent when matured. Seed size medium 6-9 mm. Seeds are closely packed in the pod. Primitive of all cowpea types.

3. *V. unguiculata subsp. Sesquipedalis – Yard long bean* – vegetable cowpea:

Pod size may be 30 to 100 cm, pendant. No fibre content in green pods. Seeds are sparsely arranged, kidney shaped and usually double coloured. Pods inflated when green, shriveld on drying.

Distinguishing feature:

- Kidney shaped seed.
- White hilum surrounded by brown or black ring.

Cultivated types of cowpea

Brittingham (1946) classified cultivated types as follow:

1. Asparagus bean group: yard long bean or long white – Trinidad and Hongkong. It is divided into,
   a) Green podded forms – 1.5 to 3 ft long
   b) White podded forms – upto 1.5 ft long
2. Catjung group – Puerto Rico
3. Cowpea group.

   It is subdivided into:

   a) Crowder : cultivars with seeds crowded , brown eyed, Puerto Rica
   b) Black eye: seeds not crowded, white with a black eye pattern round the hilum – California and Puerto Rica.
   c) Cream Cultivars : seeds not crowded, cream in colour
   d) Intermediate between crowder and black eye: seeds spaced intermediate, mature pods deep purple and seeds with a buff or maroon eye.
   e) Forage cultivars: useful for forage, hay and silage making

Botany of Cowpea:

Habitat	:	Subtropical and tropical, sensitive to cold and frost
Habit	:	Annual, spreading, twining, rarely sub erect and erect herb
Root	:	Tap root stout with numerous spreading laterals, nodules large globular
Stem	:	Slightly ridged, erect or sub erect almost glabrous and hairy at the nodes.
Leaves	:	Alternate, stipulate, stipules foliaceous, petiolate, pulvinate, pinnately trifoliate, leaflets stipulate, ovate, entire, acute, both

surfaces with scattered short hairs, palmately reticulate and lateral leaflets obliques

Inflorescence : Axillary raceme with flowers congested at the top of the nodes, peduncle often in alternate pairs, flowers showy, white or yellow or pink, bracteate, bracteolate, bracteoles two, shortly pedicellate, bisexual, hypogynous, zygomorphic, complete, pentamerous, cyclic.

Calyx : Sepals 5, gamosepalous, valvate

Corolla : Papilionaceous, petals five, polypetalous, descendingly imbricate.

Androecium : Stamens 10, diadelphous (9+1), filaments alternately long and short, anthers uniform, dithecous, introrse, dorsifixed

Gynoecium : Ovary superior, monocarpellary, unilocular with many ovules on marginal placentation. Style terminal stigma capitate, oblique

Pods : Long, smooth, cylindrical somewhat constricted between seeds. Seeds globular, kidney shaped. Smooth or wrinkled in many colours. Hilum white, surrounded by dark ring

Chemical composition:

Water	Protein	Fat	CHO	Fibre	ASH
11%	23.4%	1.3%	57.%	4%	3.6%

Economic uses:

- Used as a pulse either whole as dhal and also as flour after husking.
- The pods are used as vegetable when tender.
- The protein content is 23.4%.
- Tender pod as vegetable cowpea, tender leaves used as greens.
- Sprouted seed as vegetable, grain as pulse.
- Whole plant as green fodder. Cowpea and maize green fodder mixture is excellent for cattle.

HORSE GRAM – *Macrotyloma uniflorus* (2n= 24)

(Syn. Dolichos uniflorus)

(Kollu/kaanum/muthira/Ulava/Koaltee/Kulthi)

Horse gram is the poor man's pulse crop in southern India. It is a hardy, drought resistant annual grain legume. The seeds are parched and then eaten after boiling or frying. The seeds are an important food for cattle and horses and are usually fed after boiling. The stems, leaves and husks are used as fodder.

Division	:Phanerogams
Sub-division	:Angiosperms
Class	:Dicotyledon
Series	:Calyciflorae
Order	:Rosales
Family	:Fabaceae

Place of Origin **:** South East Asia.
Distribution **:** India, Malaysia, West Indies, Marutitious Island.
In India **:** Tamil Nadu, Karnataka, Andhra Pradesh.

Related wild species : *Dolichus uniflorus*

Distinquishing Features:

1. Pubescent plant body
2. Sickle shaped pod
3. Compressed seed.

Botanical description of Horse gram:

Habitat	:	Subtropical, tropical.
Habit	:	Annual, bushy herb
Stem	:	Slightly angular, sub erect, hairy
Leaves	:	Alternate, trifoliately compound, stipulate, stipules foliaceous. Petiolate, pulvinate, leaflets stipulate, ovate, entire, acute, herbaceous, lateral leaflets oblique.
Inflorescence	:	Fascicle of one to three flowers in the leaf axils, flowers bracteate, bracteolate, bracteoles two, pedicillate, bisexual, hypogynous, zygomorphic,complete, pentamerous.
Calyx	:	Companulate, sepals 5, gamosepalous, imbricate
Corolla	:	Papilonaceous, petals 5, polypetalous, descendingly imbricate
Androecium	:	Stamens ten, diadelphous (9+1), filaments alternately short and long, anthers dithecous, introrse, uniform, dorsifixed
Gynoecium	:	Superior ovary, monocarpellary, unilocular with four to six ovules on marginal placentation, style terminal, curved, stigma capitate and hairy around
Fruit	:	Pods are short (3-5cm) hairy, with 5-7 small flattened seeds may

be light red, brown grey, black, mottled, seed coat is hard and shinning

Chemical composition:

Protein	CHO	Fat	FIBRE	ASH
24.0%	57.0%	1.3%	5.3%	3.1%

Economic uses:

- Seeds are used as pulse. It is the poor man's pulse.
- It can be eaten as boiled and fried.
- Sprouted seed used for making dishes.
- It is most largely used as a feed for cattle and horses.
- Horse gram dhal is said to be good for patients suffering from kidney trouble. – Diuretic.

GROUNDNUT – *Arachis hypogaea* (2n = 40)
(Peanut/Monkeynut/Nila kadalai/ Moongphallee)

The genus *Arachis* belongs to family *Fabaceae*, subfamily *Papilionaceae*, tribe eschynomeneae, subtribe *Stylosanthinae*. This genus is morphologically well defined and distinguished from other genera by having a peg and geocarpic reproductive growth. The genus *Arachis* has more than 70 wild species, of which only *Arachis hypogaea* L. is domesticated and commonly cultivated. Groundnut is extensively cultivated in tropical and sub-tropical regions all over the world. Groundnut was introduced in India by Portuguese travellers through Kerala. Later in Tamil Nadu, spread by East India company.

Systematic position:

Division : Phanerogams
Sub-division : Angiosperms
Class : Dicotyledon
Series : Calyciflorae
Order : Rosales/Leguminales
Family : Fabaceae
Sub family : Papilionidae

Place of Origin **:** Brazil.

Distribution : Throughout the tropical countries of the world. India, USA, Sudan, Senegal, Sough Africa, Nigeria, Indonesia, Brazil**,** Burma, Argentina, Thailand**.**

In India :Gujarat, A.P., Tamil Nadu, Karnataka, U.P., M.P. and Rajasthan.

Putative parent:

Archis hypogaea is found to be a hybrid derivative between *A. Cardenasii x A. batizocoi.*

Botanical classification:

The genus *Archis* is divided into 9 sections**.**

1. *Arachis*
2. *Erectoides*
3. *Rhizomatasae*
4. *Extranervosae*
5. *Triseminale*
6. *Cauliorhizae*
7. *Heteranthae,*
8. *Procumbentes,*
9. *Trierectoides*

The cultivated groundnut comes under section *Arachis*. This section includes two series (Annuae and Perennes) and 12 species which include both diploid and teraploid forms. Some of the important wild species in series Annuae are.

A. batizocoi 2n = 20
A. cardenasii 2n = 20
A. villosa 2n = 20
A. chacoense 2n = 20
A. monticola 2n = 40

Classification based on habit: Agronomically there are three types**.**

Spreading	-	Virginia runner
Semi spreading	-	Virginia bunch
Bunch	-	Spanish Bunch, Valencia

1. *A. hypogaea subsp hypogaea var hypogaea* – Virginia runner
2. *A. hypogaea subsp hypogaea var hirsute* – Peruvian
3. *A hypogaea subsp fastigiata var vulgaris* – Spanish bunch
4. *A hypogaea subsp fastigiata var fastigiata* – Valencia

Subspecies	Variety	Type	Description
Hypogaea	Hypogaea	Virginia	No floral axes on main stem, alternating pairs of floral and vegetative axes on branches, branches short less hairy
	Hirsuta	Peruvian	No floral axes in main stem, alternating pairs of floral and vegetative axes on branches, long, more hairy.
Fastigiata	Vulgaris	Spanish	Floral axes on main stem sequential floral axes on branches, more branches, upright branches.

	Fastigiata	Valencia	Floral axes on main stem, sequential floral axes on branches, little branched, curved branches.

There are four main varieties of peanuts. These are:

Varieties in hot climates:

a) **Spanish peanut**: erect, compact plant. From 2 to 3 peanuts in each fruit. These are small and compact with good flavor, very sweet and good for grilling or for peanut butter. They have lots of oil and protein.
b) **Virginia peanut**: Trailing plant. 2 peanuts per pod. Large elongated fruit with a little oil
c) **Valencia peanut**: Bushy plant up to five feet tall. It produces from 2 to four seeds per pod, rich in oil and protein. It is mainly used for the manufacture of butter or as a supplement in the manufacture of chocolate tablets.
d) Peruvian peanut: A variety resulting from the crossing between Virginia and Spanish. The plant has a creeping appearance hence, in English, is known as "runner peanut". It is primarily used to produce peanut butter.

Varieties of cold weather:

Early Spanish: It is used to grow in areas of low temperatures.

Pod development:

On fertilization, the thalamus positioned below the ovary begins to grow into a peg or gynophores (to be more specific - Carpophore). The peg grows towards the soil *i.e*. positively geotrophic, to begin with, a lignified tissue forms a protective cap at the tip for the fertilized ovary. The peg carrying the ovary pushes itself into the soil. After entering the soil to a specific depth which is characteristic for a variety, it takes a horizontal position and the ovary begins to develop into a pod

Botany of Groundnut:

Habitat : Tropical and subtropical
Habit : Low growing, annual herb.
Stem : There are three cultivated forms
(1) bunch, (2) semi-spreading and (3) Spreading types. The central axis of the stem erect, often hairy with short internodes. Somewhat angular, slightly pithy. In bunchy types, the lateral branches also grow almost erect whereas, in the spreading (prostrate) types the laterals are procumbent or prostrate.
Leaves : Alternate, stipules adnate, the petioles fairly long with two pairs of ovate leaflets, has a central groove running throughout the length, leaflets are arranged opposite to each other in pairs, stipules absent, pulvinus of the petiole is distinct, above the joint of the adnate stipules.

Flowers : Single or three to four per leaf axil in condensed raceme. The flower is sessile, yellow in colour with fairly long calyx tube which gives the false appearance of a pedicel. A single bract and two bracteoles are present in each flower

Calyx : Tubular, slender, ending in five lobes, of which three are united into one big structure and the two linear lanceolate Tubular, slender, ending in five lobes, of which three are united into one big structure and the two linear lanceolate. The long slender calyx tube is also called as Hypanthium.

Corolla : Papilionaceous, five, keels are united

Androceium Stamens monoadelphous, eight fertile and two staminodes. The eight anthers are dimorphic with four having long anther lobes and four with rounded anther lobes.

Gynoecium : Monocarpellary, superior ovary arises at the base of the flowers, style slender, passes through the length of the calyx tubes, stigma terminal, hairy, ovary unilocular with one to three ovules on marginal placentation

Fruit : An indehiscent pod but structurally dehiscent, carried on a long stalk which is the gynophore. One to three seeds per pod. The testa is commonly rose or varying from dark purple to red colour or variegated.

Seeds : Seeds are non endospermic, contain 26 per cent protein and 45 to 50 per cent oil. Kernel rich sources of phosphorus and vitamins.

Chemical composition of groundnut

Seeds(%)		**Oil (%)**		**Oil cake (%)**	
Oil	35-47	Oleic acid	53	Water	10.3
Protein	30.4	Linoleic acid	25	Protein	46.8
Carbohydrate	11.7	Vitamin B and E		Fat	7.5
Fibre	2.5			Carbohydrate	23.2
Ash	2.3			Fibre	6.4
Water	5.4			Ash	5.8

Economic uses:

- The nuts are eaten raw of after roasting. For this purpose bunch types with extra large kernals are preferred since they contain relatively low oil content than Virginia type.
- Kernel rich source of phosphorus, vitamin, protein (26 %) and oil (45 to 50 %).
- Oil as a cooking media. Oil cake as cattle feed.
- Hydrogenated oil-for preparation of vanaspathi/vegetable ghee.
- Manufacture of margarine – butter like substance (Peanut butter).
- Moist oil cake for production of aflotoxin from *Aspergilus flavus*.

- Oil – non drying and finds application in pharmaceutical industry and soap industry; used as lubricant.
- New textile fibre 'Ardil' - manufactured from peanut protein.
- Nuts used in confectionery and in curries.
- Green haulms are excellent fodder and hay.

Review Questions

1.The oil content in groundnut is ----------

2.Common cowpea is botanically called----------

3.Name the primitive cowpea?

4.Which of the following does have diadelphous stamen?

a) Groundnut
b) Soybean
c) Blackgram
d) Green gram
e) Both c and d

5.The fruit of groundnut is **structurally dehiscent but functionally indehiscent**

6.2n number of cowpea and horse gram

7. Which is the flatulence free pulse crop?

8.The pegging in groundnut is accomplished by the elongation of intercalary meristem of **gynophores**

9.The common ancestor of black gram and green gram?

10. Textile fibre derived from groundnut protein is ------

Short answers:

1.What is pegging? Explain the various steps in pegging?

2. Write the key botanical features of groundnut, back gram, green gram?

3.Write the classification of cowpea?

4.Elucidate the classification of groundnut?

5. What is ardil. Explain the other economic uses of peanut?

6. Difference between field bean and garden bean?

7. Distinguish between black gram and green gram?

8. What are the distinguishing botanical features of family Fabaceae?

9. List out the pulse crops used for dual purpose and write their economic importance.

10. Why horse gram is called poor man's crop?

To think:

1 Give reason: why green gram is free from flatulence and known for good digestibility?

2. How much pulse is being imported by India? Give the list of crops and foreign exchange on that crops.

3. Is India export any of the above Pulse crops?
4. Status of Pulse crops in Indian economy?
5. Read and know in detail about the medicinal properties of above pulse crops.

Lecture 9

Fabaceae – Lucerne, Stylosanthes, Clitoria, Agathi, Sunhemp and Sesbania

LUCERNE (Alfalfa/Kudhirai masal) *Medicago sativa* Linn. (2n = 16, 32 & 64)

It is productive perennial drought tolerant multipurpose forage grown in deep well drained soil. The plant contains five times as much as protein and high vitamin A content. The cultivated species is tetraploid. It is called as queen of fodders

Systematic Position

Class **:** Dicotyledonae

Subclass **:** Polypetalae

Series **:** Calyciflorae

Order : Leguminales

Family **:** Fabaceae

Subfamily **:** Papilionoideae

Place of origin **:** Meiterranean

Related species **:** *Medicago falcata.*

Botany of Lucerne:

Family	:	Fabaceae
Habitat	:	Subtropical, tropical
Habit	:	Deep rooted perennial, herb with diffuse branching
Stem	:	Procumbent, Erect, 50-60 cm height, arising from the crown which is a woody base
Leaves	:	Trifoliate, petiolate, stipules triangular, Alternate, long narrow leaflets and sharply toothed, pubescent on lower surface and glabrous on upper surface
Inflorescence	:	Axillary raceme, flowers small, yellow, white, purple, violet or blue, bracteolate, zygomorphic
Calyx	:	Five, gamopetalous, tubular with pointed teeth
Corolla		Papilionaceous
Androecum	:	Stamens ten, diadelphous (9+1), didynamous
Gynoecium		Ovary superior, monocarpellary with many ovules, marginal placentation, style simple, stigma capitate
Fruit	:	Spirally coiled legume, indehiscent, 2- 6 seeds, Seed yellow to

brown, kidney shaped to ovoid.

Economic uses:

- ✓ It is very good fodder crop with 22-25% protein with well balanced calcium and phosphorus.
- ✓ Fiber content is low and is easily digestible.
- ✓ Dried leaves are powdered and used in the preparation of concentrates.
- ✓ It is also used in poultry feed. Seeds can be used for human consumption as sprouts.

Toxicity: Bloating is a common problem which can be rectified when mixed with grass fodder.

STYLOSANTHES (MUYAL MASAL*) Stylosanthes hamata* (2n = 40)

Tropical drought resistant forage legume much liked by rabbits. Both diploids and tetraploids are present. Diploids are long day plants grown in regions of rain fall 1000 mm to 2000 mm. Diploids can tolerate alkaline soil. Tetraploids show intermediate response to short day period. Tetraploids comes well in acid soil

Systematic Position

Class	**:** Dicotyledonae
Subclass	**:** Polypetalae
Series	**:** Calyciflorae
Order	: Leguminales
Family	**:** Fabaceae
Subfamily	**:** Papilionoideae

Place of origin **:** West Africa and South America

Related species **:** *Stylosanthes humilis and Stylosanthes gracillis*

Botany of Stylosanthes:

Family	:	Fabaceae
Habitat	:	Tropical forests
Habit	:	Annual to short lived perennial herb, with many branches
Stem	:	Woody stem with dichotomous branching
Leaves	:	Pinnately trifoliate, stipules large, adnate to the base of the petiole
Inflorescence	:	Terminal raceme. Small, yellow in dense terminal cluster. Calyx five, tubular, corolla five, standard orbicular, wings oblong, free

keel incurved, stamens ten, monoadelphous, dimorphic anthers, superior ovary, monocarpellary. Ovules two to three, marginal placentation style filiform, stigma minute

Fruit : Pods compressed, hooked apex, seeds compressed. Seeds medium to dark brown in colour, rich in protein.

Economic uses:

- ✓ Leaves are rich in protein 29%.
- ✓ Used as feed, fertilizer, fuel, can be maintained as a bush and leaves can be clipped and used as forage.
- ✓ Has an amino acid mimosin. Excess feeding leads to falling or hairs, thyroid gland swelling and stunted growth.
- ✓ Green pod can also be fed to animals.

CLITORIA *Clitorira ternata (*Suangu pushpom*)* (2n = 22)

Clitoria ternatea, common names including butterfly pea, blue pea, Cordofan pea and Asian pigeon wings. It is tropical forage legume grown in waste lands and field boundaries. It is also grown as ornamental flower plant.

Systematic Position

Class **:** Dicotyledonae

Subclass **:** Polypetalae

Series **:** Calyciflorae

Order : Leguminales

Family **:** Fabaceae

Subfamily **:** Papilionoideae

Place of origin **:** Tropical equatorial Asia

Related species **:** *Clitorira laurifolia*

Botany of Clitoria:

Family : Fabaceae

Habitat : Tropical

Habit : Twining herb, perennial legume

Stem : Slender twining

Leaves : Pinnately trifoliate with persistent stipules, narrowly triangular, leaflets elliptic or ovate, tip acute or round, both surface sparingly pubescent.

Inflorescence : Solitary, axillary. Flowers fragrant, yellow in axillary globose heads. Peduncles in slender fasicles, whorls of bracts appear

above the middle. Calyx tube cup shaped. Sepals are double the lengths of sepals stamens 10 (9+1), ovary monocarpellary, superior, many ovuled, marginal placentation style incurved.

Fruit : Pods linear, seeds oblong. contains 8-15 seeds stalked, convex, fleshy, distinct compartments occur between the seed. Occurs during the monsoon months. Flowering takes place in the winter season.

Economic uses:

- ✓ Suited to dry land pastures, protein 16-18%.
- ✓ Whole plant used as green fodder.
- ✓ In Southeast Asia the flowers are used to colour food.
- ✓ In Thailand, a syrupy blue drink is made called *nam dok anchan*, it is sometimes consumed with a drop of sweet lime juice to increase acidity and turn the juice into pink-purple.
- ✓ In Burmese and Thai cuisine the flowers are also dipped in batter and fried.
- ✓ Roots have medicinal value In traditional Ayurvedic medicine, it has been used for centuries as a memory enhancer, nootropic, antistress, anxiolytic, antidepressant, anticonvulsant, tranquilizing and sedative agent

AGATHI (*Sesbania grandiflora) (2n = 14)*

It is also known as hummingbird tree. It is a fast-growing tree, leaves are regular and rounded and the flowers white and red in color according to its species. The fruits look like flat, long and thin green beans. The tree thrives under full exposure to sunshine and is extremely frost sensitive. It contain arginine, cysteine, histidine, isolcucine, phenylalanine, tryptophan, valine, threonine, alanine, aspargine, aspartic acid, oleanolic acid, galactose, Rhamnose & glucuronic acid.

Systematic Position

Class **:** Dicotyledonae

Subclass **:** Polypetalae

Series **:** Calyciflorae

Order : Leguminales

Family **:** Fabaceae

Subfamily **:** Papilionoideae

Place of origin **:** Tropics

Related species **:** *Sesbania sesban*

Botany of Agathi:

Family	:	Fabaceae
Habitat	:	Tropical
Habit	:	Medium to tall growing tree with attractive white flowers.
Stem	:	Pithy, late becomes woody
Leaves	:	Pinnately compound with numerous leaflets. The leaflets near the pulvinous are larger than at tip. Stipules prominent with acute tip.
Inflorescence	:	Long lax drooping raceme. Flowers large, white, yellowish, rpink or red in colour.
Fruit	:	Pods very long drooping with 40-45 seeds.

Economic uses:

- ✓ Green leaf manure, also used as fodder
- ✓ *Leaves* used as tonic, diuretic, laxative, antipyretic, chewed to disinfect mouth and throat. *Flower* in headache, dimness of vision, Catarrh, Headache, cooling and improving appetite. *Bark* is used for cooling (ayurvedha and siddha medicinal terms), bitter tonic, anthelmintic, febrifuge, diarrhea, Small pox, Astringent.
- ✓ *Fruits* in Bitter & acrid, laxative, fever, pain, bronchitis, anemia, tumors, colic, jaundice, poisoning.
- ✓ *Root* used in Rheumatism, Expectorant, Painful swelling, Catarrh.
- ✓ The flowers of *S. grandiflora* are eaten as a vegetable in Southeast Asia, like Laos, Thailand, Java in Indonesia, Vietnam, and the Ilocos Region of the Philippines.
- ✓ The young pods are also eaten, along with the leaves.
- ✓ In Sri Lanka, agati leaves, are sometimes widely eaten with thin coconut gravy and is believed locally to be a cure for canker sores.
- ✓ In India this plant are both the leaves and the flowers have culinary uses.

` **SUNN HEMP** – *Crotalaria juncea L*. (2n = 26)

(Channapai / Sunn / San)

Sunn hemp is a source of bast fibre, grown in tropical countries. It is also grown as a fodder and green manure. India exports this fibre to United Kindom. Belgium and United States.

Systematic Position

Class	**:** Dicotyledonae
Subclass	**:** Polypetalae
Series	**:** Calyciflorae
Order	: Leguminales

Family **:** Fabaceae

Subfamily **:** Papilionoideae

Place of origin **:** Asia

In India **:** Uttar Pradesh is the largest producer, other major producing areas are Bihar, Andhra Pradesh Tamil Nadu and Madhya Pradesh.

Related species **:** *Clitorira mucronata*

Botany of Sunnhemp:

Family	:	Fabaceae
Habitat	:	Tropical
Habit	:	Erect growing annual
Leaves	:	Leaves alternate, short petiolate.
Inflorescence	:	Inflorescence is terminal raceme, flowers papilonaceous bright yellow. Calyx gamosepalous. Corolla polypetalous, standard broad, wing oblong, keel much pointed, slightly twisted at apex. Stamens 10 in monadelphous condition, dimorphic with five short versatile anthers on slender filaments alternating with long basifixed anthers with flattened filaments. Ovary superior, manocarpellay with marginal placentation.
Fruit	:	Pod or capsule.
Seed	:	Kidney shaped exendospermous.

Economic uses:

- ✓ It is a green manure as well as fibre crop
- ✓ Cordage fibre, marine cordage, manufacture of sail cloth, canvas, matting.
- ✓ Rope, soles of shoes and sandals used for making cigarete papers, tissue paper, fishing net.

DAINCHA *Sesbania aculeate (*2n=24)

It is an annual shrub which can grow to seven metres in height but usually only reaches one to two metres. It sends out fibrous, pithy stems with long leaves and bears purple-spotted yellow flowers. It produces pods which contain light brown beans.

Systematic Position

Class **:** Dicotyledonae

Subclass **:** Polypetalae

Series **:** Calyciflorae

Order : Leguminales

Family **:** Fabaceae

Subfamily **:** Papilionoideae

Place of origin **:** India

Related species **:** *Sesbania pachycarapa*

Botany of Daincha:

Family	:	Fabaceae
Habitat	:	Tropical
Habit	:	A soft stemmed shrub with or without prickles, growing to 15-20 metres.
Leaves	:	Long, pinnately compound, with small oblong leaflets, stipules small and deciduous
Inflorescence	:	Terminal / axillary raceme. Flowers yellowish in lax axillary racemes, partly drooping
Fruit	:	Fruiting profuse, fruit long, cylindrical with, 25-30 seed per pod, seeds oblong, greyish brown in colour.

Economic uses:

- ✓ Primarily used as green manure crop
- ✓ It can be used like industrial hemp for rope, fish nets, sackcloth and sailcloth.
- ✓ The foliage makes a good fodder for livestock and the beans can be fed to fowl.
- ✓ Natural gum from the plant is useful as a thickening agent.
- ✓ Like other legumes, it can be planted to improve the soil via nitrogen fixation.
- ✓ It makes good firewood.
- ✓ The beans have historically been used in poultices to treat ringworm and other skin infections.
- ✓ The yellow flowers of *S. aculeata* are eaten as a vegetable in Southeast Asia. They are much smaller than the more popular white flowers of *Sesbania grandiflora*, but similar in shape.
- ✓ The flowers are used in Thai cuisine both cooked and raw, they can also be used to make omelettes and sweets.

Lecture 10

Pedaliaceae - Gingelly, Asteraceae - Sunflower, Safflower, Chrysanthemum, Oleaceae - Jasmine

In some plant species the metabolic activity leads to the production of reserve food substances in the form of oils or fats. Oil is in liquid form under ordinary temperature and fat is in solid state in ordinary temperature. The oils are synthesised by plants from carbohydrates and stored as insoluble droplets with in the tissues of plant parts. The vegetable oils (produced by plants) are divided in to two groups.

a) **Fixed or non volatile oils**: Which will not evaporate under normal conditions of temperature and exposure. The plants producing this type or oil are dealt with in this chapter.

b) **The essential or volatile oils:** Volatilize or evaporate in the atmospheric air on exposure. There oils are having an aromatic scent and of quite different composition from the fixed oils.

Fixed oils or non volatile oils can be classified as:

1. Drying oils
2. Semi drying oils
3. Non drying oils
4. Fats

i. Drying Oils:

On exposure to air these oils absorb oxygen and dry into thin elastic film. Such oils are useful for the manufacture of varnishes and paints. Some of the drying oils are used for food, for the manufacture of soaps and for illuminating purposes. The unsaturated fatty acids in drying oil include linolenic and linoleic acid in their glycerides and other acids like tri-ethenoid acids. Some examples for drying oil are given.

Common name	Botanical name	Family
Linseed oil	*Linum usitaticimum*	Linaceae
Safflower oil	*Carthamus tinctorius*	Asteraceae
Soybean oil	*Glyline max*	fabaceae

ii. Semidrying oils:

This oil absorb oxygen slowly and drying slowly on continued exposure to atmospheric air. This form only a soft film after long exposure. Some examples are given below.

Common name	Botanical name	Family
Gingelly oil	*Sesamum indicum*	Peadaliaceae
Mustard oil	*Brassica sp.*	Brassicaceae
Cotton seed oil	*Gossypium sp.*	Malvaceae
Corn oil	*Zea mays*	Poaceae
Sunflower oil	*Helianthus annuus*	asteraceae

iii. Non-drying oils:

These oils remain liquid at ordinary temperature and do not form film on exposure to air. They react with oxygen very slowly or not at all. They are characterised by high content of Oleic acid. These are generally used for soap making and for lubrication purposes. Some examples are given below.

Common name	Botanical name	Family
Castor oil	*Ricinus communis*	Euphorbiaceae
Groundnut oil	*Archis hypogaea*	Fabaceae
Coconut oil	*Cocos nucifere*	Arecaceae
Palm oil	*Elaeis guineensis*	Arecaceae
Olive oil	*Olea eurpea*	oleaceae

iv. Fats:

This includes vegetable oils which remain solid or semi solid at ordinary temperature. Used as food and also in candle and soap manufacturing industry. Examples.

Common name	Botanical name	Family
Coco butter	*Theobroma cacao*	Sterculaceae
Palm oil & Palm	*Elaeis guineensis*	Arecaceae
Kernel oil		

Oil seeds are also classified as:

1. Major oil seeds – Eg. Groundnut, Gingelly, Mustard, Sunflower and coconut.
2. Minor oilseeds – Eg. Safflower.

Non conventional oilseeds:

New plant species are identified for their potential use of oil.

Eg. : Jojoba - *Simmondsia chinensis* (Bauxaceae)

Jatropha - *Jatropha* sp. (Euphorbiaceae)

Uses of oil seeds:

- Source of energy
- Medicinal value
- Industrial oil – soap making cosmetics, lubricants.
- Oil cake as cattle feed, and fertilizer.
- Green and dried plant as fodder.

Location of oils:

Vegetable oils and fats are located as small insoluble droplets in plant cells either in vascular or found along the cell wall. They occurs mostly in seeds (Endosperm / Cotyledon), occurs in mesocarp, embryo and less frequently in root, stem and foliage, Examples given below.

Endosperm	Cotyledon	Mesocarp	Embryo	Root, stem & foliage
Sesame	Groundnut	Olive,	Cereals	Sandal wood
Castor	Sunflower	Oil palm		Eucalyptus
Coconut	Safflower			Pepper Mint
Oilpalm				Lemon grass

Description of Pedaliaceae family:

- Herbs (mostly), or shrubs (rarely).
- Leaves are simple. Lamina dissected, or entire, exstipulate. Hairs present; eglandular and glandular (mucilage hairs).
- Stem Pith with diaphragms (sometimes) or without diaphragms. Cork cambium present
- The inflorescence is cymose. Flowers solitary, or aggregated. axillary.
- Flowers bracteate Flowers pentamerous, *Perianth* with distinct calyx and corolla. gamosepalous (forming a lobed tube); Corolla 5 gamopetalous; imbricate;
- Plants hermaphrodite. Pollination entomophilous. *Androecium* 5. 1 staminode. Fertile stamens 4, epipetalous;
- *Gynoecium* 2 carpelled. The pistil 2–8 celled. syncarpous; superior ovary 2–4 locular, Styles 1, Placentation axile. Ovules 1 per locule (*Josephinia*), or 2–50 per locule (to many)
- *Fruit* non-fleshy (often with hooks, or prickly); dehiscent, or indehiscent; a capsule, or a nut.
- Seeds thinly endospermic, or non-endospermic. Endosperm oily. Seeds with amyloid. Cotyledons 2. Embryo straight.

Division : Phanerogams
Sub-division : Angiosperms
Class : Dicotyledon
Series : Bicarpellatae
Order : Personales
Family : pedaliaceae

List of cultivated crops under Pedaliaceae

Sl. No	Crop	Botanical Name	Chromosome number	Economic Part
1.	**SESAMUM**	**Sesamum *indicum* L.**	26	Seed

SESAMUM – Sesamum *indicum* L. (2n = 26) *syn. S.orientale*

(Gingelly/Sesame/Ellu/Til)

Sesamum is an oilseed crop in the hotter and drier parts of the world. It is sensitive to low temperature. Sesamum and coconut are regarded as the oldest oil yielding plant known to man.

Systematic Position:

Division : Phanerogams
Sub-division : Angiosperms

Class	:	Dicotyledon
Series	:	Bicarpellatae
Order	:	Personales
Family	:	pedaliaceae

Place of Origin: Africa (Secondary centre - India)

Distribution : India, Africa, China, Burma, Sudan.

In India : U.P., Rajasthan, M.P., A.P., Tamil Nadu, Maharastra, Gujarat.

Related Wild Specis:

The genus Sesamum includes 36 species of which 20 occur in Africa. Some of the wild species used in crop improvement are: *S. alatum, S.malabaricum, S. laciniatum. S.prostratum, S.radiatum.*

Distinguishing Characters of the Genus Sesamum:

- Stem-quadrangular in shape
- Basal leaf opposite, upper leaf alternate.
- Presence of extra floral nectary gland on peduncle base.
- Corolla bell shaped, bilipped and five lobed.
- Androecium – epipetalous, didynamous stamens.
- Ovary – bicarpellary, by presence of false septa appear as four loculed.

Key Botanical features of Sesamum

Family	:	Pedaliaceae
Habitat	:	Tropical and subtropical
Habit	:	Herbaceous, annual, growing to a metre or more.
Stem	:	Erect, quadrangular, longitudinally furrowed with dense hairs
Leaves	:	Variously arranged, opposite below, alternate above, the leaves are entire, lanceolate whereas the leaves below are broad lobed with serrated margins.
Inflorescence	:	Axillary, solitary or in groups of two to three flowers, shortly pedicellate with two aborted glands on either side of the pedicel
Calyx	:	Five lobes, gamosepalous
Corolla	:	Tubular, ventricose, slightly gibbous at base, two liped, the upper lip of two lobes usually smaller, the lower bigger and of three lobes, a ring of hairs is often present inside the corolla towards the base below the stamens. Flowers variously coloured from pure white to purple or to deep violet.
Androceium	:	Stamens 4, Epipetalous, didynamous, a fifth staminode may be present

Gynoecium	:	Superior ovary, bicarpellary, looks like four by the formation of a false septa, many ovuled on axile placentation. The style is forked at the tip and carries the two stigmatic hairy lobes.
Fruit	:	Oblong or ovoid capsule with bony walls, loculicidal dehiscence, two types of fruits are recognised. One is four loculed and the other eight loculed.
Seeds	:	Seeds compressed, ranging from white to brown or black with a smooth or rough surface enclosing an embryo with prominent cotyledon. Endosperm found as a thin layer around embryo, endosperm contains oil and protein.

Economic Uses:

- Seeds contain semidrying oil (50%) and 20 – 25% protein.
- Good source of cooking oil – (85% unsaturated fatty acid).
- Seeds mixed with jaggery and eaten – chikki.
- Manufacture of margarine.
- Soap, paint, illuminant, base for scented oil.
- Carrier for antibiotics, vitamins and hormones.
- Oil cake – rich in calcium, phosphorus and the vitamin niacin: used as cattle feed.
- Seed and green plant have medicinal value.

Asteraceae

The Asteraceae is one of the largest plant families (the largest dicot family, and second only to the Orchidaceae in flowering plants), having 2 subfamilies, 13 tribes, 1,100 genera, and about 25,000 species. It occurs throughout the world, with its greatest diversity in the semi-arid tropics. Asteraceae, the sunflower family, is one of the easiest plant families to recognize. Compositae refers to the superficial resemblance of the head to a single, large flower. What looks like an ordinary flower is really a composite of small florets.

Description of Asteraceae family

- The calyx is so highly modified it is given a different name pappus.
- The pappus may consist of capillary hairs (fine hairs) that may be plumose or they may have bristles, awns, scales, or no pappus at all (epappose).
- Androecium consists of 5, epipetalous stamens. In almost all species the anthers are fused together, forming a ring (tube) around the style (syantherous condition). The tube of the anthers is an important part of the pollen presentation of composites.
- The anthers and pollen mature before the stigmas (protandry), and shed their pollen into the cylinder formed by the anthers.
- The ovary is inferior, and encloses a single seed.

- The fruit is an **achene**, with the ovule basally attached to the seed pericarp.
- There is only 1 style, but it ends in two style branches (stigmas) which are stigmatic only on the inner, facing surface.

Distinctive features of Asteraceae

A. Inflorescence

- Inflorescence consists of several small flowers, called florets, that are crowded together, sessile, on a receptacle. This inflorescence is often mistaken for a single flower. The inflorescence is called a capitulum, or head.
- The flower cluster is surrounded by bracts, called involucral bracts and the whole structure is referred to as an involucre.
- Some members of the family have only one row (uniseriate) of involucral bracts (Senecio); others have several rows.
- In some species, some or all the florets are subtended by their own bracts. These bracts are attached to the receptacle, and are referred to as receptacular bracts, or chaff. They are generally not visible unless you pull apart the capitulum. Species without chaff are said to have a naked receptacle. The receptacle is the enlarged portion of the peduncle upon which the florets are borne.

B. Flower

- **Disk florets** - In most members of Asteraceae, the central florets have a radially symmetrical, tubular corolla, with 5 short lobes. These florets are called **disk florets**. They form the central disk of the capitulum in typical daisies. Disk florets are often perfect flowers. The entire inflorescence may be composed of disk florets only (a condition referred to as **homogamous**); when so, the inflorescence is said to be **discoid**.
- **Ray florets** - Surrounding the disk florets are sometimes an outer ring of **ray florets**. These have zygomorphic symmetry, and are usually either sterile or pistillate, with **3 apical teeth**. Ray florets are strap-shaped, imperfect, and never occur alone in the inflorescence (a condition referred to as **heterogamous**). They are always associated with disk florets (although disk florets may occur without ray florets), and form a circle around the margin of the head, the center filled with disk florets.
- **Ligulate floret** the best known weedy composite, the common dandelion, has a third kind of floret, a ligulate floret. These resemble ray florets with their zygomorphic symmetry, but ligulate florets are perfect (bisexual), and have **5 apical teeth** at the end of the strap.
- **Bilabiate floret** these florets have zygomorphic symmetry, but not so much as the ray or ligule. They have 3-4 lobes on the lower (long) lip, and 1-2 lobes on the upper (shorter) lip. They are also bisexual, can be represented by thistles, and are relatively rare in the U.S.

List of cultivated crops under Asteraceae

Sl. No	Crop	Botanical Name	Chromosome number	Economic Part
1.	**SUNFLOWER**	**Helianthus annuus**	34	Seed
2.	**SAFFLOWER**	***Carthamus tinutorius* L.**	24	Seed & Petals
3.	**CHRYSANTHEMUM**	***Chysanthemum indicum***	36	Flower

SUNFLOWER – Helianthus annuus (2n = 34)
(Sooryakanthi/Adhithyabakthi/Surajmukhi)

Sunflower is an important oilseed crop after soybean and oil palm in the world and accounts for about 12.8 per cent of the world production of edible oil. Its oil content ranges from 35 to 45 per cent and is of high quality having non-cholesterol and anticholesterol properties. Sunflower seed oil production is more in temperate regions but it is adapted to tropical conditions also. The Soviet Union is the largest producer.

Systematic Position:

Division : Phanerogams
Sub-division : Angiosperms
Class : Dicotyledon
Sub-class : Gamopetalae
Series : Interae
Family : Asterales

Place of Origin: North America

Putative parent: Weed sunflower by natural crossing with *H.petiolaris* gave rise to cultivated sunflower.

Distribution : Russia, Canada, USA, India

In India : Maharastra, Karnataka, A.P. and Tamil Nadu.

Classification:

The genus Helianthus consists of more than 67 species. Of which two are cultivated.

i. *H annuus* : Sunflower (diploid. 2n = 34) – Oilseed

ii. *H. tuberosus* : Jersalam Artichoke (hexaploid. 2n = 104) – Cultivated for its tubers.

Wild species: *H. hirsutus. H.rigidus. H. petiolaris*.

Cultivars:

Based on plant height the cultivated sunflower is classified into:

a. Giant types:
   Tall (6' – 14') Late maturing. Large heads. Oil content very low (<30%).
b. Semi dwarf type:

Medium tall (4’ to 6’) Early maturing high oil content (35%).

c. Dwarf types:
Short (2’ to 4’) early maturing, small seeds – high oil content (37%).

Key Botanical features of Sunflower

Family	:	Asteraceae
Habitat	:	Tropical and subtropical
Habit	:	Tall annual herb. Two varieties 1. Tall unbranched, single headed type 2. Short branched, multiheaded type
Stem	:	Rough, hairy and pithy
Leaves	:	Simple, alternate, large, rough, hairy, cordate, irregularly toothed on the margins, pointed at the apex.
Inflorescence	:	Heterogamous capitilum (head). Receptacle is flat, slightly convex with two to three rows of large pointed involucre of bracts, head has outer row of ray florets and inner rows of disc florets. Florets are subtended by broad scales (bracteoles)
Ray floret	:	Ligulate corolla, yellow in colour, zygomorphic and calyx is reduced to pappus hairs. Normally florets are sterile or sometimes pistillate
Dise floret	:	Actinomorphic, bisexual, calyx is reduced to pappus hairs, garmosepalaous, corolla united to form a tube. Stamens five, Syngenesious anthers, epipetalous stamens, ovary inferior, monocarpellary with single ovule and the style passes through syngenesious anthes with bifid stigma.
Fruit	:	Achenes, broad, angular, large
Seeds	:	Seeds are non endospermic, major source of semi-drying oil. Seeds are also consumed raw, roasted or salted.

Economic Uses:

- Seed is a source of semidrying oil (35-40%).
- Oil as cooking media. It contains 90% Poly unsaturated fatty acid (PUFA) and 10% Saturated Fatty acid. It has non cholesteral and anti cholestrol properties.
- Used in cooking and for salads. Used in paints, varnishes, soap, cosmetics.
- Oil cake and hulls as cattle feed and fuel.
- From dried stalk paper is made.
- Sunflower also produces excellent honey and wax.
- Fried sunflower seeds are edible

SAFFLOWER – *Carthamus tinutorius* L. (2n = 24)

(Kusumba/Senthoorakam/Koosum)

Safflower is slowly becoming of increasing importance as an oil crop for the drier parts of the tropics and sub-tropics. It is grown in countries like India, the Middle East and East Africa. It is not only grown for its oil but for the orange dye which can be extracted from the flower heads.

Systematic Position:

Division	:	Phanerogams
Sub-division	:	Angiosperms
Class	:	Dicotyledon
Sub-class	:	Gamopetalae
Series	:	Interae
Family	:	Asterales
Order	:	Asteraceae

Place of Origin: Africa

Key Botanical features of Safflower

Family	:	Asteraceae
Habitat	:	Tropical and subtropical
Habit	:	Annual herb, plants may be glabrous or pubescent.
Stem		Erect, woody, glabrous and grooved
Leaves		Alternate, rigid, entire and unarmed or spinulose – serrated
Inflorescence	:	Head or capitilum, homogamous, outer involucre or bracts ovate, oblong, constricted above the base, green spinous or not, inner involucre of bracts, oblong, acute. Florets are tubular, light yellow to orange red in colour, hermophrodite, bracts and bracteoles of each floret modified into thin soft hairs. Calyx absent, corolla long, tubular, arising on the inferior ovary, stamens five, epipetalous, syngenesious, ovary inferior, bicarpellary, single celled, single ovuled, basal placentation, sometimes a few of the marginal florets are sterile.
Fruit	:	An achene which is obovate, truncate at top, exendospermous

Economic Uses:

- The oil content of the seed varies from 24 to 36 percent. Oil is fairly good drying oil.
- Contains high percentages of linoleic acid, but little or no linoleic acid.
- Cooking media (Saffola). Corolla used in dyeing industry.
- Oil cake – stock feed. Preparation of paints and varnishes.
- Seed is source of drying oil (29-32%)

CHRYSANTHEMUM- *Chysanthemum indicum* (2n = 36)

Chrysanthemums are the iconic symbol of Mother's Day and are popular gifts. Chrysanthemum has been growing in China for more than 2500 years. Some varieties, such as florists' chrysanthemum (Chrysanthemum x grandiflorum), produce large impressive flower heads on strong, upright stems, with colours that range from pure white, through every shade of pink, burgundy, bronze and to bright lime green. The forms of these pretty flowers are even more diverse than the colours, with more than 10 classifications, including: single and semi-double; regular, irregular and intermediate incurved; quill; spoon; pompon; reflexed; anemone; spider; decorative; and brush or thistle. In Japan, the flower is very symbolic, with the Royal Family said to rule from the Chrysanthemum Throne. It has been their national flower for the past 100 years and is a symbol of happiness and longevity.

Systematic Position:

Division	:	Phanerogams
Sub-division	:	Angiosperms
Class	:	Dicotyledon
Sub-class	:	Gamopetalae
Series	:	Interae
Family	:	Asterales
Order	:	Asteraceae

Place of Origin: China

Key Botanical features of Chrysanthemum

Family	:	Asteraceae
Habitat	:	Tropical and subtropical
Habit	:	Herbaceous perennial, 50-150 cm tall.
Stem		Erect, woody, glabrous, branched
Leaves		Alternate, deeply lobed with serrate margin.
Inflorescence	:	Head or capitilum. Heads many in small clusters on short peduncles. Disc florets bisexual and usually fertile. Ray florets are pistillate and they are entire or toothed.
Fruit	:	Achene obovate, truncate at top.

Economic Uses

- It is used for ornamental purpose and an important cut flower next to rose.
- The flowers are long-lasting cut flowers that can easily look good for up to three weeks in a vase. To get the best from a bunch, change the water regularly and re-cut stems every few days.
- It is used for medicinal and flavouring purposes, as well as for its beautiful blooms

Oleaceae

Description of Oleaceae family

- Mesophytic. Trees and shrubs or climbing; the climbers stem twiners,
- Leaves deciduous (often), or evergreen; opposite (nearly always), or alternate; petiolate; non-sheathing; simple, or compound; when compound ternate, or pinnate. Leaves exstipulate.
- Stem Pith homogeneous, or heterogeneous. Secretory cavities absent. Cork cambium present;
- Plants hermaphrodite (usually), or polygamomonoecious.
- Flowers solitary, or aggregated in 'inflorescences'; when aggregated, in racemes, or in fascicles, or in panicles. The ultimate inflorescence units cymose. Flowers bracteate, or ebracteate; regular; usually pentamerous; cyclic Free hypanthium absent.
- *Perianth* with distinct calyx and corolla (usually), or sepaline (the corolla sometimes lacking); typically 8; 2 whorled (usually), or 1 whorled; Calyx 4, 1 whorled; gamosepalous; entire, or lobulate, or blunt-lobed, or toothed (sometimes obsolete); regular; valvate. Corolla when present (i.e. usually) 4, 1 whorled; polypetalous (rarely, more or less), or gamopetalous; imbricate, or valvate (or induplicate-valvate), or contorted; regular.
- *Androecium* 2 (usually), or 4 (rarely). Androecial members adnate (to the corolla), or free of the perianth; free of one another; 1 whorled. Androecium exclusively of fertile stamens. Stamens 2, reduced in number relative to the adjacent perianth; oppositisepalous; filantherous, or with sessile anthers. Anthers dorsifixed, or basifixed; dehiscing via longitudinal slits; introrse. Endothecium developing fibrous thickenings.
- Hypogynous disk present (around G), or absent; intrastaminal.
- *Gynoecium* 2 carpelled. Carpels reduced in number relative to the perianth. The pistil 2 celled. Gynoecium syncarpous ovary superior. Ovary 2 locular. Styles 1; apical. Stigmas 2 lobed; dry type;
- Placentation axile. Ovules (1–)2(–50) per locule (usually two, but Jasminoideae with 1, 4 or 'many'); pendulous, or ascending;
- *Fruit* fleshy, or non-fleshy; dehiscent, or indehiscent, or a schizocarp. Mericarps when schizocarpic, Fruit when non-schizocarpic, a capsule, or a berry, or a drupe. Capsules loculicidal. Fruit 1–4 seeded. Seeds endospermic, or non-endospermic

List of cultivated crops under Oleaceae

Sl. No	Crop	Botanical Name	Chromosome number	Economic Part
1.	**JASMINE**	***Jasminum sp.***	26	Flower

JASMINE – *Jasminum sp.* (2n = 26)

J. grandiflorum, J. angustifolium, J.multiflorum, J. Sambac

Widely cultivated for its flowers, jasmine is enjoyed in the garden, as a house plant, and as cut flowers. The flowers are worn by women in their hair in southern and southeast Asia. The delicate jasmine flower opens only at night and may be plucked in the morning when the tiny petals are tightly closed, then stored in a cool place until night. The petals begin to open in the evening, as the temperature lowers.

The basic chromosome number of the genus is 13, and most species are diploid (2n=26). However, natural polyploidy exists, particularly in *Jasminum sambac* (2n=39), *Jasminum flexile* (2n=52), *Jasminum primulinum* (2n=39), and *Jasminum angustifolium* (2n=52).

Key Botanical features of Jasmine

Family	:	Oleaceae
Habitat	:	Tropical and subtropical deciduous (leaves falling in autumn) or evergreen (green all year round),
Habit	:	erect shrub, spreading, or climbing shrubs and vines.
Stem	:	Green, glabrous, angled almost four sided.
Leaves	:	Opposite or sometimes alternate, imparipinnate with 3-7 leaflets or reduced to one leaflet, petiole articulated. opposite or alternate. They can be simple, trifoliate, or pinnate.
Inflorescence	:	Simple or dichotomous terminal cymes or rarely solitary. They are white or yellow in color, although in rare instances they can be slightly reddish. The flowers are borne in cymose clusters with a minimum of three flowers, though they can also be solitary on the ends of branchlets. Each flower has about four to nine petals, two locules, and one to four ovules. They have two stamens with very short filaments. The bracts are linear or ovate. The calyx is bell-shaped. They are usually very fragrant. Calyx campanulate with 4-9 teeth of varying length. Corolla 4-9 lobed with cylindrical tube.
Fruit	:	Berry, capsule or drupe

Economic Uses

- **Jasmine tea:** Green tea with jasmine flowers. Jasmine tea is consumed in China, where it is called jasmine-flower tea. *Jasminum sambac* flowers are also used to make jasmine tea, which often has a base of green tea or white tea, but sometimes an Oolong base is used. In Japan, jasmine tea is known as *sanpin*

- **Jasmine syrup:** Jasmine syrup, made from jasmine flowers, is used as a flavouring agent.
- **Jasmine essential oil:** Jasmine is considered an absolute and not an essential oil as the petals of the flower are much too delicate and would be destroyed by the distillation process used in creating essential oils.
- **Jasmine absolute used in perfume and incense**: Many species also yield an absolute, which is used in perfumes and incense. Its chemical constituents include methyl anthranilate, indole, benzyl alcohol, linalool, and skatole.
- **Medicine:** Jasmine scent and linalool (licareol), one of its major odor components, has been reported to have sedative properties now being investigated for medical applications.
- **Jasmonates:** Jasmine gave name to the jasmonate plant hormones as methyl jasmonate isolated from the jasmine oil of *Jasminum grandiflorum* led to the discovery of the molecular structure of jasmonates.

Jasmine as a national flower

Several countries and states consider jasmine as a national symbol. They are the following:

- Hawaii: *Jasminum sambac* ("*pikake*") is perhaps the most popular of flowers. It is often strung in leis and is the subject of many songs.
- Indonesia: *Jasminum sambac* is the national flower, adopted in 1990. It goes by the name "*melati putih*" and is the most important flower in wedding ceremonies for ethnic Indonesians, especially in the island of Java.
- Pakistan: *Jasminum officinale* is known as the "*chambeli*" or "*yasmin*", it is the national flower.
- Philippines: *Jasminum sambac* is the national flower. Adopted in 1935, it is known as "*sampaguita*" in the islands. It is usually strung in garlands which are then used to adorn religious images.

Lecture 11

Brassicaceae and Euphorbiaceae; Key botanical features of Rape and Mustard, Cabbage, Cauliflower, Castor, Jatropha and Tapioca.

Brassicaceae

The family consists mostly of herbaceous plants with annual, biennial or perennial lifespans

- The **leaves** are alternate (rarely opposite), sometimes organized in basal rosettes; in rare shrubby crucifers of Mediterranean their leaves are mostly in terminal rosettes, and may be coriaceous and evergreen. They are very often pinnately incised and do not have stipules.
- The structure of the **flowers** is extremely uniform throughout the family. They have four free saccate sepals and four clawed free petals, staggered. They can be disymmetric or slightly zygomorphic, with a typical cross-like arrangement
- They have six stamens, four of which are longer (as long as the petals, so relatively short in fact) and are arranged in a cross like the petals and the other two are shorter (**tetradynamous** flower).
- The pistil is made up of two fused carpels and the style is very short, with two lobes. Superior ovary. The flowers form ebracteate racemose inflorescences, often apically corymb-like.
- Pollination occurs by entomogamy, nectar is produced at the base of the stamens and stored on the sepals.
- The fruit is a peculiar kind of capsule named siliqua (plural siliquae). It opens by two valves, which are the modified carpels, leaving the seeds attached to a framework made up of the placenta and tissue from the junction between the valves (replum). There is often an indehiscent beak at the top of the style and one or more seeds may be borne there

Four diploids are:

- 1. *B.nigra* - Black mustard
- 2. *B.oleracea* - Cabbage
- 3. *B.campestris* - Rape seed.
- 4. *B.tourne frotii* - Wild turnip

Three allopoly ploids

- 1. *B.napus* - Rape seed of Europe
- 2. *B.juncea* - Indian mustard
- 3. *B.carinata* - sthipplam mustard (veg / oil seed)

RAPE SEED AND MUSTRAD –

Brassica spp. (2n = 16, 18, 20, 22, 36)

Oilseed Brassicas, the rape seed and mustard, occupy about 4.5 million ha and produce about three million tonnes of seed annually, contributing to about 20 per cent of the total oilseed production in India. The genus Brassica is a member of the family Brassicaceae, contain more than 3000 species, of which 40 are of economic importance.

SYSTEMATIC POSITION:

Division	:	Phanerogams
Sub-division	:	Angiosperms
Class	:	Dicotyledon
Sub-class	:	Polypetalae
Series	:	Thalamiflorae
Order	:	Parietales
Family	:	Brassicaceae

Cultivated brassicas can be broadly divided into two distinct types.

1. Vegetable type – Cabbage (***B. oleracea var. capitata***), Cauliflower (***B.o. var . botritis***.), Turnip (***B. oleracea var. rapa***).
2. Oilseed type - Rape seed and mustard.

KEY CHARACTERS:

Leaves two types:

i. Stem leaf bigger, lance shaped, serrated and.

ii. Flower leaf small, smooth margin.

Androecium : Tetradynamons stamen.

Fruit **:** Siliqua.

RAPE SEED

1. *B. campestris*: (2n = 20)

Indian Rape seed. Self sterile in nature, important oil seed crop of North India. There are three cultivated types.

B. campestris var. brown sarson - (Brown sarson)

B. campestris var. yellow sarson - *(Yellow sarson)*

B. campestris var. toria - (Toria)

2. *B. napus*: (2n = 20)

European rape seed. Self fertile grown in Eurupe for green fodder as well as oilsed.

***Brassica napus* –** rape

- ***B. napus* subsp. *napus* –** Argentine canola**,** canola**,** colza**,** oilseed rape**, and** rape

- ***B. napus* subsp. *napus* f. *annua* –** annual rape **and** summer rape **(treated as *B. napus* var. *annua*)**
- ***B. napus* subsp. *napus* f. *napus* –** Swede rape **(treated as *B. napus* var. *biennis*)**

- ***B. napus* subsp. *napus* var. *pabularia* –** Hanover-salad**,** rape kale**, and** Siberian kale
- ***B. napus* subsp. *rapifera* –** rutabaga**,** swede **(treated as *B. napus* var. *napobrassica*),** Swedish turnip **(treated as *B. napus* Napobrassica Group), and** winter rape

MUSTRAD:

1. *B. nigra*: (2n = 16)

Black or true mustrad or Banarsi rai. Native of Eurasia. Countain 28 per cent fixed oil used as medicine. Oil is pungent due to presence of glucoside sinigrin mostly used as condiment.

2. *B. alba*: (2n = 24)

White mustrad or Ujli sarson. Young seedlings used as salad. Seeds are yellowish in colour. Contains 30 per cent oil. Native of Mediterranean region.

3. ***B. juncea*: (2n = 39)**

Indian mustrad or Brown sarson. Popularly known as Rai. Contains 35 per cent oil. Leaves are used in herbal medicines. Most pungent among cultivated oil seeds contain glucoside sinigirin.

Botanical description of Brassicaceae *spp* of Rape and Mustard

Family	:	Brassicaceae
Habitat	:	Temperate and subtropical
Habit	:	Herbaceous, annual
Leaves	:	Alternate, exstipulate, simple leaves, often pinnately lobed. The lower leaves are known as the stem leaves and the upper leaves on the axis of the inflorescence known as floral leaves.
Inflorescence	:	Long racemose with a few bracts. Flowers conspicuous, actinomorphic. Seplas four, erect or spreading. Petals four with narrow basal claw, spreading or erect limb. Stamens six, the outer two shorter than the four inner. Gynoecium superior, two jointed carpels with single short style and capitate stigma, ovule many in parietal

placentation.

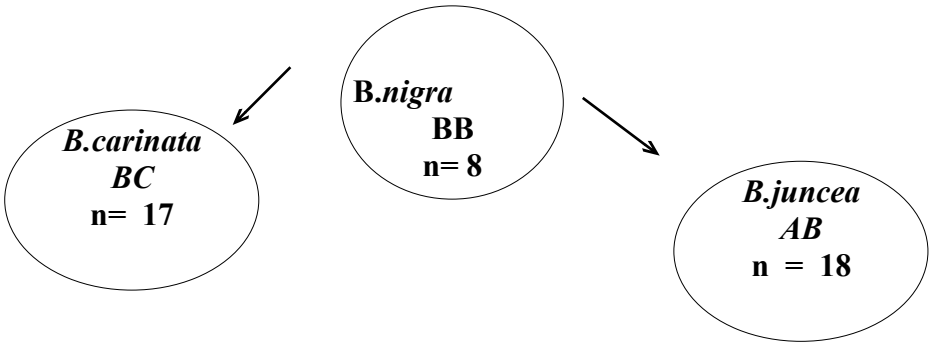
Fruit : Siliqua, dehiscing by the carpel walls splitting longitudinally along the line of placenta. The seeds are black or white depending on the varieties. The cotyledons contain the oil

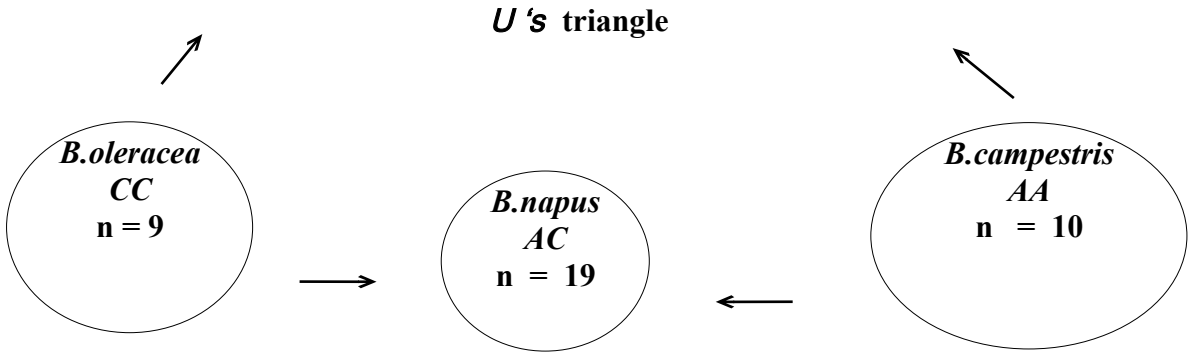
Seeds : The oil content of the seed varies from 30 to 45 per cent depending on the variety. Yellow seeds contain more oil and brown seed contain less oil. The seeds also contain 20 per cent protein and high percentage of erucic acid (45-50 per cent or total fatty acids) olecic acid (20-30 per cent) and acid (15-25 per cent) and other saturated acids such as palmitic, stearic lignoceric are present in small quantities. Edible purpose mustard oil must contain less erucic acid and for industrial purpuse high erucic acid content is preferred.

Economic Uses:

- Seeds as condiment
- Seeds for extraction of oil which is edible.
- Oil – cooking, llluminant, lubricant, soap industry, fertilizer industry, plastic industry
- Green plant as fodder
- The essential oil in mustard has medicinal properties. Used as counter irritant.
- The leaves of young plants used as green or leafy vegetable.
- Rapeseed is grown for the production of animal feed, vegetable oil for human consumption, and biodiesel
- Recent research has studied varieties of mustards with high oil contents for use in the production of biodiesel, a renewable liquid fuel similar to diesel fuel. The biodiesel made from mustard oil has good cold flow properties and cetane ratings. The leftover meal after pressing out the oil has also been found to be an effective pesticide.

An interesting genetic relationship between many species of mustard has been observed, and is described as the triangle of U.





Rape seed

Botanical name	2n	*Economic characters*
1.*Brassica compestris*	20	Indian Rape Seed. Self sterile in nature. Important oil seed crop of North India. 3 Cultivated types. B.*campestris* var. Brown sarson B.*campestris* var. Yellow sarson B.*campestris* var. toria
2. B.*napus*	38	European Rape Seed. Self fertile.
Mustard		
1. *B.nigra*	16	Black mustard : Native of Eurasia. 28% fixed oil. Used as medicine pungent due to glucoside sinigrin.
2. *B.alba*	24	White mustard : Young seedling used as Salad, yellowish seed 30 % oil.
3. *B.juncea*	36	Indian mustard. RAI 35% oil. Leaves used as herb contains sinigrin.

CABBAGE- *Brassica oleracea* var. *capitata* 2n = 18

Cabbage is herbaceous flowering plant with leaves forming a compact head chrematistics. Approximately 400 species of cabbage have been documented into five groups:

- ✓ The first group includes the familiar round, smooth-leafed cabbages with the colors of white, green or red, and wrinkled-leafed varieties, such as Savoy.
- ✓ The second group comprises the pointed cabbages like European spring and Chinese cabbages.
- ✓ The third group contains the cabbages with abnormally large, budding stems like Brussels
- ✓ sprouts.

- ✓ The fourth group comprises the cabbages with green curly types, such as kale and collard greens. Cabbage species in this group are often used as animal food or decoration of dishes for presentation.
- ✓ Finally, the last group includes flowing cabbages, like cauliflower and broccoli (Kiple & Ornelas, 290).

In addition, Cabbages are out breeding plants. Therefore, cabbages only produce viable seeds through insect and hand pollination. Most cabbages are self-incompatible, meaning that the pollen is viable, but is unable to grow in a flower on the same plant. Because the insects must carry pollen from one plant to another instead of just carrying from one flower to another in the same plant, the more in a group of plants the better the pollination and seed production.

There are several cultivar groups of cabbage, each including many cultivars:

- Savoy – Characterized by crimped or curly leaves, mild flavor and tender texture
- Spring Greens – Loose-headed, commonly sliced and steamed
- Green – Light to dark green, slightly pointed heads. This is the most commonly grown cultivar.
- Red – Smooth red leaves, often used for pickling or stewing
- White, also called Dutch – Smooth, pale green leaves

Botany of Cabbage

Family	:	Brassicaceae
Habitat	:	Sub tropical and temperate
Habit	:	Herbaceous biennial
Root	:	Cabbage seedlings have a thin taproot and cordate (heart-shaped) cotyledons. Plants have root systems that are fibrous and shallow
Stem	:	Low and stout with short stalk
Leaves	:	The first leaves produced are ovate (egg-shaped) with a lobed petiole. Most cabbages have thick, alternating leaves, with margins that range from wavy or lobed to highly dissected; some varieties have a waxy bloom on the leaves Large oblong- ovate. Due to extreme condensing of the node the glabrous leaves ball together a few nodes above the base to give the typical compact, swollen ‘cabbage’.
Inflorescence	:	Terminal head The inflorescence is an unbranched and indeterminate terminal raceme measuring 50–100 cm (20–40 in) tall,[15] with flowers

that are yellow or white. Each flower has four petals set in a perpendicular pattern, as well as four sepals, six stamens, and a superior ovary that is two-celled and contains a single stigma and style. Two of the six stamens have shorter filaments.

Fruit : The fruit is a silique that opens at maturity through dehiscence to reveal brown or black seeds that are small and round in shape.

Economic Uses:

Cabbage is bursting with various health-giving properties such as an abundant supply of vitamin C, vitamin A, as well as other minerals, phosphorus, calcium and iron. Cabbage also has lactic acid which helps digestion and is low in calories. Cole crops were mainly suggested for medicinal purposes during the 19th century: ―They were used against such ailments as gout, diarrhoea, coeliac trouble, stomach trouble, deafness, and headache. Cabbage juice was said to be a remedy against poisonous mushrooms, and was also used as a gargle against hoarseness‖

Bloating in Cabbage

Excessive consumption of cabbage may lead to increased intestinal gas which causes bloating and flatulence due to the trisaccharide raffinose, which the human small intestine cannot digest.

Cabbage Health Hazards

Food-borne illness

Cabbage has been linked to outbreaks of some food-borne illnesses, including *Listeria monocytogenes* and *Clostridium botulinum*. The latter toxin has been traced to pre-made, packaged coleslaw mixes, while the spores were found on whole cabbages that were otherwise acceptable in appearance. *Shigella* species are able to survive in shredded cabbage. Two outbreaks of *E. coli* in the United States have been linked to cabbage consumption. Biological risk assessments have concluded that there is the potential for further outbreaks linked to uncooked cabbage, due to contamination at many stages of the growing, harvesting and packaging processes. Contaminants from water, humans, animals and soil have the potential to be transferred to cabbage and from there to the end consumer.

Goiter and iodine intake

Cabbage and other cruciferous vegetables contain small amounts of thiocyanate, a compound associated with goiter formation when iodine intake is deficient.

CAULIFLOWER - *Brassica oleracea* var. *Botrytis*, 2n =18

Cauliflower is a biennial and frost tolerant vegetable with compact heads of immature or aborted flowers contracted into a single head. Its heads are usually white but can also be yellow or purple. Cauliflower is also an outbreeding plant. Cauliflower and 14 broccoli will cross with other varieties within the huge *B. oleracea* species, which include all cabbages (except Chinese cabbage), Brussels spouts, kale, collards, and kohlrabi, as well as with each other (Ashworth, 52). In addition, cauliflower must undergo vernalization in order to flower. In some regions where winter temperature does not drop below 28F, brassicas can be planted in the fall, and seed is harvested the following summer. Most cauliflower is self-incompatible. For the purpose of providing a good seed set and of preserving much genetic diversity, a minimum of six plants are ought to be used for seed saving

There are four major groups of cauliflower.

Italian

Diverse in appearance, and biennial and annual in type, this group includes white, Romanesco, various brown, green, purple, and yellow cultivars. This type is the ancestral form from which the others were derived.

Northern European annuals

Used in Europe and North America for summer and fall harvest, it was developed in Germany in the 18th century, and includes the old cultivars Erfurt and Snowball.

Northwest European biennial

Used in Europe for winter and early spring harvest, this was developed in France in the 19th century, and includes the old cultivars Angers and Roscoff.

Asian

A tropical cauliflower used in China and India, it was developed in India during the 19th century from the now-abandoned Cornish type,[6] and includes old varieties Early Benaras and Early Patna.

Varieties

There are hundreds of historic and current commercial varieties used around the world. A comprehensive list of about 80 North American varieties is maintained at North Carolina State University.

Colors

White

White cauliflower is the most common color of cauliflower.

Orange

Orange cauliflower (*B. oleracea* L. var. *botrytis*) contains 25% more vitamin A than white varieties.[8] This trait came from a natural mutant found in a cauliflower field in Canada.[9] Cultivars include 'Cheddar' and 'Orange Bouquet'.

Green

Green cauliflower, of the *B. oleracea* botrytis group, is sometimes called broccoflower. It is available both with the normal curd shape and a variant spiky curd called Romanesco broccoli. Both types have been commercially available in the U.S. and Europe since the early 1990s. Green-curded varieties include 'Alverda', 'Green Goddess' and 'Vorda'. Romanesco varieties include 'Minaret' and 'Veronica'.

Purple

The purple color in this cauliflower is caused by the presence of the antioxidant group anthocyanins, which can also be found in red cabbage and red wine.[10] Varieties include 'Graffiti' and 'Purple Cape'. In Great Britain and southern Italy, a broccoli with tiny flower buds is sold as a vegetable under the name "purple cauliflower"; it is not the same as standard cauliflower with a purple curd.

Botany of Cauliflower

Family	:	Brassicaceae
Habitat	:	Sub tropical and temperate
Habit	:	Herbaceous biennial
Stem	:	Low and stout with short stalk
Leaves	:	Large oblong or elliptical, strongly ascending
Inflorescence	:	Terminal teratological head overtopped by leaves, comprised of transformed and consolidated mass of short thick decoloured peduncle and pedicles, undeveloped abortive flowers and bracts.
Fruit	:	Inflorescence eaten raw or cooked as vegetable.

Economic Uses:

- One cup of boiled cauliflower is an excellent source of vitamin C (91.5% of the DV), folate (13.6% of the DV), and dietary fiber (13.4% of the DV).
- That same amount of cauliflower also serves as a very good source of vitamin B5, vitamin B6, manganese 16 and omega-3 fatty acids.
- Consumption of cauliflower is known to reduce the risk of a number of cancers, such as lung, colon, breast, ovarian and bladder cancer.

- Recent research from University of Hawaii reveals that crucifers like cauliflower also provide important cardiovascular benefits.
- Researchers have shown that a phytonutrient called indole-3-carbinol found in cruciferous vegetables, even in the tiny concentration of 100 micromoles per liter, can lower liver cell's secretion of the cholesterol transporter ApolipoproteinB-100 (ApoB-100) by 56%. ApoB-100 is the main carrier of LDL cholesterol to tissues, and high levels have been linked to plaque formation in the blood vessels. When liver cells were treated with I-3-C, researchers found not only apoB-100 secretion was cut by more than half, but also the synthesis of lipids (fats) was decreased significantly.
- Cauliflower is low in fat, low in carbohydrates but high in dietary fiber, folate, water, and vitamin C, possessing a high nutritional density.
- Cauliflower contains several phytochemicals, common in the cabbage family, that may be beneficial to human health.

Blanching Cauliflower

Blanching is an essential operation to protect the heads from suborning and yellowing, so that they may not loose part of the flavor and attractive appearances. This operation may be done by drawing and trying of the leaves when the heads are formed. If is not possible, place a cauliflower leaf over the heads to protect it from the sun. This will induce milky white colour to the curd which may be sold at premium in the market.

According to the variety heads are ready to harvest in 60 – 70 days 9 Early) 90- 100 days 9 Medium), and 110- 120 days 9 late) after transplanting. Beaching should be done only when the head has grown fully, and leaves should not be left tied over for more than 4- 5 days. But these periods is increased to one week in cold weather and reduces to 2 – 3 days during the hot weather. This process is called as blanching.

Blanching Cauliflower Plants (Gardening)

Check whether blanching is necessary. If you are growing purple or green cauliflower varieties, you do not need to blanch the plants. Some white varieties, including Snow Crown and Early Snowball, are "self-blanching."[7] In these plants, the leaves should grow over the edible white section naturally, and only need to be blanched manually if this fails to occur.

Begin when the head of the cauliflower is about the size of a chicken egg. The edible head, or "curd," of the cauliflower plant, typically reaches this stage four or more weeks after planting.[8] Check every one or two days, however, as different varieties develop at different rates. Once the white curd is approximately the size of a chicken egg, or about 2–3 inches (5–7.5 cm) in diameter, move on to the next step.

Blanch when the plant is dry. If possible, blanch during dry weather and warm, sunny conditions, when there is little or no moisture on the curd.[9] Too much moisture trapped on the curd can cause rot or fungal infection.

Gently bend the outer leaves over the curd. Take the largest, outer leaves and bend them over the curd. Shade the curd from most of the sun, especially directly above the curd, but allow small gaps between the leaves for air circulation, to prevent moisture. Curve them around the plant in a rounded ball shape. Tuck the leaf tips underneath leaves on the opposite side when possible, to help keep them in position.

- Bunching them together in a vertical position, rather than using the correct rounded shape, can cause rainwater to collect between them and rot the plant.[10]
- Don't worry if the leaves snap partway through while bending.

Tie the leaves loosely in this position. Use soft twine, large rubber bands, or gardening tape to hold the leaves over the developing, white curd. Keep this relatively loose to allow for growth, but tight enough that the leaves won't easily slip out.

- Avoid the use of wire or other sharp material, which may cut through the leaves.

Check on your cauliflower plants daily to make adjustments. You may need to tie a cauliflower plant again if the leaves slip out, which may occur as the curd grows. You may need to keep checking less developed plants for curd growth as well, and blanch those once they reach the correct size.

Harvest the plants. While the exact conditions for harvesting depends on the cauliflower variety, as a general rule the plant is harvested once the curd reaches 6 inches (15 cm) in diameter.[11] Cut the stalk beneath some of the outer leaves, taking care not to bruise the curd. Soak in lightly salted water for 30 minutes to drive out insects, then store in a closed container in the refrigerator.[12]

- Growth may take anywhere from four days to 21 days after the curd first appears. The warmer the weather, the faster it should grow.

Blanching Cauliflower (Cooking)

The term blanching has two different meanings, both covered in this article. In a cooking context, blanching or parboiling refers to a process that partially cooks a vegetable, then rapidly cools it. This destroys the bacteria and enzymes that cause vegetables to break down, allowing you to freeze the cauliflower without losing flavor and texture.

In a gardening context, blanching is the process of hiding part of a plant from light, which prevents it from developing color. In the case of cauliflower, this process results in a white edible portion with a lighter, less overpowering taste

Wash the cauliflower. Rinse the cauliflower under cool, running water to remove traces of dirt and pesticides. Rubbing the vegetable with your fingers while rinsing makes the process much more effective.

Cut off the cauliflower florets. Use a sharp knife to remove leaves and thick portions of the main stalk. Cut the florets into pieces about 1 inch (2.5 cm) across, so they blanch at a consistent rate.

Start boiling a pot of water. Fill a pot 2/3 full of fresh water, allowing at least 1 gallon of water per pound of cut cauliflower (4 liters per 0.5 kg).[2] Set it on the stove at high heat. While waiting for it to boil, move on to the next step.

- Using less water than the recommended amount may result in mushy, overcooked cauliflower, since the water will take longer to return to a boil once the vegetables are added.

Prepare an ice bath. Fill a large bowl or a second pot with cold water and ice. This will be used to rapidly cool the cauliflower, and will work best if kept at 60ºF (16ºC) or below.[3] Leave enough space in the bowl to avoid overflowing once the cauliflower is added.

- If you do not have ice, try cooling tap water in the freezer while the water on the stovetop boils.

Add the cauliflower to the boiling water and cover. Once the water has reached a rolling boil, add the cauliflower pieces. Cover the lid to keep the water hot, so it returns to a boil as quickly as possible.

- If you have a wire basket that fits into the pot, this can make the cauliflower easier to remove. If the cauliflower is loose in the water, locate a slotted spoon so you can remove the cauliflower once boiled.
- Decide whether to add salt. Optionally, you may add salt to the water at this stage, using 4 teaspoons per gallon of water (5 mL per liter).[4] This may enhance the flavor, but is not recommended if you plan to freeze the cauliflower, as salt can break down the cell walls and make the vegetables soft and less flavorful.[5]

Boil the cauliflower for three minutes. As soon as the water has returned to a boil, set a timer for three minutes, or note the time on a clock. Once three minutes have elapsed, remove the cauliflower with a slotted spoon.

- The cauliflower should emerge partially cooked, but still firm. If it has become soft or mushy, it may not retain its flavor or nutrients for long.

- Alternatively, you may drain the cauliflower over a colander or sieve to remove it from the water. However, this prevents you from using the water for an additional purpose, such as blanching the next batch or cooking pasta.

Immediately submerge the cauliflower in the ice bath. Place the hot cauliflower florets into the ice bath. This rapid cooling seals in the flavor and nutrients of the vegetable, as well as the color if you are preparing colored cauliflower.

Dry the cauliflower once cooled. Once the cauliflower is cold to the touch, remove it from the ice bath and pat dry with a paper towel. Excess water on the surface may break down the cauliflower once it freezes into ice crystals, making this step especially important if you plan to store the cauliflower long term.[6]

Freeze any cauliflower you do not use immediately. Once blanched, the cauliflower can typically maintain its high quality for at least 12 months in the freezer. Freeze the pieces on a flat tray first so they do not stick together, then keep them in airtight containers in the freezer.

- There is no need to leave additional space in the containers, as cauliflower does not expand in the freezer.

Serve the blanched cauliflower or finish cooking it later. Although some people enjoy eating blanched cauliflower plain or lightly flavored with salt, the crunchy texture of blanched cauliflower may make it especially suitable as a salad ingredient. If you wish to make the cauliflower softer, boil it for a few minutes longer, or add it to a recipe during cooking.

- Thaw the cauliflower before thawing or cooking, unless you are adding the pieces to a stir fry.

Euphorbiaceae

Euphorbiaceae, the spurge family, in common English sometimes called "euphorbias", which is also the name of a genus in the family. It is a large family of flowering plants with about 300 genera and 7,500 species.

- This family occurs mainly in the **tropics**, with the majority of the species in the Indo-Malayan region and tropical America a good second. A large variety occurs in tropical Africa, but they are not as abundant or varied as in the two other tropical regions. However, *Euphorbia* also has many species in nontropical areas such as the Mediterranean Basin, the Middle East, South Africa, and southern USA.
- The **leaves** are alternate, seldom opposite, with stipules. They are mainly simple, but where compound, are always palmate, never pinnate. Stipules may be reduced to hairs, glands, or spines, or in succulent species are sometimes absent.
- The plants can be **monoecious or dioecious**. The radially symmetrical flowers are unisexual, with the male and female flowers usually on the same plant. As can be expected from such a large family, there is a wide variety in the structure of the flowers.
- The **stamens** (the male organs) number from one to 10 (or even more).
- The **female flowers** are hypogynous, that is, with superior ovaries.
- The genera in tribe Euphorbieae, subtribe Euphorbiinae (*Euphorbia* and close relatives) show a highly specialized form of pseudanthium ("**false flower**" made up of several true flowers) called a cyathium. This is usually a small, cup-like involucre consisting of fused-together bracts and peripheral nectary glands, surrounding a ring of male flowers, each a single stamen. In the middle of the cyathium stands a female flower: a single pistil with branched stigmas. This whole arrangement resembles a single flower.
- The **fruit** is usually a schizocarp, but sometimes a drupe. A typical schizocarp is the regma, a capsular fruit with three or more cells, each of which splits open at maturity into separate parts and then breaks away explosively, scattering the small seeds.
- The family contains a large variety of **phytotoxins** (toxic substances produced by plants), mainly diterpene esters, alkaloids, glycosides, and ricin-type toxins.
- A **milky latex** is a characteristic of the subfamilies Euphorbioideae and Crotonoideae. The latex is poisonous in the Euphorbioideae, but innocuous in the Crotonoideae.[*citation*

needed] White mangrove (*Excoecaria agallocha*), or blind-your-eye mangrove latex causes blistering on contact and temporary blindness if it contacts the eyes. Other common names are milky mangrove, *buta buta* (Malay), and *gewa* (Bangladesh). The latex of spurge was used as a laxative.

CASTOR – *Ricinus communis* L. (2n = 20)

(Amanakku / Kottamuthu / Arend)

Castor is a plant which grows wild in tropical and sub-tropicl regions of the world. This crop is extensively grown in India. Even though the genus Ricinus is monotypic, there are numerous varieties of the plant both perennial and annual.

SYSTEMATIC POSITION:

Division	:	Phanerogams
Sub-division	:	Angiosperms
Class	:	Monochlamydeae
Series	:	Unisexuals
Family	:	euphorbiaceae

Place of Origin:		Ethiopia
Distribution	:	India, China, Egypt, Africa and many tropical and subtropical countries.
In India		: Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Orissa, Bihar,

CLASSIFICATION:

The genus Ricinus is Monotypic (Popova 1932). But there are eight subspecies varying from dwarf annuals to tree perennials. They are listed below.

Ricinus communis subsp. Persicus	-	Persian castor
R. communis subsp. Chinensis	-	Chinese castor
R. communis subsp. Zanzibarensis	-	Zanzibar castor
R. communis subsp. Sanquinens	-	Crimoson castor
R. communis subsp. Africanus	-	African castor
R. communis subsp. Mexicanus	-	Mexican castor
R. communis subsp. Gibsoni	-	Red castor
R. communis subsp. Cambogenisis -	-	Red castor

DISTINGUIGHING CHARACTERS:

- Presence of bloom – Ashy coating on the leaves and stem of the plant.

- Monoecious condition – male flower at the bottom of panicle and female at top.
- Androecium – polyadelphous condition. Filaments branched.
- The hilum almost concealed under the caruncle.
- Presence of thin leaf like cotyledon.
- Toxic alkaloids like ricin (blood coagulant) ricinin and allergen are present**.**

Alkaloids are vegetable bases containing nitrogen, they are the decomposition products of protein. They have marked by physiological effect on animals. They have much value in medicine and drugs.

EXTRACTION OF OIL:

The castor seed contain 50 per cent oil. This is extracted by giving mechanical presure on the seeds. To remove the toxic alkaloids the seeds are first pounded and later boiled in hot water. The oil floating on surface is skimmed off. By boiling, the toxic principles are neutralised.

CHEMICAL COMPOSITION:

The oil is nearly colourless or very pale greenish yellow viscous fluid. The typical fatty acid composition of castor oil is ricinoleic acid, 91-95 per cent; linoleic acid, 4.5 per cent: palmitic and stearic acid 1:2 per cent and a negligible amount of oleic acid.

Botany of Castor

Family	:	Euphorbiaceae
Habitat	:	Tropical and subtropical
Habit	:	Tall, annual or perennial growing to a shrub or small tree
Stem	:	Glabrous, pithy, with prominent nodes and leaf scars, colour of stem is rose or green.
Leaves	:	Alternate, palmately seven to eleven lobed, serrated margin, petiole four to twelve inches long, glands distributed on the petiole. Some varieties have ashy coating (bloom) on the surface of the leaves
Inflorescence	:	Erect, terminal panicle, flowers unisexual, monoecious, male flowers crowded at the base of the peduncle and the female flowers at the top.
Male flowers	:	Perianth greenish, splitting to 3-5, valvate segments, stamens many, filaments much branched, anthers subglobose.
Female flowers	:	Calyx spathaccous, caducous, ovary superior, three carpelled, three celled. Each cell having a single ovule, axile placentation, style short and branched trifid or bifid.

Fruit : A capsule or schizocarp, pericarp smooth or warty or echinate or spinulose.

Seed : Testa smooth, mottled, endosperm prominent, cotyledons membranous

USES:

- Paints, varnishes and other protective coverings
- Illuminant.
- Lubricant for aeroengines will not freeze in higher altitudes.
- Hydraulic brake fluid.
- Soap, printing ink, wax, polish.
- Used in nylon fibre and plastic industry.
- "Rilson"; a polyamide nylon type fibre manufactured.
- Oil cake as fertilizer.
- Stem as fuel, making paper board.

Jatropha curcas

Jatropha curucas L) is a soft-wooded small tree or shrub with smooth gray bark, which exudes a whitish colored, watery latex when cut. Normally it grows to between thre and five meters in height, but can attain a height of up to eight or ten meters under favorable growing conditions. It root system consists of five major roots with one primary root which grows downward and four equally spaced outer roots which grow out laterally at relatively shallow depths. The large (10-15 cm x 7.5 – 12.5 cm) green to palegreen leaves of the palant are alternate to sub-opposite, and three-to five-lobed with a spiral phyllotaxis. Petioble length ranges from 6-23 mm.

The inflorescence is ormed in the leaf axil and floweres are formed terminally, individually measuring approximately 7-11 mm across, with female flowers usually slightly larger. Flowering occurs in the hot and rainly seasonsl; pollination is carried out by insects, particularly moths which are attracted at night by the sweet, heavy perfume of the greenish-white flowers. Both male and female flowers are found on the same plant, although occasionally single flowers have been observed to be hermaphroditic. In conditions where continuous growth occurs (resulting from long days and irrigated conditions) an imbalance of pistillate or staminate flower production results in a higher number of female flowers.

Fruits are set in winter when the shrub is leafless of it may produce several crops during the year if sokl moisture is not limiting and temperatures are significantly high. Each

inflorescence yield a bunch of appromximately 10 or more ovoid fruits measuring approximately 2.0 – 3-5 cm long and 1.5 – 2.5 cm wide. A three, bi-valved cocci is formed after the seeds mature and the fleshy exocarp dries. The seds are mature when the capsule changes from green to yellow, two to four months after fertilization. The blackish, thin shelled seeds are oblong (approximately 1.0 – 2.5 cm x 1.0 cm) and resemble small castor seeds.

Characteristics of Oil and Latex

The oil content of jatropha's seeds (curcas oil) ranges from 30-50 percen oil by weight and the kernel itself ranges from about 45-60 percent oil. The fatty acid composition in the oil of the seds of several Jatropha species are presented in. Oil content and fatty acid composition vary according to growing conditions which also affects the degree of saturation of the oil. (Warm climates generally result in a higher degree of saturation). This is a slow-drying oil which is odorless and colorless upon extraction, but becomes yellow and acquires an unpleasant odor if left standing. The oil is easily soluble in hexane, diesel fuel or gasoline, and is slightly soluble in alcohol. Additional physical nd chemical properties related to curcas oil's suitablility as a diesel oil substitute are discussed later.

The latex, which is present in all parts of the palant, is a sticky, opalescent, acrid, and astringent substance. It contains approximately 14.6 percent latex coagulum (a resinous substance), but no rubber. Upon drying the latex hardens into a reddish brown, brittle substance. Tannin is present in the latex at 10 percent and in the bark at 37 percent. The bark also contains saponins, a resinous substance, and a wax consisting of melissyl alcohol and melissyl melissate.

The latex, oil, twigs, wood, and leaves are all rerpordly used externally for healing wounds, to stop bleeding, and to treat rheumatism and skin diseases. As an internal medicine, the plants' purgative or vomit-inducing property(particularly exhibited when the seed or oil is ingested) is also commonly exploited. Other plant medicinal uses are as a laxative, cough remedy, antidote for poisoning, relief for toothaches and to strengthen gums. Pregnancy (for the inducement of abortions), treatment of heart problems and cancers (which is currently being further researched), destroying intestinal parasites, treatment of gonorrhea and syphilis, and for sprains. Often, when taken internally, a tea or watery extract is decocted of leaves, seds, oils, etc., or the plant is mixed with another substance (e.g. molasses.

Jatropha's seed yield up to 50 percent by weight, a slow – dryin oil (known as "curcas oil") which is utilized as an industrial raw material and for manufacturing on a smaller scale. Been used in the manufacture of candles and particularly, soap. A good quality

household soap which lathers heavily is produced using curcas oil and a finer quality soap is produced if curcas oil is combined with palm oil. The Chinese have boiled curcas oil with iron oxide for use as a furniture varnish, although its slow-drying quality makes it less desirable than other materials available for varnish manufacture.

Botany of Jatropha

Family	:	Euphorbiaceae
Habitat	:	Tropical
Habit	:	Small tree or shrub
Stem	:	Grey colored soft wooded stem which exudes a white colored watery latex when cut
Leaves	:	Large pale green- green leaves, alternate to sub-opposite, 3-5 lobed, spirally arranged.
Inflorescence	:	Cyme formed in the axils of leaves.monecious and unisexual occassionaly hermaphrodite flowers occur. Flowers formed terminally, individually. In conditions were continous growth occurs or under hot climate there is an unbalance in number of pistillate and staminate flowers and there is higher number of female flowers. Ten stamens arranged in two whorls of five each in a single column and close proximity with each other. Gynoecium with 3 slender styles which are connate to about two third of its length, dilating to massive bifurcate stigmata.
Fruit	:	Smooth schizocarp.a bunch of atleast 10 ovoid fruits can be seen from a single inflorescence. Once the seeds are matured they form a three or bi -valved cocci with a fleshy outer outer layer. The fruits do not drop on their own, need to be manually harvested.
Economic importance	:	Seed used for extraction of oil (used as bio-fuel).

TAPIOCA

Manihot esculenta (2n=36)

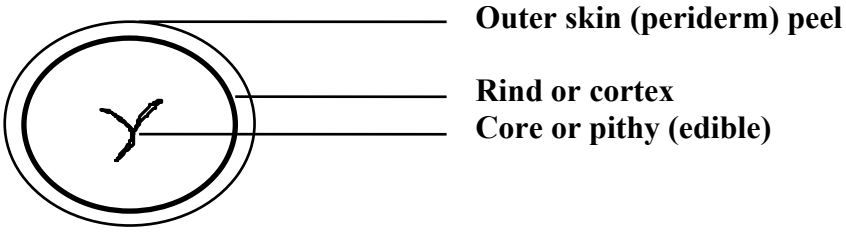
Family: Euphorbiaceae

Origin: Central America.

There are no wild species seen in the cultivated *Manihot esculenta*. The cultivated cassava can be classified into two broad groups viz. a) Sweet cassava and b)Bitter cassava.

a) **Sweet cassava** : Shorter in duration tubers maturing in 6-9 months. The cynogenic glucoside in confined mainly to the outer skin (periderm).
b) **Bitter cassava** : Longer in duration 12-18 months to mature, the cynogenic glucoside is distributed throughout the tuber including core.The glucoside will be more in varieties having yellow flesh.

Structure of tuber*:*



i. **Periderm** : Composed of dead cells which seals the surface of the tuber. Normally brown in colour.
ii. **Cortex**: 1- 2 mm thick, usually white in colour but may be some time pinkish or brown. The periderm and cortex are collectively known as peel.
iii. Core or pith: It is the edible portion and consists mostly of parenchymatous cells containing large amount of stored starch. Latex in tuber occur in the flesh of the tuber and also on the cortex.

Root tuber development:

The cassava tuber originates when secondary thickening occurs in a fibrous root that has previously been entered in the soil. As such, tuber growth consists essentially of increase in girth of a root. The increase in girth commences by the end of second month after planting and accumulation of large amount of starch taken place. Accumulation of starch occurs first at proximal end (towards attachment of root) and later at distal end (away from attachment). Physiologically the cassava tuber is inactive, since no eyes or buds present, as such cassava tuber cannot be used as a means of propagation.

Family	:	Euphorbiaceae
Habitat	:	Tropical
Habit	:	Slender shrub, 2-7 m high, sparingly branched
Stem	:	Thick with prominent, leaf scars, variously coloured.
Leaves	:	Simple, alternate, long stalked, palmately lobed, segments obovate lanceolate, petiole terrete, glabrous.
Inflorescence	:	Flowers borne in axillary racemes near the end of the branches. Inflorescence is monoecious with male flowers at the top and female flowers in the bottom. The female flowers will be larger in size than

the male ones. Each flower (male and female) have five united sepals which may be yellow tinged. There are no petals. The male flower has ten stamens arranged in two whorls of five stamens each. The filaments are free and anthers small. The female flower has an ovary mounted on a ten lobed glandular disc. The ovary has three locules and six ridges. Each locule contains a single ovule. The stigma has three lobes which unite to form a single style.

The female flowers open first and male flowers open 7 to 10 days later. Therefore cross pollination the rule. The maturity of seeds takes place 3-5 months after pollination.

Fruit : Ovoid, globose with six longitudinal plicate wings

: Swollen tap roots. A mature tuber consists of 3 distinct zones, an outer periderm which may be thick rough or thin and smooth, varying in colour from white to pink, red or brown. A thin cortex or rind usually white but streaked with brown.

Economic part : Tapioca is a staple food in some regions, and it is used worldwide as a thickening agent in various foods. It is a gluten-free food. Tapioca root can be used to manufacture biodegradable bags. A polymer resin produced from the plant is a viable plastic substitute. Not only is it biodegradable, but it can be composted, is renewable, and is recyclable.

Tapioca starch is used worldwide for starching shirts and garments before ironing. It can be sold in bottles of gum starch to be dissolved in water, or in spray can format.

Lecture 12

Arecaceae and Malvaceae; Key botanical features of Coconut, Arecanut, Oilpalm, Sugarpalm, Cotton, Mesta and Bhendi

FIBRES

Fibre refers to practically all small, thin fragments of many substances. Botanically the fibre consists of very long narrow cells, manytimes longer than they are broad. They are invariably quite thick walled having a correspondingly small lumen. Chemically the fibre cells consist of cellulose with lignins or semicellulose or any other substance. Fibre cells are nonliving structures when mature and serve a purely mechanical function i.e., they impart strength and rigidity to the plant body.

CLASSIFICATION:

Fibres are broadly classified into:

I. Natural fibres - Obtained from plants and animals:

II. Synthetic fibres - Asbestos, glass wool etc.

Plant fibres (natural fibres) are classified based on their morphological nature, structure and position in the plant, and the uses to which they are put.

a) Classification based on their botanical origin:

BAST FIBRE (STEM/ SOFT/PHLOEM)	STRUCTURAL FIBRE (HARD / LEAF)	SURFACE FIBRE (SEED / FRUIT)
Derived mostly from stems of dicotyledonous plants. Fibres are found in groups of many cells strongly cemented to adjoining fibres, usually seperated by "Retting". Eg**. Jute, hemp, kenaf, roselle and ramie,**	Strands of small, short lighified, sclerenchymatous tissues ensheathing both xylem and phloem (fibrovascular bundle) and are primarily scattered in the leaves of the monocotyledonous plants. These fibres are highly lignified, usually seperated by "Scrapping " Eg**. Manila hemp, sisal, sansiveria.**	Borne on the surface of wall of fruits and seeds. most important members of this group are the fibres arising as single celled outgrowths from the seeds or inner walls of the fruits, usually seperated by "ginning" Eg. **Cotton, Kapok.**

Classification based on use (commercial classification):

Based on the use, the fibres are classified into:

Textile fibres	Manufacture of fabrics and netting, the fibres are twisted together into threads or yarn and then woven. Eg. Cotton, Jute.
Brush fibres	Manufacture of brushes and brooms. Eg. Palm, Sisal.
Filling fibres	Used in upholstery and for stuffing cushions, mattresses, life belts and for reinforcement and wallboard insulation.

	Eg. kapok, Cotton, Jute.
Cordage fibres	Used for making twines or ropes, cables and hawsers. Eg. Hemp, Jute, agave, sansiveria
Plaiting fibres	Used for making baskets, mat. Eg. Cyperus sp.
Stuffing fibres	Used for upholstry, life belt, pilloins, matress. Eg. Silk Cotton, Cotton.

Malvaceae

The Malvaceae, or the mallows, are a family of flowering plants estimated to contain 243 genera with 4225+ species. Well-known members of this family include okra, cotton, and cacao. The largest genera in terms of number of species include *Hibiscus* (300 species), *Sterculia* (250 species), *Dombeya* (250 species), *Pavonia* (200 species), and *Sida* (200 species).

- Most species are herbs or shrubs, but some are trees and lianas.
- Leaves are generally alternate, often palmately lobed or compound and palmately veined. The margin may be entire, but when dentate, a vein ends at the tip of each tooth (malvoid teeth). Stipules are present.
- The stems contain mucous canals and often also mucous cavities. Hairs are common, and are most typically stellate.
- The flowers are commonly borne in definite or indefinite axillary inflorescences, which are often reduced to a single flower, but may also be cauliflorous, oppositifolious, or terminal. They often bear supernumerary bracts. They can be unisexual or bisexual, and are generally actinomorphic, often associated with conspicuous bracts, forming an epicalyx. They generally have five valvate sepals, most frequently basally connate, with five imbricate petals.
- The stamens are five to numerous, and connate at least at their bases, but often forming a tube around the pistils.
- The pistils are composed of two to many connate carpels. The ovary is superior, with axial placentation, with capitate or lobed stigma. The flowers have nectaries made of many tightly packed glandular hairs, usually positioned on the sepals.
- The fruits are most often loculicidal capsules, schizocarps or nuts.
- Self-pollination is often avoided by means of protandry. Most species are entomophilous (pollinated by insects).

Cotton – *Gossypium sp.* (2n = 26, 2n = 52)

(Paruthy / Kapas)

Cotton is the most valued fibre plant among several fibre yielding plant. It is the world's most important non – food agricultural commodity, rank second in importance to food. Cotton fibre is unchallenged natural textile fibre even today, which entres our daily life in a variety of ways.

The genus *Gossypium* consists of diploid and tetraploid cultivated cottons.

Diploid (2n = 26) Old World cotton (Desi Cotton)			
Botanical name	Common name	Place of origin	Distribution
G. herbaceum *G. arboreum*	Uppam Cotton Karunkanni Cotton	Africa Indochina	India, China, Africa, Burma, Malaysia

Tetraploid (2n = 52) New World Cotton / American Cotton			
Botanical name	Common name	Place of origin	Distribution
G. hirsutum	Upland cotton (cambodia)	Central America	Tropical & subtropical countries. Russia, USA.
G. barbadense	Sea Island cotton (egyptian)	South America	China, India, Burma, Thailand, Australia.

CLASSIFICATION:

The genus Gossypium is divided into 8 Section by Hutchinsan et. al., (1947). In this the Old world Cottons belongs to section VII Herbacea, designated with A genome. The New World Cottons belongs to section VIII Hirsuta. Denoted by AD genome.

Origin of cultivated diploid (2n = 26) cottons – Harland (1967)

G. herbaceum (most primitive, non linted)

|

G. herbaceum race africanum

mutation for lint

|

G. herbaceum (cultivated)

G. herbaceum race acerifolium

| |

G. arbnoreum race indicum

|

G. arboreum (cultivated)

Origin of cultivated tetraploid cottons (2n = 52) - according to Phillips

G. barbadense = Old world Linted cotton (A genome) x G. raimondii (D genome)

G. hirsutum = Old world Linted cotton (A genome) x G. thruberi (Dgenome)

Origin of G. barbadense

G. herbaceum x *G. raimondii*

A gonome (2n = 26)	D genome (2n = 26)

F 1

AD genome – Sterile

(2n = 26) Naturai doubling

AA DD genome

G. barbadense (2n = 52)

Tetraploid fertile cotton

Origin of g. barbadense

G. arboreum x G. thurberi

A gonome (2n = 26)	D genome (2n = 26)

F1

AD genome – Sterile

(2n = 26) Natural doubling

AA DD genome

G. hirsutum (2n = 52)

Tetraploid fertile cotton

Wild species used in crop improvement:

G. raimondii - Jassid resistance.

G. anamalum - Jassid resistance.

G. thurberi - Boll worm resistance

G. harknessi - induction of male sterility

COTTON FIBRE:

Fibres are epidermal prolongation of seed coat cells. Certain of the epidermal protoplasm and the nucleus enter it. The longer out growths make lint and the shorter one make the fuzz.

Lint – Long and seperable and spinnable.

Fuzz – short and useperable.

In diploid cotton and upland cotton both line and fuzz are present whereas in Sea Island cotton (*G. barbadense*) only lint were present and fuzz absent, such seeds are called naked seeds.

FORMATION OF LINT:

During first 25 days after fertilization the fibres attain full length after which they start to increase in thickness by deposition of cellulose on the inside of the primary wall. Complete maturity of fibres take places in 45 to 50 days.

$$\frac{\text{Fertilization \& attain full length}}{\text{25 days}} + \frac{\text{Thickening and maturity}}{\text{25 days}} = 50 \text{ days}$$

During thickening process, the cellulose deposition is not regular. The cellulose deposition occurs in layers mostly during nights and stops during day time. Also the direction of deposition is erratic so that there may be formation of pits point and due to pits twisting of fibre takes place which makes the fibre spinnable. A mature fibre is flattened, translucent, twisted, tubular structure.

STRUCTURE OF THE FIBRE:

i) The integument or outer layer also called cuticle or waxy layer.

ii) Outer cellulose layer-original cell wall.

iii) Layer of secondary depositspure cellulose in numerous concentric layers.

iv) Walls of the lumen – wall around the lumen.

v) Substance in lumen-more of nitrogenous in nature.

TERMINOLOGY

Seed cotton (Kapas):

Cotton along with seed removed from locks of the boll.

Lint: Ginned cotton, cotton without seed. It is the fibre developed on the epidermal layer of the seed. It is removable by ginning.

Fuzz:

Fibre developed on the subepidermal layer of the seed, short in nature, not removable by ginning. Acid defuzzing is done to destroy pathogens before sowing.

Ginning:

The process of separation of separation of lint from seed with the use of machinery known as Gin.

Ginning percentage:

The ratio between lint and seed. Expressed in percentage.

$$\text{Ginning percentage (G.P.)} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

Ginning percentage is a composite character. It depends primarily on seed weight and lint weight. Seed weight is determined by seed volume and specific gravity, while lint weight varies according to the number of fibres per seed and weight of individual fibre. This inturn depends on fibre length, thickness and specific gravity of fibre walls. Smaller seeds raise the ginning out turn, but it does not necessarily increase the lint production.

Lint Index:

Weight of lint per seed or per 100 seeds. Lint index represents the absolute weight of lint produced per seed and it more useful in breeding than ginning percentage.

$$\text{Lint Index} = \frac{\text{Weight of 100 seeds x G.P}}{100 - \text{G. P.}}$$

Fibre length or Halo length or Staple length:

Most important among fibre properties. This character is determined in a number of ways viz.,

- Pulling method – Professional estimate based on eye and hand judgement.
- By combing the fibre with brass comb and measuring the combed fibre by celluloid disc scale (Halodisc / Halo – butterfly).
- Use of fibre sorting instruments like Ball 'sorter or Baer's sorter.
- Use of photoelectric instruments viz., Fibro graph.

Commercial cotton can be classified based on the length of the fibre as:

Long staple	:>2 inches length.	*Eg. G. barbadence*
Medium staple	: 0.5 to 2.0 inches.	*Eg. G. hirsutum*
Short staple	:< 0.5 inches.	*Eg. G. herbaceum & G. arboreum*

Counts:

Ability of individual fibre to stretch while spinning lower count – lower value, higher count – super spinning quality.

Botany of Cotton

Family : Malvaceae

Habitat : Tropical and subtropical.

Habit	:	Herbaceous annual growing to a height of 1-1.5m. Primary axis is erect and branched. Branches are dimorphic in nature, 1. Vegetative axillary bud (monopodial) 2. Fruiting extra axillary bud (sympodial) in upper nodes.
Vegetative branch	:	Vegetative branches are monopodial and they are morphologically similar to main stem, do not bear flowers directly but gives out secondary branches
Fruiting branch	:	Fruiting branches are sympodial. They arise from the axes of subtending leaf, another branch develop terminating in a fruiting point.
Leaves	:	Alternate, cordate, petiolate, 3-9 lobed and palmately veined. The size, texture, shape and hairiness are widely varying.
Flowers	:	Simple, solitary, terminal extra axillary, showy, yellow to cream in colour and hermophrodite. Bracteoles called epicalyx, three in number and deeply serrated and persistent at the base of the flower. Nectary gland is present on each bracteole.
Calyx	:	Five, united, cup shaped.
Corolla	:	Five, polypetalous, a purple spot is found on the inner side of the claw of the petal (petal spot) in some species.
Androecum	:	Stamens many, monoadelphous, reniform anthers.
Gynoecium	:	Superior ovary, pentacarpellary, style slender, passes through staminal columm with three to five lobed stigma. Ovules many in axile placentation
Fruit	:	Loculicidal dehiscent capsule called boll. Seeds are covered with one to two layers of hairs. Lint arises from the epidermal layer and fuzz arises from the sub epidermal layer. Fuzz cannot be separated from the seed. Lint is separable.
Economic importance		Cotton lint is a valuable textile fibre. Lint -Textile, absorbent cotton, wiping, polishing material, clothing, house hold articles**,** industrial articles, twines,cellulose, plastic for making tyre cord and machinery belt. Various plant parts are useful. Lint - Textile, absorbent cotton, wiping , polishing material, clothing, house hold articles, industrial articles, twines, cellulose, plastic. In Industries for making tyrecord and machinery belt. Cotton seed- Cattle feed, Cotton seed oil- oil 20 per cent (semi drying oil) Root bark - ergot like drug. Stalk - Fuel, paper pulp, bast fibre extracted. Leaves -Fodder. Gossypol content in the seed is associated with resistance to pests.

MESTA – *Hibiscus cannabinus* (2n = 36)

(Kenaf/Deccan/hemp/Bimplipatam jute/ Java jute / Pulichai/ Kanchava / Gogu/ Nalita/ Patsan / Ambari)

This fibre crop is successfully grown in many countries throughout the tropics and subtropics as a commercial crop. The bast fibre obtained from the stem is used in a similar manner to jute.

Place of Origin	:	Africa,
Distribution	:	India, Thailand, Brazil, China, USA, Mexico, South Africa, USSR.
In India	:	Andhra Predesh, Tamil Nadu, Karnataka.

The fibre strands are 1.5 to 3.5 m long and are comparable to jute in lustre. They are somewhat coarser but are tougher and stronger and resistant to roting.

Botany of Mesta

Family	:	Malvaceae
Habit	:	Herbaceous annual, growing to a height of even 5 metres.
Stem	:	Straight with small prickels
Leaves	:	Alternate stipulate. Variously lobed with serrated margins, stipules long and pointed.
Flowers	:	Solitary with short pedicels and axillary, epicalyx stiff, consisting of seven to eight bracteoles which are connate below and free above and inserted on the base of calyx. Calyx bristled, lanceolate, united upto the middle. Corolla long spreading. Pale yellow to sulphur with crimson or purpled centre
Andreccium	:	Stamens numerous on a staminal column.
Gynoecium	:	Ovary superior, five carpelled, style passes through staminal column and terminates in five stigmatic branches
Fruit	:	Capsule, five loculed, each locule containing four to five seeds. Capsule pointed and bristled, seed glabrous.

USES:

Fibre is mixed with jute for manufacture of bags, sacks, netting, ropes. Also used for the manufacture sand paper and abrasives. The seeds contain about 20 per cent oil which is sometimes extracted and used as a lubricant and for illumination; for manufacture of soap, linoleum and in paints and varnishes. Fibre is obtained from cortical cells, which are tightly

packed, glassier and more flexible. The bulk of fibers are found in the lower portion of the stem. The fibre is comparable to that of jute in lusture, coarser but tougher and stronger.

BHENDI

Abelmoschus esculentus (2n=56)

Botany of Bhendi

Family	:	Malvaceae
Habit	:	Annual
Stem	:	Straight with sparse branching
Leaves	:	Long and broad, cordate- ovate, palmately lobed with 5-7 lobes.lobes narrow or broad, magins coarsely toothed.
Flowers	:	Solitary and axillary flowers white to yellow with red or purple spot at the base of each petal. Flower bud appears in the axil of each leaf above 6^{th} to 8^{th} leaf. Style surrounded by staminal column which bears 100 anthers.
Fruit	:	A long ribbed beaked light hairy or nearly glabrous capsule.
Economic importance	:	Fruit as vegetable.

Arecaceae

The Arecaceae are notable among monocots for their height and for the size of their seeds, leaves, and inflorescences. *Ceroxylon quindiuense*, Colombia's national tree, is the tallest monocot in the world, reaching up to 60 meters tall. The *coco de mer* (*Lodoicea maldivica*) has the largest seeds of any plant, 40–50 cm in diameter and weighing 15–30 kg each. Raffia palms (*Raphia* spp.) have the largest leaves of any plant, up to 25 m long and 3 m wide. The *Corypha* species have the largest inflorescence of any plant, up to 7.5 m tall and containing millions of small flowers. *Calamus* stems can reach 200 m in length.

Whether as shrubs, trees, or vines, palms have two methods of growth: solitary or clustered. The common representation is that of a solitary shoot ending in a crown of leaves. This monopodial character may be exhibited by prostrate, trunkless, and trunk-forming members. The trunk develops an axillary bud at a leaf node, usually near the base, from which a new shoot emerges. The new shoot, in turn, produces an axillary bud and a clustering habit results. Several palm genera have both solitary and clustering members. Palms which are usually solitary may grow in clusters, and *vice versa*.

- Palms have large, evergreen leaves that are either palmately ('fan-leaved') or pinnately ('feather-leaved') compound and spirally arranged at the top of the stem.
- The leaves have a tubular sheath at the base that usually splits open on one side at maturity.
- The inflorescence is a spadix or spike surrounded by one or more bracts or spathes that become woody at maturity.
- The flowers are generally small and white, radially symmetric, and can be either uni- or bisexual.
- The sepals and petals usually number three each, and may be distinct or joined at the base.
- The stamens generally number six, with filaments that may be separate, attached to each other, or attached to the pistil at the base.
- The fruit is usually a single-seeded drupe (sometimes berry-like) but some genera (e.g. *Salacca*) may contain two or more seeds in each fruit.

COCONUT

Cocos nucifera (2n = 32)

Arecaceae

Place of origin:

According to Thampan (1991) Malaysia or Indonesia may be the place of origin

Classification:

The genus *Cocos* formerly included about 30 species have been subsequently assigned to several new genera and now the genus *Cocos* is considered to be monotypic having only one species *Cocos nucifera*

In coconut palm especially tall variety, there is a distinct gap between the male and female phases (Flowering). The female flowers do not become receptive until all the male flower in the spadix have shed their pollen. This makes cross pollination customary. In dwarf variety palms and hybrids the interval between the two phases is nil there by increasing the chances of self pollination.

On the basis of reproductive cycle four distinct coconut types could be identified.

Type I : There is no over lapping of phases and hence strict cross pollination is the rule. The West African tall belongs to this group.

Type II : There is over lapping of female phase of first inflorescence. Indirect self pollination takes places in this group.

Type III : The female phase is entirely covered by the male phase of the same inflorescence and hence direct self pollination is the rule. Dwarf cultivars belong to this group.

Type IV : Over lapping of the female phase is partly by the male phase of the same inflorescence and partly by that of successive inflorescence. Consequently semi - direct self pollination takes place. This is seen in dwarfs and hybrids.

Types grown in India.

Tall : West coast Tall
East coast Tall
Lakshadweep ordinary -
Andaman ordinary.
Kappadam - grown in Kerala.

Dwarf : Dwarf green
Dwarf orange
Ganga bondan

Chowghat orange.

Botany of Coconut

Family	:	Arecaceae
Habitat	:	Tropical and subtrophical
Habit	:	Tall perennial unbranced tree with terminal crown.
Stem	:	Trunk long, stout, cylindrical marked by ring like leaf scars. Trunks with swollen base with a mass of adventitious roots.
Leaves	:	Paripinnately compound leaves born in round fashion. Leaflets are occupied at equidistance. Leaflets are narrow, lanceolate, acute, entire and soft, petiole is stout.
Inflorescence	:	Compound spike called spadix arises in axils of the leaf. Inflorescenc consists of a central axis with many laterals upto 40, enclosed in a spathe. Male flower are borne individually or in two or three. Perianth six, small, in two whorls. Three outer tepals are smaller than inner three. Stamens six, in two whorls. Anthers linear, dorsifixed. Female flowers are with six perianth in two whorls of equal size, ovary large tricarpellary, three ovules, two will abort and one will develop. Three sessile stigmas.
Fruit	:	A fibrous drupe differentiated into exocarp, fibrous mesocarp and hard endocarp enclosing the liquid and solid endosperm.
Economic Importance	:	The husk of the fruit is the source of coir, used for ropes and mats; the hard inner fruit layer (endocarp) is used as fuel and to make charcoal, cups, bottles, and trinkets; coconut "juice" or "water" (liquid endosperm) is a tasty beverage; the flesh (solid endosperm) is eaten raw or dried to form copra, a source of oil (widely used for food preparation and industrial purposes) and oil cake (cattle feed); the flesh may also be grated, mixed with water, and pressed to obtain coconut milk, used in food preparation and as a substitute for cow's milk. The sap obtained from tapping the inflorescence, or flower stalk, is drunk unfermented or fermented (toddy) and is a source of sugar, alcohol, and vinegar. Trunks are used in construction and furniture making, and leaves are used in a variety of ways

OIL PALM

Elaeis guinensis (2n = 32)

Origin **:** Africa.

Four varieties of the palm can be distinguished on the basis of the fruit structure, especially the thickness of the endocarp.

Var. Mero carpa : 40 - 60% shell

Var. Dura - 20- 40% shell

Var. Tenera - 20 % shell (Hybrid between dura x pisifera)

var. Pisifera - a shell less form.

Propagation :

a) Seed propagation :

The material is highly heterozygous because the seeds produced from different sets of parents are not inbreds.

b) Clonal propagation : Tissue culture cloning technique is followed.

Var. Pisifera

Var. Dura crosses with tenera and F_1's are clonaly propagated. By this way 30% oil increase was obtained.

Botany of Oilpalm

Family	:	Arecaceae
Habitat	:	Tropical and sub trophical
Habit	:	Perennial tree
Stem	:	Erect grows to a height of 20 m at maturity. Trunk is characterized by persistent spirally arranged leaf bases.
Leaves	:	Palmately compound
Inflorescence	:	Compound spadix. Both male and female primordial initiated in each leaf axil, but expressed based on environment. In very drought conditions male flower get expresed.
Male spadix	:	Short stout peduncle supported by mass of finger like spikes each one with a many as 1200 closely packed minute male flowers sunk in tissues of rachis.
Female spadix	:	Short stout peduncle, carries upto 150 branches each with 20-30 widely separated flowers. Each flower ha one bract with acuminate tip, two bracteoles, six perianth, ovary three celled with a short style divided at the top into three stigmatic lobes.
Fruit	:	Small ovoid drupe
Economic Importance	:	Fruit contains oil.

PALM SUGAR – *Borasus flabellifer* (2n = 36)

(Palmayra palm/ Panai maram)

Family **:** Arecaceae

Place of origin **:** Africa

Distribution **:** India, Burma, Srilanka, Malaysia.

EXTRACTION OF SUGAR:

Neera tapped from un opened inflorescence. Generally the tip is cut off and the sap oozes out and is collected in containers. The yield of neera amonts to 3 or 4 qt. A day for several months. the sap processes a sugar content of about 14 per cent. The sweet juice is

boiled down to a syrupy consistency and pressed in to leaves to cool and harden into the crude sugar, known as *jaggary.*

Botany of Palm Sugar

Family	:	Arecaceae
Habitat	:	Tropical
Habit	:	Tall, stout, greyish black, unbranched
Leaves	:	Simple. Palmately fan shaped, petiole spinous
Inflorescence	:	Dioecious, branched, peduncle sheathed with open spathe, male flowers small, mixed with scaly bracts, sepals three, imbricate, petals three, shorter, obovate, spathulate, imbricate, stamens six, pistillode of three bristles, female flowers large, globose, perianth fleshy, sepals reniform, imbricate, petals three, smaller, staminode, ovary tricarpellary.
Fruit	:	A large subglobose drupe

Economic Uses:

Juice from male peduncle used as toddy, fermented into arrack, treated with lime and boiled down into jaggary. Wood is used as rafters, posts and fence. Leaves are used for thatch, fans, hats, baskets etc.

Neera contains 14 per cent sucrose

Toddy	-	Fermented neera.
Palm jaggery	-	By boiling neera.
Leaf	-	For brushes and brooms, Baskets, mat etc.
Timber	-	Rafters, pillar. Posts. Fuel

ARECANUT *Areca catechu* (2n= 32)

Family	:	Arecaceae
Habitat	:	Tropical
Habit	:	Slender, unbranched tree
Stem	:	Straight, thin regularly, annual
Leaves	:	Pinnately compound leaf, spirally arranged crowded at the top, leaf sheath broad, thickly coriaceous, embrace the trunk like a tube, petioles short.
Inflorescence	:	Monoecious spadix, axillary, spathes thick coriaceous, after anthesis longitudinally splits and falls off, flowers monoecious, sessile, perianth six in two whorls, minute, stamens six, connate at base, anthers linear, lanceolate with a sagitate, auricled base. Female flowers triangular perianth six, orbicular, ovate, ovary tricarpellary.
Fruit	:	A fibrous drupe with ruminate endosperm. It contains alkaloid acrecoline. It is used in veterinary medicine.
Economic Importance	:	Fruit contains alkaloid acrecoline, arcecotin, arecaidine. Used in veterinary medicine also.

Lecture 13

Tiliaceae, Piperaceae and Chenopodiaceae; Key botanical features of Jute, Betelvine, Sugar beet.

TILIACEAE

The Tiliaceae are trees, shrubs, or rarely herbs comprising about 50 genera and 450 species that are further characterized by the presence of branched or stellate hairs.

- The leaves are simple and nearly always alternate, stipules are present.
- The flowers are actinomorphic and nearly always bisexual.
- Flowers solitary, or aggregated in 'inflorescences' (and sometimes paired); when solitary, axillary; when aggregated, in cymes. The ultimate inflorescence units cymose (mostly), or racemose.
- Flowers regular; (3–)5 merous; cyclic, or partially acyclic. Sometimes the androecium acyclic. Floral receptacle developing an androphore, or with neither androphore nor gynophore. Free hypanthium absent.
- *Perianth* with distinct calyx and corolla, or sepaline (corolla rarely lacking). The perianth consists of a valvate calyx with usually 5 distinct or basally connate sepals and a corolla of an equal number of petals or sometimes the corolla is sepaloid or absent. polysepalous, or gamosepalous (sometimes basally connate); regular; imbricate.
- Epicalyx present, or absent. Corolla normally (4–)5; 1 whorled; polypetalous; imbricate, or contorted; regular. Petals deeply bifid, or entire.
- Plants hermaphrodite, or monoecious, or polygamomonoecious.
- The androecium consists of usually many stamens that are distinct or basally connate or in fascicles.
- The gynoecium is a single compound pistil of 2-10 carpels, an equal number of stigmas, and a 2-10-loculed superior ovary with 1-several axile ovules in each locule.
- Placentation when unilocular (i.e. rarely), free central; usually axile
- The fruit is variable.

JUTE *Corchorus sp (*2n= 14)

Family : Tiliaceae

Habitat : Tropical and subtropical

Habit : There are two species *C.olitorius* and *C. capsularis*

C. olitorius Tall growing herbaceous annual growing upto five metres. It is an

upland species. Stem is green or reddish. Branches develop more than *capsularis.* Leaves glabrous, flowers axillary, stamens 30-60, ovary elongated 5-6 carpelled. Fruit is an elongated capsule, 5-6 loculed with lengthwise ridge on the pericarp. Seeds smaller than *capsularis,* blackish to bluish green in colour.

C.capsularis Herbaceous annual growing from 15cm to 4m, stem slender, cylindrical greyish, branches sparsely produced, leaves simple, alternate , stipulate, ovate to oblong, acuminate, coarsely toothed, flowers small, yellow, axillary cymes of two to five, stamens 20- 30, ovary superior, 5 carpelled, syncarpous with axile placentation

Fruit : Capsule, wrinkled. Fairly toothed, five loculed, seeds smaller and brownish in colour

Fibre : The fibre in jute is a bast fibre extracted from the base of the stem. Fibre occurs in long wedge shaped bundles outside the xylem. They are grouped in concentric rings alternating with the thin walled tissue of the phloem which disintegrate during retting. Each of the fibre bundles represents one strand of filament composed of four to fifty cells. Individual fibre is less than 2-3 mm and polygonal in cross section. The cells which make up a fibre stand are elongated and the longest fibre cells occur in the stems of the longest internodes. In general, the fibre cells of jute are much shorter than other fibre and hence the use of jute fibre is limited to coarse fabrics only.

Economic importance : Fibre used for making gunny bags, packing cloths, thread and rope. Jute is used chiefly for rough weaving. The thick cloth made from jute is used for making gunny-bags, sails for country boats. Another type of fine cloth prepared from jute fibre is chiefly used as a cloth to sleep on. Jute is also extensively used in manufacture of carpets, curtains, shirtings and twine and ropes. Jute butts (short fibres) are used for making paper.

PIPERACEAE

The Piperaceae, also known as the pepper family, are a large family of flowering plants. The group contains roughly 1,920 currently accepted species in 13 genera. The vast majority of peppers can be found within the two main genera: *Piper* (2000 species) and *Peperomia* (1600 species). Members of the Piperaceae may be small trees, shrubs, or herbs. The distribution of this group is best described as pantropical. The most well-known species is *Piper nigrum*, which yields most peppercorns that are used as spices, including black pepper, although its relatives in the family include many other spices.

- Plants are often rhizomatous, and can be terrestrial or epiphytic.
- The stems can be either simple or branched.
- Leaves are simple with entire margins, and are positioned at the base of the plant or along the stem, and can be alternate, opposite, or whorled in arrangement. Stipules are

usually present, as are petioles. The leaves are often noticeably aromatic when crushed.

- Inflorescences (in the form of spikes) are terminal, opposite the leaves, or located in the axils. Flowers are bisexual, with no perianth, each flower is subtended by a peltate bract. Stamens are 2-6, and hypogynous, with 2-locular anthers. There are usually 3-4 stigmas attached to a single pistil per flower, which is 1 or 3-4 carpellate. The ovary is 1 locular, and superior.
- Fruits and seeds
- Fruits are drupelike, with a single seed per fruit. The seeds have a minute embryo, and mealy perisperm.

BETELVINE

***Piper betle* L. (2n=32)**

Family	:	Piperaceae
Habitat	:	Tropical
Habit	:	A perennial creeper, shrub, branches with swollen nodes
Stem	:	Slender, twining.
Leaves	:	Simple, entire, stipules vary in size, ovate-oblong large cordate, often fleshy and palmately lobed.
Inflorescence	:	Dioecious, arranged in spikes in the axil of bract with or without lateral bracts, perianth, stamens two-four, filaments short, 1 celled ovary, ovule solitary, style short, stigma 2-5.
Fruit	:	A small ovoid or globose one seeded berry.
Economic Importance	:	Leaves chewed with arecanut and lime.

CHENOPODIACEAE

This family consists of 102 genera and 1400 species. It has worldwide distribution. Its members are abundantly found in sea shore and marshy places.

- Habit: perennial herbs; very rare shrubs, or tree. Most of Is; plants are halophytes (salt tolerant). They have xerophytic chaa-teristics. They grow on saline soil.
- Roots: Most fibrous tap root except beat which has tuberous root.
- Stem: Herbaceous; Cylindrical; dense covering of hairs on stem.

- Leaves: Their leaves are fleshy; alternate; simple; exstipulate; often scale like; some are completely leafless.
- Inflorescence: Dense cymose clusters with uniparous Or biparous or both. These clusters are arranged on panicles or spike.
- Flower: Pedicilate; ebracteate; actinomorphic; regular; incomplete; hermaphrodite (rarely unisexual); hypogynous;
- Perianth: 3 perianth leaves
- Stamens: 5 stamens or variable; free; opposite to perianth
- Carpel: Bicarpellary, syncarpous with unilocular superior ovary; basal placentation.
- Fruits: Indehiscent nut. Often enclose by persistant perianth.
- Seed: Endospermic or non-endospermic.

Economic Importance

1. **Vegetables:** This family gives some very important vegetables. Their leaves and stems are succulents and used as green vegetables. Some of these are: spinach. *Chenopodium albu* and garden beet.
2. **Source of cane sugar:** Sugar beet is source of sugar. About 1/3 sugar of the world is extracted from sugar beet.
3. **Fodder:** Chenopodiaceae has great value as fodder. None of its member is poisonous. Some of fodders are *Salsola. Artiplex.*
4. **Reclamation of alkaline soil:** Most members of this family are halophytes. They easily grow on alkaline soil and absorb salts from its.
5. **Washing soda.** The ashes of *Soisaia* and *Sucteda* yields washing soda.
6. **Ornamental plants:** Some plants of this family are grown for ornamental purpose. Some of these are *Kochia stroparia* and *Kochia trichophylla.*
7. **Weeds:** Some plants of this family are dangerous weeds. *Saluda. Chenopodium* are some important weeds in our country.
8. **Medicinal uses:** Some members of this family give different medicinal products. Oil of *Chenopodium* is used against hook worm.

SUGARBEET

Beta vulgaris (L) (2n=18)

Place of origin: Northern Europe

Classification: The genus *Beta* includes thirteen species which have been grouped under Four sections. Viz.

1. Vulgares	*B.vulgaris*
2. *Caollinae*	*B.maritima*
3. *Nanae*	*B.macrocarpa*
4. *Patellares*	Includes both 2n = 18 and 36 form *B.nanae* 3 species all of them 2n = 18

The cultivated *Beta vulgaris* includes Beet Sugar, Vegetable beet root and forage beet root. All the members of section *vulgares* inter cross freely.

Bolting in Sugar beet:

Sugar beet is normally a biennial. It develops a large succulent root the first year and a seed stalk the second year. Occasionally a plant will produce a seed stalk the first year itself which is known as **bolting**. The **bolters** do not make a normal root development and so the yield will be reduced. Bolting can be induced by prolonged cool periods which is utilised for seed production. Certain wild species are annual in habit.

For rapid generation advancement in breeding programme as well as for seed production the process of Photothermal induction is used. This involves continuous artificial light and cool temperature.

The procedure for photothermal induction of sugar beet is as follows

a) **Pre induction period**: The plants are grown in pots for two weeks in screen house. Provide a continuous light from 150 walt electric bulb which is 30 inches height from pot.

b) **Induction treatment:**

Continue the provision of light but it must be from 20" ht. This is done for ten weeks. During this ten weeks period temp. Maintained at 46 to 49^0F

c) **Post induction period**:

Transplant the seedlings in field. Continue the lighting for another two weeks. Prevent warm temperature. By this way we can get seeds with in 6 months. But seeds obtained will be smaller in quantity

Family	:	Chenopodiaceae
Habitat	:	Subtropical
Habit	:	Herb, annual
Stem		Very much reduced

Leaves	:	Arise in basal rosettes on the much condensed stem. Succulent, spiral, ovate to oblong-ovate, entire or wavy, surface smooth or crinkly, base cordate, the colour ranges from dark red to light green
Inflorescence	:	Terminal open panicle. Flowers small , sessile and occur singly or in groups to two or seven, bracteate, bracts are linear, flowers bisexual, nearly epigynous, actinomorphic, pentamerous, perianth five lobed, lobes concave and incurved. Stamens five, anthers dithecous, ovary embedded in the fleshy receptacles and three celled, syncarpous, unilocular with a single ovule, style short, stigma short.
Fruit	:	Nut like enclosed in hard woody perianth.
Economic Importance	:	Source of sugar (12-18%) from swollen hypocotyl and base of the stem. Also used as a vegetable.

Lecture 14
Solanaceae and Mimosae; Key botanical features of Tobacco, Potato, Chilli, Tomato and Brinjal, Desmanthes, Subabul and Acacia.

SOLANACEAE

The Solanaceae are herbs, shrubs, or trees comprising about 85 genera and2,800 species that are frequently lianous or creeping. Even though the Solanaceae are found on all the continents except Antarctica, the greatest variety of species are found in Central America and South America.Another two centres of diversity include Australia and Africa. They occupy a great number of different ecosystems, from deserts to rainforests, and they are often found in the secondary vegetation that colonizes disturbed areas.In general, the plants are of trpical and temperate distribution.In Pakistan 14 genera and 52 species are reported.

- Plants in the Solanaceae can take the form of herbs, shrubs, trees, vines and lianas, and sometimes epiphytes. They can be annuals, biennials, or perennials, upright or decumbent. Some have subterranean tubers. They do not have laticifers, nor latex, nor coloured saps.
- The leaves are alternate, usually simple, and lack stipules. The leaves can be herbaceous, leathery, or transformed into spines. The leaves are generally petiolate or subsessile, rarely sessile. The leaves have reticulated venation and lack a basal meristem
- The flowers can be solitary or grouped into terminal, cymose, or axillary inflorescences.The flowers are bisexual and actinomorphic or only slightly zygomorphic.
- The perianth and androecium whorls generally are isomerous and usually are 5- or sometimes 4- or 6-merous.

- Flower: Ebracteate, actinomorphic, bisexual, pedicellate, heterochlamydeous, hypogynous.
- Calyx: Sepals 5, gamosepalous, persistent (in the fruit condition also) valvate aestivation.
- The corolla usually has five petals that are also joined together forming a tube. Flower shapes are typically rotate (wheel-shaped, spreading in one plane, with a short tube) or tubular (elongated cylindrical tube), campanulated or funnel-shaped. Twisted or valvate aestivation.

- Androecium: Stamens 5, epipetalous, The stamens are distinct, alternating with the lobes of the corolla, and adnate to the corolla tube or perigynous zone. The anthers touch on their upper end forming a ring, or they are completely free, dorsifixed, or basifixed The stamen's filament can be filliform or flat
- Gynoecium: Bicarpellary, syncarpous, bilocular or tetralocular due to pseudoseptum. single style, and a superior ovary with 2 or rarely more locules by false partitioning, each with nearly always numerous axile ovules. A nectary disk is generally present around the base of the ovary. Many ovules on axile placentation
- The fruit is a berry or septicidal capsule.

The diversity of some characteristics

Despite the previous description, the Solanaceae exhibit a large morphological variability, even in their reproductive characteristics. Examples of this diversity include:

- **The number of carpels that form the gynoecium**

In general, the Solanaceae have a gynoecium (the female part of the flower) formed of two carpels. However, *Melananthus* has a monocarpelar gynoecium, there are three or four carpels in *Capsicum*, three to five in *Nicandra*, some species of *Jaborosa* and *Trianaea* and four carpels in *Iochroma umbellatum*.

- **The number of locules in the ovary**

The number of locules in the ovary is usually the same as the number of carpels. However, some species occur in which the numbers are not the same due to the existence of false septa (internal walls that subdivide each locule), such as in *Datura* and some members of the Lycieae (the genera *Grabowskia* and *Vassobia*).

- **Type of ovules and their number**

The ovules are generally inverted, folded sharply backwards (anatropous), but some genera have ovules that are rotated at right angles to their stalk (campilotropous) as in *Phrodus*, *Grabowskia* or *Vassobia*), or are partially inverted (hemitropous as in *Cestrum*, *Capsicum*, *Schizanthus* and *Lycium*). The number of ovules per locule also varies from a few (two pairs in each locule in *Grabowskia*, one pair in each locule in *Lycium*) and very occasionally only one ovule is in each locule as for example in *Melananthus*.

- **The type of fruit**

The fruits of the great majority of the Solanaceae are berries or capsules (including pyxidia) and less often drupes. Berries are common in the subfamilies Cestroideae, Solanoideae (with the exception of *Datura*, *Oryctus*, *Grabowskia* and the tribe Hyoscyameae) and the tribe

Juanulloideae (with the exception of *Markea*). Capsules are characteristic of the subfamilies Cestroideae (with the exception of *Cestrum*) and Schizanthoideae, the tribes Salpiglossoideae and Anthocercidoideae, and the genus *Datura*. The tribe Hyoscyameae has pyxidia. Drupes are typical of the Lycieae tribe and in Iochrominae.

Alkaloids

Alkaloids are nitrogenous organic substances produced by plants as a secondary metabolite and which have an intense physiological action on animals even at low doses. Solanaceae are known for having a diverse range of alkaloids. To humans, these alkaloids can be desirable, toxic, or both. The tropanes are the most well-known of the alkaloids found in the Solanaceae. The plants that contain these substances have been used for centuries as poisons. However, despite being recognized as poisons, many of these substances have invaluable pharmaceutical properties. Many species contain a variety of alkaloids that can be more or less active or poisonous, such as scopolamine, atropine, hyoscyamine, and nicotine. They are found in plants such as the henbane (*Hyoscyamus albus*), belladonna (*Atropa belladonna*), datura or jimson (*Datura stramonium*), mandrake (*Mandragora autumnalis*), tobacco, and others. Some of the main types of alkaloids are:

Chemical structure of solanine

- Solanine: A toxic glycoalkaloid with a bitter taste, it has the formula $C_{45}H_{73}NO_{15}$. It is formed by the alkaloid solanidine with a carbohydrate side chain. It is found in leaves, fruit, and tubers of various Solanaceae such as the potato and tomato. Its production is thought to be an adaptive defence strategy against herbivores. Substance intoxication from solanine is characterized by gastrointestinal disorders (diarrhoea, vomiting, abdominal pain) and neurological disorders (hallucinations and headache). The median lethal dose is between 2 and 5 mg per kg of body weight. Symptoms become manifest 8 to 12 hr after ingestion. The amount of these glycoalkaloids in potatoes, for example, varies significantly depending of environmental conditions during their cultivation, the length of storage, and the variety. The average glycoalkaloid concentration is 0.075 mg/g of potato.[8] Solanine has occasionally been responsible for poisonings in people who ate berries from species such as *Solanum nigrum* or *Solanum dulcamara*, or green potatoes.[9][10]

Chemical structure of the tropanes.

- Tropanes: The term "tropane" comes from a genus in which they are found, *Atropa* (the belladonna genus). *Atropa* is named after the Greek Fate, Atropos, who cut the thread of life. This nomenclature reflects its toxicity and lethality. They are bicyclic

organic nitrogen compounds (IUPAC nomenclature: 8-Methyl-8-azabicyclo[3.2.1]octane), with the chemical formula of $C_8H_{15}N$. These alkaloids include, among others, atropine, cocaine, scopolamine, and hyoscyamine. They are found in various species, such as mandrake *(Mandragora autumnalis),* black henbane or stinking nightshade *(Hyoscyamus niger)*, belladonna *(Atropa belladonna)* the stramonium *(Datura stramonium*) and *Brugmansia* species, as well as many others in the Solanaceae family.[11] Pharmacologically, they are the most powerful known anticholinergics in existence, meaning they inhibit the neurological signals transmitted by the endogenous neurotransmitter, acetylcholine. More commonly, they can halt many types of allergic reactions. Symptoms of overdose may include dry mouth, dilated pupils, ataxia, urinary retention, hallucinations, convulsions, coma, and death. Atropine, a commonly used ophthalmological agent, dilates the pupils and thus facilitates examination of the interior of the eye. In fact, juice from the berries of *A. belladonna* were used by Italian courtesans during the Renaissance to exaggerate the size of their eyes by causing the dilation of their pupils. Despite the extreme toxicity of the tropanes, they are useful drugs when administered in extremely small dosages. They can reverse cholinergic poisoning, which can be caused by overexposure to organophosphate insecticides and chemical warfare agents such as sarin and VX. Scopolamine (found in *Hyoscyamus muticus* and *Scopolia atropioides*), is used as an antiemetic against motion sickness or for people suffering from nausea as a result of receiving chemotherapy.[12][13] Scopolamine and hyoscyamine are the most widely used tropane alkaloids in pharmacology and medicine due to their effects on the parasympathetic nervous system. Atropine has a stimulant effect on the central nervous system and heart, whereas scopolamine has a sedative effect. These alkaloids cannot be substituted by any other class of compounds, so they are still in demand. This is one of the reasons for the development of an active field of research into the metabolism of the alkaloids, the enzymes involved, and the genes that produce them. Hyoscyamine 6-β hydroxylase, for example, catalyses the hydroxylation of hyoscyamine that leads to the production of scopolamine at the end of the tropane's biosynthetic pathway. This enzyme has been isolated and the corresponding gene cloned from three species: *H. niger*, *A. belladonna* and *B. candida*.[14][15][16]

Chemical structure of nicotine.

- Nicotine: Nicotine (IUPAC nomenclature (S)-3-(1-methylpyrrolidin-2-il) pyridine) is a pyrrolidine alkaloid produced in large quantities in the tobacco plant (*Nicotiana*

tabacum), but is also found in lower concentrations in other species such as the potato, tomato, and pepper. Its function in a plant is to act as a defence against herbivores, as it is an excellent neurotoxin, in particular against insects. In fact, nicotine has been used for many years as an insecticide, although its use is currently being replaced by synthetic molecules derived from its structure. At low concentrations, nicotine acts as a stimulant in mammals, which causes the dependency in smokers. Like the tropanes, it acts on cholinergic neurons, but with the opposite effect (it is an agonist as opposed to an antagonist). It has a higher specificity for nicotinic acetylcholine receptors than other ACh proteins.

Chemical structure of capsaicin

- Capsaicin: Capsaicin (IUPAC nomenclature 8-methyl-N-vanillyl-*trans*-6-nonenamide) is structurally different from nicotine and the tropanes. It is found in species of the genus *Capsicum*, which includes chillies and habaneros and it is the active ingredient that determines the Scoville rating of these spices. The compound is not noticeably toxic to humans. However, it stimulates specific pain receptors in the majority of mammals, specifically those related to the perception of heat in the oral mucosa and other epithelial tissues. When capsaicin comes into contact with these mucosae, it causes a burning sensation little different from a burn caused by fire. Capsaicin affects only mammals, not birds. Pepper seeds can survive the digestive tracts of birds; their fruit becomes brightly coloured once its seeds are mature enough to germinate, thereby attracting the attention of birds that then distribute the seeds. Capsaicin extract is used to make pepper spray, a useful deterrent against aggressive mammals.

TOBACCO

Nicotiana tabacum (2n=48)

The genus *Nicotiana* includes 60 valid species but only two ie. *Nicotiana tabacum* and *N. rustica* are cultivated extensively. India grows both the species but the largest area is under *tabcum*. Since *rustica* requires cooler climate its cultivation is confined mainly to Punjab, UP, Bihar, W. Bengal and Assam.

N. tabacum : Otherwise known as Desi types, have tall plants with long broad leaves and usually pink flowers. Leaves used for cigarette, cigar and cheroot, bidi, hookah, chewing and snuff tobacco.

N. rustica : Short plants with round puckered leaves and yellow flowers. This species is used only for hookah, chewing and snuff.

A.1. Origin of *N. tubacum*

It is supposed to be an amphidiploid which originated by hybridization and doubling.

N. sylvestris (2n = 24) x *N. otophora* (2n = 24)

↓

F1 sterile

↓ Doubling

N. tabacum (2n = 48)

2. origin of *N. rustica*

N. Paniculata x *N. undulata*

↓

F_1 sterile

↓ Doubling

N. rustica

Family	:	Solanaceae
Habitat	:	Tropical
Habit	:	Stout, annual, about three meters high
Stem	:	Erect, thick, producing a few branches
Leaves	:	Simple, petiole, cordate or semicordate shape, apex acuminate, winged petiole, frilled auricle clasping the stem
Inflorescence	:	Panicle, flowers pedicellate and hermophrodite, sepals five, forming a calyx tube, corolla tube 10-15 mm long and 2-3 mm wide, lower half cylindric, pale green or creamy, upper half similar in colour or pink to red, stamens inserted on base of corolla throat, erect with four stamens of one length, the fifth being shorter. Superior ovary, bicarpellary, axile placentation, ovules numerous, style slender, stigma capitate, capsule narrow, elliptic, ovoid, acute or blunt, seeds numerous and minute.
Fruit	:	A capsule, elliptic, seeds very small, oval dusty brown
Economic Importance	:	Leaf for cigarette, beedi, cigar and cheroot, hookah, chewing and snuff. The alkaloid nicotine obtained from the stems, midribs and other waste products is used as a contact insecticide. Refined tobacco seed oil can be used for culinary purposes

POTATO

Solanum tuberosum L. (2n=48)

Tetraploid

Place of origin: South America.

Ancestry:

a) Natural doubling of diploid cultivar *S. stenotomum* (2n = 24)

b) By a natural crossing of diploid wild species *S.sparsipilum* and *S.vernerii*

Classification : According Hawkes (1992) in addition to *solanum tuberosum* some six other cultivated species and over 230 wild species of potato are generally recognised.

Diploid (2n=24)

1. *S.ajanhuiri* - Frost resistant
2. *S.phureja* - Sort duration. 4 month no dormancy
3. *S.stenotomum* - Longer in duration 6 months dormancy.

Triploid (2n = 36)

4. *S.chauca*
5. *S.juseczuki*

Tetraploid (2n = 48)

Solanum tuberosum

6. subspecies

S.t.ssp tuberosum

S.t.ssp andigena - High altitude potato

Pentaploids

7. *S.curtilobium* - Frost resistant.

Family	:	Solanaceae
Habitat	:	Sub tropical
Habit	:	Erect, juicy herb with numerous branches and subterraneous tuberiferous stolons. Tubers develop at the tip of the stolons (part of stem) variable in size.
Stem	:	Flaccid, robust, hollow, angular stem above with subterraneous tuberiferous stolons below.
Leaves	:	Alternate, shortly stalked, imparipinnately compound, leaflets very small, opposite or alternate unequal in size.

Inflorescence	:	Many flowered cyme in a compressed, thin, hairy, peduncle.
Flowers	:	Calyx five, partite, companulate, corolla five, gamopetalous, stamens five, opens at the top pores.
Stem Tuber	:	The tuber is the short, greatly enlarged, apical portion of the stolon, full of stored food. Morphologically, it is a shortened, thickened stem bearing buds 'eyes' in the axils of scale like leaves which are soon shed, leaving a rudimentary leaf scar (eye brow).
Fruit	:	A berry, two celled, many seeds.
Economic Importance	:	Stem tuber as a source of carbohydrate

CHILLI

Capsicum annum or *C. frutescens* (2n= 26)

Family	:	Solanaceae
Habitat	:	Tropical
Habit	:	Stout annual herb
Stem	:	Erect, highly branched
Leaves	:	Simple, alternate, exstipulate, elliptical, lanceolate, glabrous with unequal margin.
Flowers	:	Solitary, extra axillary sometimes occurs in pairs, actinomorphic, pedicillate, bisexual. Calyx is campanulate, sepals five gamosepalous. Corolla is bell shaped rotate 5 to 6 lobed twisted in bud. Lobes are thin veined and incurred in tips. Androecium introse, anthers dehisce longitudinally by lateral sutures. Carpels 2 syncarpous. Ovary hypogynous, carpels 2, syncarpous, axile placentation. Style slender, terminal and linear. Stigma is subcapitate and faintly bifid.
Fruit	:	Berry. Fruits vary in shape, colour and pungency. Pericarp is leathery or succulent which turns from green to purple or red, orange, orange red. Seeds compressed, orbicular and minutely pitted.
Economic Importance	:	Used as spice on account of its pungency and pleasant flavour. Chilli accounts for 20-30% of total Indian spices exports valuing approx Rs. 400-500 crores. Oleoresin is important product being exported to European countries. When chillies taken with food stimulates our taste buds and there by increase the flow of saliva which contains the enzyme amylase which inturn helps in the digestion of starchy or cereal foods etc., into the easily assimible sugar namely glucose. Capsaicin has significant physiological action which is used in many pharmaceutical

preparations and ointments for cold, sore throat, chest congestion etc., It is also used in cosmetics like prickly heat powders and skin ointments.

4. TOMATO- *Lycopericum esculentum* Mill. (2n= 26)

Family	:	Solanaceae
Habitat	:	Tropical
Habit	:	Herbaceous annual. Growth may be determinate or indeterminate.
Stem	:	Flaccid, hairy, weak, angular trailing stems growing up to 2.4 m long.
Leaves	:	Alternate, shortly stalked, hairy, variable in shape.
Inflorescence	:	Many flowered cyme in a compressed, thin, hairy peduncle. Flowers small yellow borne in clusters. Calyx five, partite, campanulate, corolla 5 , gamopetalous, stamens 5 opens at the top pores.
Fruit	:	Round or lobed berry. Seeds numerous and small, spherical/elliptical, light brown in colour.
Economic Importance	:	Fruit eaten raw or cooked. They have very high nutritional value with high levels of pro-vitamin A and C.

BRINJAL

***Solanum melongena* L. (2n= 24)**

Brinjal is a species of Solanum, native to southern India and Sri Lanka. It is an annual plant growing 16 in - 57 in tall, often spiny, with large, coarsely lobed leaves 10-20 cm long and 5-10 cm broad. Brinjal is an important food crop grown for its large pendulous purple or white fruit. It has been cultivated in southern and eastern Asia countries since prehistory, but appears to have become known to the Western world no more than about 1,500 years ago. The raw fruit has a somewhat disagreeable taste, but when cooked, becomes tender and develops a rich, complex flavour and firm texture. Salting and then rinsing the sliced eggplant can also remove much of its bitterness. It is especially useful culinarily owing to its ability to absorb great amounts of cooking fats, making possible extraordinarily rich dishes. The fruit flesh is smooth; the numerous seeds are soft and (as in the related Tomato) edible along with the rest of the fruit.

Family	:	Solanaceae
Habitat	:	Tropical
Habit	:	Herbaceous annual with erect or semi spreading habit. It is a perennial cultivated as annual. Has indeterminate growth.
Stem	:	Erect, thick stem producing few branches.
Leaves	:	Simple , alternate
Flowers	:	Four types of flowers. Long styled (70-86% fruit set) and medium styled

flowers produce fruits whereas pseudoshort styled and true short styled flowers do not set fruits.

The eggplant flowers are hermaphrodite; they are single or arranged in inflorescences composed of 2–7 flowers each, and show positive geotropism. The flower buds develop in the corners of the same leaves as vegetative buds. The flowers are white to purple, with a five-lobed corolla and yellow stamens. The eggplant flowers are quite large 3–5 cm in diameter. The corolla consists of 5–10 accreted petals of purple, pink, or white color depending on a variety. Number of stamens is 5–7. Filaments are short, 6–20 bicameral anthers are yellow and arranged around pistil. The anthers break in upper direction 15–30 minutes after flower opening. The pollen is quite heavy.

Fruit : The eggplant fruits are multi-chamber berries of different shapes. Berry borne singly or in clusters. Depending on a variety, they may be: spherical, through oval, ovoid, piriform, to elongated and spiral. Epidermis is thin or smooth. Fruit has fleshy placenta, in which seeds are embedded in a mass of spongy tissue. Fruit purple coloured. Some are yellowish white to red, and to blackish purple. There are also white-colored varieties, the skin of which does not contain those pigments.

Economic Importance : Fruits used as vegetable

MIMOSAE

- Root: Taproot with root nodules.
- Stem: Herbaceous or woody, branched.
- Leaves: Compound, alternate, stipulate and pulvinate.
- Inflorescence: Mostly globose head or spike.
- Flowers: Actinomorphic, bisexual, sessile, heterochlamydeous, pentamerous, hypogynous.
- Calyx: Sepals 5 (or 4), gamosepalous or polysepalous, valvate aestivation.
- Corolla: Petals 5 (or 4), polypetalous, valvate aestivation.
- Androecium: Stamens 10, sometimes more, free, of the same size, brightly coloured.
- Gynoecium: Monocarpellary, unilocular with ovules on marginal placentation, ovary superior, style filiform.
- Fruit: Legume or lomentum.
- Seeds: Non endospermic

1. DESMANTHUS (VELIMASAL)- *Desmanthus virgatus* (2n= 28)

Family	:	Mimosae
Habitat	:	Subtropical and tropical
Habit	:	Perennial shrub can be maintained as a hedge plant, tolerant to heavy grazing with quick regrowth
Stem	:	Slender become hardly twig by repeated cutting
Leaves	:	Bipinnate, leaflets small in pairs
Inflorescence	:	In small peduncled heads, flowers small, calyx and corolla five gamo, numerous stamens, ovary superior, monocarpellary with many ovules.
Fruit	:	Pod
Economic Importance	:	Leaves are good fodder for cattle. Quick regrowth is advantageous for introduction of this crop in varying cropping systems.

2. SUBABUL (Soundal) *Lucaena leucocephalaor L. glauca* (2n= 104)

Family	:	Mimosae
Habitat	:	Subtropical and tropical
Habit	:	A tall single trunked tree occurs as many branched shrubs also.
Stem	:	Erect and woody.
Leaves	:	Bipinnate, leaflets small in many pairs, stipulate.
Inflorescence	:	Small peduncled heads. Flowers small. calyx five, tubular, corolla five tubular, stamens 10, exerted, ovary monocarpellary, many ovuled.
Fruit	:	Pod stalked and flattened. Seeds elliptical and compressed.
Economic Importance	:	Leaves as green leaf manure. It is very good tree fodder

3. ACACIA (Wattle tree) *Acacia arbica* (2n= 26)

Family	:	Mimosae
Habit	:	Medium sized decidous tree. Crown is very well developed.
Stem	:	Bark dark brown to almost black with long fissures. White pointed spines occur on bark.
Leaves	:	Leaves 2-5 cm long, 3 to 5 pairs of pinnae, a number of glands occur, leaflets 10-20 pairs, linear, glabrous.
Flower	:	Fragrant, yellow in axillary globes heads which are 1cm in diameter.

		Peduncle in slender fascicles, a whorl of bracts appears above the middle. Calyx tube cup shaped. Sepals are double the length of sepals.
Fruit	:	Lomentum or constricted pod containing 8-15 seeds. Stalked, convex, fleshy, distinct compartments occur between seeds.
Economic Importance	:	Stem used for making furnitures. Leaves used as green fodder.

Lecture 15

Cucurbitaceae and Alliaceae; Key botanical features of Pumpkin, Ashgourd, Melon, Onion, Garlic and Ginger.

A. CUCURBITACAE

1. PUMPKIN Cucurbita *moschata* (2n= 40)

Family	:	Cucurbitacae
Habitat	:	Tropical
Habit	:	Annual climbing herb
Stem	:	Prostrate (climber), hollow, 5 angled, hairy, weak stem with tendrils for climbing.
Leaves	:	Alternate, cordate and lobed.
Inflorescence	:	Solitary flowers, large and monecious. Calyx 5 gamosepalous, 5 lobed campanulate. Corolla 5, gamopetalous, campanulate. Male flower: long, pedicillate: usually appear before the female flowers and are produced in greater numbers. Female flowers: peduncle short, tricarpellary, syncarpous, inferior ovary, unilocular with parietal placentation. Styles short and thick with 3-5 stigma.
Fruit	:	Special form of berry called pepo. Large or small. The epicarp develops into hard rind, enclosing a fleshy mesocarp.
Seeds	:	Seeds are flattened without endosperm.
Economic Importance	:	Fruit as vegetable and seed as a snack. Pumpkin seed oil contains fatty acids, such as oleic acid and alpha-linolenic acid.

2. ASHGOURD- *Benincasa hipida* (2n=24)

Family	:	Cucurbitacae
Habitat	:	Tropical
Habit	:	Annual Climbing herb
Stem	:	Stout light green with scattered rough hairs, often five angled
Leaves	:	Large, alternate, exstipulate, petiole long, lamina 5-11 angled or lobed, dentate,base cordate,coiled tendrils situated at the upper base of the petiole base.
Inflorescence	:	Cymose axillary and solitary. Flower regular monoecious, large, actinomorphic, epigynous. Calyx five lobed, gamosepalous,

		campanulate, petals 5, almost free, rotate. Staminate flowers long stalked, stamens 5, single celled, but usually connate in pairs and remains free (2+1+1). Pistillate flowers have single pistil, ovary inferior, tricarpellary, syncarpous, unilocular, ovule numerous, parietal, style 1, stigma 3, bilobed and curved.
Fruit	:	Large berry with hard pericarp calle pepo. Fruit at first hairy becoming glabrous and covered with white easily removable wax.
Seeds	:	Seeds are without endosperm.
Economic Importance	:	Fruit (especially fleshy edible endocarp) used as vegetable.

3. MELON

Musk melon : *Cucumis melo* L. (2n=22)

Water melon :Calocynthis *citrullus* (2n=22)

Family	:	Cucurbitacae
Habitat	:	Tropical
Habit	:	Annual climber
Stem	:	Trailing or somewhat climbing soft hairy with striated or angled stems
Leaves	:	Orbicular- ovate to nearly reiniform, lobed, margins sinuate-dentate
Inflorescence	:	Monecious yellow coloured flowers.
Fruit	:	Pepo usually large. Yellow fleshed or red fleshed bitter and sweet types are known.
Economic Importance	:	Fruit is the economic part. The root of the Common Melon is purgative, and in large doses is said to be a certain emetic, the active and bitter principle having been called Melon-emetin. Incase of water melon, seed and juice are the economic part.

B. ALLIACEAE

1. ONION – *Allium cepa* L. (2n=16)*var cepa, var. aggregatum and var. proliferum.*

Family	:	Alliaceae
Habitat	:	Tropical
Habit	:	Biennial but can be perennial by underground bulbs in

favourable situation. In cultivation, it is treated as annual.

Root	:	Adventitious
Stem	:	The true stem of onion is much reduced in size and is hard, short with condensed internodes and flat bottom. It is held underneath the soil.
Leaves	:	Acicular, long, narrow cylindrical.
Inflorescence	:	Cyme (umbel). Rose purple flowers on 2.5 to 3 foot stem. The umbels are aggregates of cymes of 5-10 flowers each and the flowers open in a definite sequence. The perianth segments are 6 in 2 whorls spreading, reflexed, free and ovate. The stamens are also six in two whorls each having three stamens. Ovary is superior.
Economic Importance	:	1.Onion is the most important commercial spice crop grown in India and exported. 2. Onion leaves and immature bulbs are consumed as vegetable. 3. It is mixed in other vegetables and soups as spice and flavouring agent. 4. It contains vit. B and vit. C and minerals Ca and Fe. 5. It has medicinal properties and used against ear-ache, colicpain etc. 6. It is used for raw consumption. 7. It is used in making sauce, ketch-up and chutnee. 8. Dried onion chips and powder have great demand for export. 9. The bulbs obtained during seed production are feed to cattle or poultry.

2. GARLIC *Allium sativum* (2n=16)

Family	:	Alliaceae
Habitat	:	Temperate
Habit	:	Biennial but cultivated as an annual.
Root	:	Adventitious
Stem	:	Reduced in size and is hard with condensed internodes and flat bottom held underneath the soil.
Leaves	:	Long, flattened, solid.
Economic Importance	:	Composite bulbs with number of sheathing membranous leaf base enclosing numerous small bulbs derived from axillary buds of the leaves called as cloves. Vary in size and shape.

Garlic is widely used around the world for its pungent flavor as a seasoning or condiment. Has significant medicinal property also. The fungicidal and insecticidal properties of garlic are well established.

C. ZINGEBERACEA

GINGER *Zingiber officinale* (2n = 22)

Family	:	Zingeberacea
Habitat	:	Tropical
Habit	:	Perennial herb. It bears large scaly rhizome which is pale yellow in colour. They contain starch, gums, an oleoresin and essential oil.
Root	:	Adventitious
Stem	:	Prostrate, thickened stem creeping horizontally under the surface of the soil (Rhizome). It is provided with distinct nodes and internodes which bears some scaly leaves at the nodes. It possesses a bud in the axil of the scaly leaf and ends in a terminal bud some slender adventitious roots are given off from its lower side. The rhizome may be unbranched or some times the axillary buds grow out into short, stout branches. It remains dormant underground and with the approach of the vegetative season the terminal bud and axillary buds grow into aerial shoots.
Leaves	:	Large leaves with a sheathing leaf base borne alternately on stem.
Inflorescence	:	Spike with yellow flowers.
Economic Importance	:	Rhizome is the economic part. The presence of gingerin a non volatile oleoresin is responsible for pungent taste whereas the essential oil gives an aromatic odour.

Lecture 16

Musaceae, Rubiaceae and Theaceae; Key botanical features of Banana, Manila hemp, Coffee and Tea

A. MUSACEAE

1. BANANA *Musa sp.* (2n=22- 88)

Plantains- *Musa paradisica*

Dessert banana – *Musa sapientum*

Family	:	Musaceae
Habitat	:	Tropical
Habit	:	A rhizome with peudostem formed by leaf sheath
Stem	:	The main or upright stem is actually pseudostem growing from corm. Each pseudostem produces a single bunch of bananas. After fruiting, the pseudostem dies, but offshoots may develop from the base of the plant. Many varities are perennials.
Leaves	:	Spirally arranged and may grow 2.7 meters long and 60cm wide. They are easily torn by wind, resulting in the familiar frond look.
Inflorescence	:	Each peeudostem normally produces a single inflorescence also known as banana heart. The inflorescence contains many bracts between rows of flowers. The female flowers appear in rows further up the stem from the rows of male flowers. The ovary is inferior.
Fruit	:	Leathery berry develop from the banana heart in a large hanging cluster, made up of tiers (called hands), with up to 20 fruits per tier. The hanging cluster is known as a bunch, comprising of 3-20 tiers, or commercially as banana stem, and can weigh from 30-50 kilograms. In common usage, bunch applies to part of a tier containing 3-10 adjacent fruits.individual bananas commonly known as finger average 125 grams, of which approximately 75% is water and 25% dry matter. There is an protective outer layer (a peel or skin) with numerous long, thin strings(the phloem bundles), which run lengthwise between the skin and the edible inner portion. The inner part of the common yellow dessert variety splits easily lengthwise into three sections that corresponds to the inner portions of the three carpels.
Economic Importance	:	Bananas are an excellent source of potassium. Potassium can be found in a variety of fruits, vegetables, and even meats, however,

a single banana provides you with 23% of the potassium that you need on a daily basis.

Bananas are also an excellent source of vitamins, including:

· A - aids in healthy teeth, bones, soft tissue, and more

· B6 - aids the body's immune system, promotes brain health, heart health, and more

· C - aids in healing, growth of tissue, ligaments, and more

· D - helps the body to absorb calcium

The banana leaves -- which are large, flexible, and waterproof -- have their uses.the banana leaves are believed to be medicinal and can heal open-skin wounds faster.

The banana leaves,blossom and stem are also used for cooking purposes.

Banana fibre extracted from the stem also have industrial applications.

2. MANILA HEMP- *Musa textilis* Nee. (2n=20)

Family	:	Musaceae
Habitat	:	Tropical
Habit	:	A rhizome with peudostem formed by leaf sheath
Stem	:	Lateral branches arise horizontally from main trunk in opposite manner
Leaves	:	Simple, spirally arranged, large oblong, sheath yields the leaf fibre.
Inflorescence	:	Monecious, stout, elongate, bracteate, male spike above and female below bracts spirally arranged, large ovate or orbicular. Bisexual flowers occur in the middle, perianth six in two series, the inner posterior tepal is large and free, the others fused, segments unequal in size and shape. Samens 6 (5 fertile and 1 staminode), ovary inferior, tricarpellary, syncarpous, stigma capitate.
Fruit	:	Leathery berry
Economic Importance	:	Fibre from leaf

B. RUBIACEAE

COFFEE- *Coffea arabica* L. (2n= 44)

Family	:	Rubiaceae

Habitat	:	Tropical, can also grow under temperate climates
Habit	:	Shrub with evergreen leaves reaches a height of 14 to 20 feet. The shrub produces dimorphic branches, *i.e*., branches of two forms, known as uprights and laterals.
Stem	:	The plants have mainstem, the upright, which produces out side shoots, the laterals. The laterals produce the secondary laterals. The laterals are produced in pairs and are opposite, the pairs being borne in whorls around the stem.
Leaves	:	Lanceolate or lance shaped being borne in pairs in opposite each other. They are 3-6 inches in length with anacuminate apex, somewhat attenuated at the base, with very short petioles which are united with the short interpetiolar stipules at the base. The leaves are thin, but of firm texture, slightly coriaceous. They are very dark green on upper surface, but much lighter underneath. The margin is entire and wavy.
Inflorescence	:	Flowers are small, white and very fragnant, having a delicate characteristic odour. They are borne in the axils of the leaves in clusters. The flowers are tubular, the tube of the corolla dividing into five white segments. The anthers of the stamens, which are 5 in number, protrude from the top of the two cleft pistil. The calyx is very small with tooth like indentations.
Fruit	:	2 Seeded berry ellipsoidal and has 2 locules each containing a little stone (the seed and its parchment covering) from which coffee bean is obtained. Some few drupes contain 3 while others at the outer ends of the branches contain one round bean known as pea berry.
Economic Importance	:	Fruit from which beans (Seeds) is obtained.

C. THEACEAE

TEA - Thea *sinensis* L.(*Camellia thea)* 2n=30

Family	:	Theaceae
Habitat	:	Tropical and subtropical
Habit	:	Evergreen shrub or small tree growing upto 30ft. with a strong taproot.
Stem	:	Glabrous

Leaves	:	Alternate simple, short petioled, serrate. The leaves are 4-15cm long and 2-5cm broad. The youngh green leaves are preferably harvested for tea production. They have short white hairs on the underside. Older leaves are deep green. Different leaf ages produce different tea qualities, since their chemical composition are different. Usually, the tip (bud) and the first 2 to 3 leaves are harvested for processing. This hand picking is rep[eated every one to two weeks.
Inflorescence	:	Pedicillate flowers, solitary or 2-4 together, sepals persistent, petals united at the base, stamens numerous in 2 series: the outer united into a short and long tube and the inner 5-15 free, anthers versatile, 3-5 filiform style, superior ovary 3-5 loculed with 4-6 ovules in axiel placentation.
Fruit	:	Loculicidally dehiscent capsule
Economic Importance	:	Dried and cured leaves are the economic part.