**PBG.101 FUNDAMENTALS OF CROP BOTANY 1+1**

**THEORY**

**Introduction to field crops –** Agricultural Classification of field crops.

**Family description, economic parts, economic uses, value additions, in the following crops:**

**Cereals and Millets**: Rice, Wheat, Maize, Sorghum, Pearl millet, Finger millet, Foxtail millet, Little millet, Barn yard millet, Proso millet and Kodo millet.

**Pulses:** Redgram, Blackgram, Greengram, Soybean, Bengalgram, Horsegram, Cowpea, Lablab and Dew gram.

**Oilseeds:** Groundnut, Gingelly, Castor, Sunflower, Safflower, Niger, Rape and Mustard, jatropha.

**Fibre crops:** Cotton, jute, Mesta, Sunnhemp, Agave and Silk cotton.

**Sugars:** Sugar cane, Sugar Palm and Sugar beet.

**Forage Crops: Grasses –** Napier, Pearl millet – Napier, Guinea grass, *Cenchrus* sp., Johnson grass, Marvel grass, Spear grass, Buffalo grass and Bermuda grass.

**Cereal Fodders:** Sorghum, Pearl millet, Maize and Minor-millets.

**Legume fodders:** Lucerne, Cowpea, Desmanthus, Desmodium, Stylosanthus, Clitoria and Siratro.

**Tree fodders:** Agathi, Glyricidia, Erythrina, Subabul and *Acacia* sp.

**Green and green leaf manures:** Sunnhemp, Sesbania, Daincha, Tephrosia, Glyricidia, Neem and Pungam.

**Narcotics –** Tobacco

**PRACTICAL**

Family features - observation and description of habit, morphology of root, stem, leaves, inflorescence, flowers, floral parts-stamen, ovary and economic parts of the above mentioned crops in Cereals, Pulses, Oilseeds, Fibre crops, Sugars, Forage grasses, Cereals and Legume fodders, tree fodders, Green and Green leaf manure, Narcotics.

**LECTURE SCHEDULE**

1. Introduction to field crops - Agricultural Classification of field crops.
   Family description, economic parts, economic uses, value additions, in the following crops:
2. Cereals: Rice.
3. Cereals: Wheat and maize.
4. Millets : Sorghum, Pearl millet and
5. Finger millet, Small millets- Foxtail millet, Little millet,
6. Barn yard millet, Proso millet, and Kodo millet.
7. Pulses : Redgram, Blackgram, and Greengram.

8. Pulses : Soybean, Cowpea, Bengal gram, Lab-lab and Dew gram.
9. MID SEMESTER EXAMINATION.
10. Oilseeds: Groundnut, Gingelly.
11. Oilseeds: Castor, Sunflower, Safflower.
12. Oilseeds: Rape, Mustard, Niger and jatropha.
13. Fibres: Cotton.
14. Fibres: Jute, Mesta, Sun hemp, Agave and Silk cotton.
15. Sugars: Sugar cane, Sugar palm and Sugar beet.
16. Forage Crops: **Grasses** - Napier, Pearl millet-Napier, Guinea grass, Cenchrus and Johnson grass. **Cereal fodders**: Sorghum, Pearl millet, Maize, Minor millets. **Legume fodders**: Lucerne, Cowpea, Desmodium, Desmanthus, Stylosanthus, Clitoria and Siratro.
17. **Tree fodders**: Agathi, Glyricidia, Erythrina, Subabul and Acacia. **Green and Green leaf manures**: Sunhemp, Sesbania, Daincha, Tephrosia, Glyricidia, Neem, Pungam, Narcotics.

**PRACTICAL SCHEDULE**

1. Observing general morphology of roots, stems and leaves.
2. Observing general morphology of inflorescence - flowers, stamens and pistils Family characters and Botany and economic parts of the following crop plants:-
3. Rice.
4. Wheat.
5. Maize, Sorghum and Pearl millet.
6. Finger millet, Foxtail millet, Little millet, Barn yard millet, Proso millet and Kodo millet.
7. Redgram, Blackgram, Greengram and Bengal gram.
8. Cowpea, Soybean Lab-lab and Dew gram.
9. Groundnut, Gingelly.
10. Sunflower, Castor, Safflower.
11. Niger, Rape and Mustard and Jatropha.
12. Cotton.
13. Jute, Mesta, Sunnhemp, Agave and Silk cotton.
14. Sugar cane, Palm sugar and Sugar beet.
15. Napier, Pearl millet - Napier, Guinea grass, Cenchrus, Cereal fodder. Legume fodders: Lucerne, Cowpea, Desmodium, Desmanthus, Stylosanthus, Clitoria and Siratro.
16. Tree fodder: Agathi, Glyricidia, Erythrina, Subabul and Acacia. Green and Green leaf manures – Danicha, Sunnhemp, Tephrosia, Glyricidia, Neem, Pungam, Narcotics.
17. PRACTICAL EXAMINATION.

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# TAMIL NADU AGRICULTURAL UNIVERSITY

## PBG 101 – Fundamentals of Crop Botany (1+1)

### THEORY


***Course Teacher***

A. KALAMANI



CENTRE FOR PLANT BREEDING AND GENETICS
TAMIL NADU AGRICULTURAL UNIVERSITY
**COIMBATORE – 641 003**

## 1. Introduction to field crops - Agricultural classification of field crops.

The grouping of the plants under the agricultural classification 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. In ancient Rome, at every harvest, a great festival in honour of Ceres was celebrated and she was worshipped as the 'giver of grain'. Wheat and barley were generally the offerings which were made to the goddess and these were called *Cerealia munera.* Subsequently the grains used for food, especially for making bread were called *Cerealia* or cereals. It generally applicable to the grains obtained from the members of the family Poaceae. Rice, wheat, maize, sorghum, ragi, barely, pearl millet, fox-tail millet, rye oats, etc., come under this group. 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 plant of the Poaceae which produces it. Botanically the characteristic fruit of the family poaceae is a caryopsis. Another term millets is generally used for the number of small grained cereals which are of minor importance as food.

There are a few species of plants other than those of Poaceae which produce small grains and used for food as in the case of cereals. These go by the name pseudocereals. Buckwheat (*Fagopyrum* spp.- Chenopodiaceae, grain amaranths (*Amaranthus* spp.- Amranthaceae), Quina (*Chenopodium quinoa* - Chenopodiaceae) and *Zostera marina* (Potamogetonaceae) are considered under pseudo-cereals.

The major cereals of India are paddy, wheat, sorghum, ragi, maize, pearl millet and the minor cereals are fox-tail millet, little millet, etc. Some of the temperate zone cereals, such as rye, oats and barely also figure as minor cereals under certain regions while they may be major ones in other places. Due to the adverse soil and climatic conditions and the generally low yield under such 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 cereals are characterised by the shallow fibrous root system tillering habit, sheathing leaf bases and inflorescences which are panicles. The primary root developed from the radicle in generally short lived; it is often the adventitious and fibrous root system which persists and is functional during the whole life time of the crop plant.

The tillering habit though a common habit in the cereals, may be suppressed as in the case of maize, or the Indian sorghums. The culms are generally enclosed within the sheathing leaf bases and the jointed nodes may be distinctly exposed or completely enveloped. Ligules are almost invariably present except in the case of barnyard millet. Spikelets which are the ultimate units of the inflorescence in Poaceae may be borne on panicles which are either free and lax or compact or in some compressed to spiciform one. The flowers in the compact panicle are compressed to spiciform one. The flowers in the spikelets may vary from one as in the case of paddy to many as in the case of ragi and wheat. The fruits generally termed as grains are the caryopsis which are either fully enveloped by the glumes as in the case of paddy of partly exerted as in the case of sorghum or fully exposed as in the case of maize.

All the cereals supply food to man and straw to animals. The flour or the meal of the grains is generally made use of and this is made up mostly of starch. The whole grains are also used as food as in the case of rice. In a few cases, the grains are popped as in maize, sorghum and rice, or used as pressed and processed food as in rice and oats. In a light form they go as cereals foods or breakfast cereals.

Rice is the staple food of nearly half of the population of the world. It contains a larger proportion of starch than all the other cereals. Wheat, a very valuable cereal, 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 miller, fox-tail 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. Barely is important mainly as a malt food and oats in a beaten and processed condition form a light food.

**(2) Pulses:** Next to the cereals, pulses form an important source of human food. The term pulse is used generally for the seeds of leguminous plants 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 utilised. Since the leguminous plants have nitrogen in root nodules which is produced with the help of nitrogen fixing bacteria, the whole plant body in legumes particularly in papilionaceous plants is rich in nitrogen and the seeds, the pods and also the leaves and shoots contain a high proportion of protein and are hence useful as food. The average per capita consumption of pulse in India is about one ounce while the minimum requirement is about three ounces according to nutrition experts. The most important pulse crops of South India, namely, *Cajanus cajan*, (red gram), *Vigna mungo* (black gram), *V.aureus* (green gram) and *lablab* are cultivated by the farmers besides many other minor pulses.

**(3) Vegetables, fruits and Nuts :** Olericulture which deals with vegetables is by itself a vast branch of crop science as vegetables comprise a wide number of species and varieties utilised by man. Similarly fruits and nuts which are rich and valuable sources of food are dealt under pomology. The aspects of horticulture, namely, the branch of agriculture relating to cultivation of fruits (pomology), vegetables (olericulture) and ornamental plants (floriculture) have not been dealt within these pages.

**(4) Oils and Oilseeds:** 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. The use of oil for medicinal purposes is also well known. As an industrial crop in the preparation of soaps, cosmetics and lubrication, the role of oils is considerable. Castor oil and coconut oil are very important industrial oils which figure in the export trade.

**(5) Sugars and Starches :** The use of sugarcane for the production of jaggery has been in existence for many centuries. The present sugar production and trade has attained national importance in the country. In Europe, Canada and the U.S.A. sugar beet is the source of sugar. This has not come into prominence in the tropical countries because of the sugarcane crop which gives high tonnage under the tropical conditions. The other sources of sugar in the country are the palms, namely, palmirah, coconut and date palm. The tapped juice from these palms are 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.

In the Indian diet, the cereals supply the bulk of the starch as in rice, sorghum, maize and other cereals. Starchy foods are also obtained from sweet potato, tapioca and sago palm. Starch is also an industrial product much needed in confectionery, textile, stationery and cosmetics industries.

**(6) Fibres :** In the needs of man, next to food, clothing is most important and is obtained from fibres. Cotton is the most important of the fibre crops 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. Today, artificial fibres obtained from wood pulp have become prominent. For the manufacture of gunny bags, hession cloth and packing material, the fibres of jute and mesta are of importance. Twines, cordages and ropes which are needed in daily life are also made from fibres obtained from coconut. The coconut fibre is used in carpets, mats, brushes and for stuffing purposes are also well known.

**(7) Beverages :** Coffee, tea and cocoa are the important beverages of the world. In general, beverages are drinks which form an essential part of human diet because of their liquid content. The abovementioned beverages have stimulating effects. Fruit juices like lemonades, orange, apple, pineapple and mango juices constitute the soft drinks. Coffee and tea are commercial crops which are grown on plantations and which figure in the export market. Cocoa is gaining importance in the country and it has great potential both as beverage and as confectionery.

**(8) Narcotics, Fumitories and Masticatories :** Products from tobacco, ganja, opium and 'stramonium' which have a stimulating effect in moderate doses come under narcotics. Narcotics are substances which produce a stimulating or drowsy or numbing effect. These substance relieve pain or produce sleep. The term is often used synonymous with the drugs. Mild stimulating preparations, adjuncts to fermentations, flavouring ingredients to beverages and mild poisons are also called as narcotics. However, the plants referred to earlier, namely, tobacco, opium, ganja (Indian hemp) and 'stramonium' come under this.

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 arecanut form the masticatories. Tobacco comes as a narcotic, a fumitory and also as a masticatory. In all the above cases the alkaloids present in the plant parts are responsible for creating the effects. Drugs are obtained from a large number of plants and study of such plants is by itself a vast subject coming under pharmaceutical botany.

**(9) Spices and Condiments :** A variety of plants products are made use of as food adjuncts to add flavour, aroma and taste. Those which give aroma and flavour, are termed as spices and those which give taste as condiments, although no clear-cut distinction can be made between these. A large number of plants come under this grouping, the chief among them being pepper, cardamom, cloves, chillies, turmeric, ginger, onion and garlic. These species and condiments have essential oils which are responsible for the flavour and taste.

**(10) Rubber :** The daily consumer use of rubber as well as its industrial consumption is fast increasing. The rubber industry is localised in South India but is has an important role in the national economy. The rubber plantations in tropical countries

grow the species *Hevea brasiliensis*, a plant introduced from Brazil. Though latex and rubber may be obtained from other plants like *Manihot glaziovii, Cryptostegia and Taraxacum*, the commercial source is mainly from *H.brasiliensis.*

**(11) Forages:** The feed for domestic animals is to a great extent obtained from grain crops and fodder crops. The term forages generally include both fodders and pasturages. The cultivated fodders 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 and 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.

**(12) Green manures and Green-leaf Manures:** The role of green manures in agricultural practices is well known. The growing of special crops for adding organic matter and nitrogen to the soil and by ploughing them *in situ* is called green manuring. Danicha, sunhemp, pillipesara, kolingi, indigo and *Sesbania speciosa* for the plains and Lupins for the hills are the popular green manure plants. The green loppings from shrups and trees incorporated in fields as from *Ipomoea carnea* and *Gliricidia* form the green leaf manure. Usually green manuring plants are papilionaceous types which fix nitrogen in the soil by the formation of bacterial nodules and have higher nitrogen content in leaves and shoots.

Besides the headings under which a number of crops have been grouped as above, there are some more minor crops which are grown by the cultivator but not dealt with in this book. Horticultural crops comprising pomology, olericulture and floriculture have also not been dealt with. An attempt has been made to deal only with the various botanical aspects of each of the important field crops. The crops have been treated under sections, namely, cereals, pulses, sugars and starches, oils and fats, fibre crops, species, condiments, etc., forages and green manures. A few cases of plants, though not grown as field crops, have been included under the above sections to give a complete picture of the subject.

Recent efforts, specially in tropical countries, to achieve an efficient and balanced exploitation of the biological resources have brought in new species and varieties of economic plants. There is also a vast research on the under-exploited tropical plants and new uses are being found. A few of such plant species have been included under the appropriate sections.

# CEREALS

The **cereals** are annual grasses grown primarily for their large seed reserves 'grains'. In general, they provide the main concentrated carbohydrate 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 climates ; rye in low temperature and low fertility; oats in cool temperature and high rainfall; in warmer regions maize and in still hotter climates rice-where irrigation by controlled flooding can be practised and where conditions are un suitable for rice, millets are grown.

The word cereal is derived from the Roman word *Cereolia munera* meaning the gift of Goddess Ceres the Roman Goddess of Agriculture. All cereals are annual grasses, members of the family **Poacea,** that are 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 cultivated by ancient Egyptians,Greeks and Romans. The millets are again sub divided into major millets and minor millets or small millets.

**Characters of cereals**

- Most of the cereals are herbaceous annuals
- Stem or culm often errect , cylindrical, hollow except at nodes
- Tillering habit, shallow fibrous root system
- Leaves alternate, distichous with parallel venation and sheathing leaf base
- Presence of auricles, ligules and lodicules
- Inflorescence is panicle or spiciform panicle or spike
- Stamens usually three (in rice - six )
- Fruit is a caryopsis (in ragi - utricle)

**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 from plants
- Grains has high nutritive value with higher percentage of carbohydrates, sufficient protein (7-10%), fats, vitamins and minerals.

**Psuedocereals**

They are certain botanicaly unrelated plants whose seeds are also used in a similar manner as that of cereals.

***Eg****. Buck wheat (Fagopyrum esculentum) and Grain amaranthus.*

**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 Eastern Asia. It is the most important tropical cereal and, on world basis production is only slightly below 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 : Pooideae
Tribe : Oryzeae

**Origin**

Place of origin : India or Africa
Distribution : China, India, Bangladesh, Japan, Pakistan, Burma, Thailand, Vietnam.
In India : All the states.

**Putative parents and origin of cultivated rice**

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

**i. Polyphyletic :** Origenated from several species. According 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.

**ii. 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 simulate except in glume pubesence, ligule size and colour of pericarp which is red in African rice.

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**Species in the genus oryza**

According to the latest view the genus oryza include 20 valid 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 | Chromo some No. | Genome | Origin |
|---|---|---|---|
| *O.sativa* | 24 | AA | Asia |
| *O.nivara* | 24 | AA | Asia |
| *O.meridionalis* | 24 | - | Australia |
| *O.longistaminata* | 24 | AA | Africa |
| *O.rufipogan* | 24 | AA | Asia |
| *O.glumaepatula* | 24 | - | America |
| *O.grandiglumis* | 48 | CCDD | America |
| *O.glaberrima* | 24 | AA | Africa |
| *O.barthii* | 24 | AA | Africa |
| *O.australiensis* | 24 | EE | Australia |
| *O.latifolia* | 48 | CCDD | America |
| *O.alata* | 48 | CCDD | America |
| *O.eichingeri* | 2448 | CCBBCC | Africa |
| *O.minuta* | 48 | BBCC | Asia |
| *O.punctata* | 48 | BBCC | Asia |
| *O.officinalis* | 24 | CC | Asia |
| *O.granulata* | 24 | - | Asia |
| *O.meyeriane* | 24 | - | Asia |
| *O.ridleyi* | 48 | - | Asian |
| *O.longiglumis* | 48 | - | New Guinea |
| *O.brachyantha* | 24 | FF | Africa |
| *O.schlechter* | - | - | New Guinea |

**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 given subspecies status.The three subspecies are:

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

Marked sterility barriers occur between the subspecies. It ranges up to 80per cent in case of *indica* x *japonica* where as it is less in case of *indica* x *javanica.*

**The morphological and physiological differences between the subspecies are summarized below.**

| Character | Indica | Japonica | Javanica |
|---|---|---|---|
| Climatic zone | Tropical | Temperate | Equatorial |
| Photoperiod | 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, |
| Plant colour | Light green | Dark green | Light green |
| Plant height | Tall | Short | Tall |
| Tiller number | Moderate | Many | Few |
| Shedding of grain | Susceptible | Resistant | Resistant |
| Flag leaf | Long, narrow, | Short, broad, | Long, wide, |
| | drooping | erect | semidrooping |
| Endosperm | Translucent | Chalky | - |
| Breaking during milling | High | Low | Low |
| Yield potential | Medium | High | Low |
| Market Price | High | Low | Medium |

**Agronomic Classification of cultivated rice**

i. Low land rice - swamp rice; grown irrigated in 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

**Quality characters**

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

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
E*g*.Basmathi. (length 9*mm* and breadth 3*mm* 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 starch. When cooked will become sticky. Useful for special preparations like 'puttu'. Used in Japan, China where people use chop sticks.

**Non glutinous type :** Contains starchy endosporm when cooked they remain flaky (non sticky). Non glutinous types are cultivated in world's 90 per cent 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

| Carbohydrate | 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 pericarp, nucellus, aleurone layer and embryo. All these are collectively known as bran. 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 24hrs 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, and 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 |

**Utilization of rice and its products**

Whole grain is cooked and eaten. Rice grain is used for producing parched rice, popped rice and beaten rice which are used as food. Rice flour is used for preperation of many edible item and is used in ice cream making. Starch from rice is used in textile industry and also for manufacture of dextrin and 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 *Taichung Native -1* (*T(N) - 1*).

Later on this *Dee Gee Woo Gen* was utilised in IRRI and released Wonder Rice IR8. (Peta x *Dee Gee Woo Gen*).

# WHEAT

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 | : | 2n = 14 |
| Tetraploid | : | 2n = 28 |
| Hexaploid | : | 2n = 42 |

## DISTRIBUTION

Wheat is baically 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 ORIGIN

| | | |
|---|---|---|
| Diploid | : | Asia minor |
| Tetraploid | : | Abyssinia, North Africas |
| Hexaploid | : | Central Asia |

## CLASSIFICATION

| Ploidy level | Species | Common name | Genome |
|---|---|---|---|
| **Diploid** | *T.boeticum* | Wild einkorn | AA |
| (2n=14) 2 | *(T.aegilopoides)* | | |
| species | *T.monococcum* | Einkorn | AA |
| **Tetraploid** | *T.dicoccoidis* | Wild Emmer | AA BB |
| (2n=28) 7 | | Emmer | AA BB |
| species | *T.dicoccum* | Macaroni | AA BB |
| | *T.durum* | wheat | AABB |
| | *T.persicum* | Persian wheat | |
| | *T.turgidum* | Rivet wheat | |
| | *T.polonicum* | Polish wheat | |
| | *T.timopheevi* | - | |

| | | | |
|---|---|---|---|
| **Hexaploid** (2n=42) 5 species | *T.aestivum* | Common or bread wheat | AABBDD |
| | *T.compactum* | Club wheat | AABBDD |
| | *T.sphaerococcum* | Dwarf wheat | AABBDD |
| | *T.spelta* | Spelt wheat | AABBDD |
| | *T.macha* | Macha wheat | |

**Fourteen species of wheat according to Vavilov (Fig.1)**

| | | |
|---|---|---|
| 1. T.boeoticum | 2. T.mono coccum | 3. T.dicoccoides |
| 4. T.dicoccum, | 5. T.durum, | 6. T.persicum, |
| 7. T.turgidum, | 8. T.polonicum, | 9. T.timopheevi, |
| 10. T.aestivum, | 11. T.sphaerococcum, | 12. T.compactum, |
| 13. T.spelta, | 14. T.macha. | |

**Origin of diploid wheat**

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

Natural mutation and selection

*T.monoccocum* Cultivated diploid

**AA** (2n = 14)

*T. boeoticum* is probably the ancester for all the cultivated wheats:

**Origin of Tetraploid wheats**

*T.boeoticum x Aegilops speiltoides*

| **AA** | **BB** |
|---|---|
| 2n = 14 | 2n 14 |

$F_1$ Sterile (2n=14) (**AB**)

Natural mutation and Doubling

*T.dicoccoides* 2n = 28

Wild emmer **AABB**

By natural selection

*T.dicoccum* (Emmer wheat)

**AABB** (2n=28) Cultivated

**Origin of hexaploid wheats (Fig.2)**

*T.dicoccum* x *Aegilops squarrosa*

| **AA BB** | **DD** |
|---|---|
| 2n = 28 | 2n = 14 |

$F_1$ **ABD**(2n = 21)

Sterile Natural doubling

*T.aestivum* **AABBDD**

(2n = 42) (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 speltoides***:(2n=14;B genome) It is naturally cross-polinating. It is the recognised donor of the B genome. **4.*T.dicoccoides***:It is an amphidiplod form resulting from the hybridization of *T.boeoticum* and *Ae. speltoides*. **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 glutin. **7. *Ae. squarrosa***:(2n=14; D genome) It is the sourse of D genome in the cultivated hexaploid wheat, high adaptability. **8. *T.spelta***: Hexaploid species, considered an amphidiploid from hybridization between *T.dicoccoides* and *Ae.squarosa.*

Fig.2. The evolution of hexaploid bread wheat from its wild relatives.

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

**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. The dorsal (back side) convey 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.

**The following 4 structures are recognised in wheat grain**.
i.Grain coat, ii.Nucellar epidermis, iii.Endosperm and iv.Embryo.

Magnified view of the transverse section through pericarp, aleurone layer and part of the starchy endosperm.

**COMPOSITION OF THE GRAIN**

| | | |
|---|---|---|
| Bran coat | : | 9-10 % |
| Embryo | : | 2.5 % |
| Starchy endosperm | : | 85-86 % |
| Aleurone layer. | : | 3 -4 % |

## CHEMICAL COMPOSITION

| | Grain | | Flour | |
|---|---|---|---|---|
| Water | 13 | % | 12.4 | % |
| Protein | 11.5 | % | 10 | % |
| Fat | 2 | % | 1.0 | % |
| Carbohydrate | 70 | % | 76 | % |
| Fibre | 2 | % | 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%.

### Market grouping

In USA grouping is done not on botanical classification. Seven grades are done

1. Hard red spring
2. Durum
3. Hard red winter
4. Soft red winter
5. Soft red spring
6. White wheat
7. Mixed wheat

## UTILIZATION OF WHEAT

1. Staple food in the form of bread, biscuit, cookies, chappati, etc.
2. Industrially starch, gluten, malt, distilled spirit.
3. Wheat bran is rich in proteins, Valuable live stock feed.
4. Used as roughage in human food.
5. Wheat straw as livestock feed.
6. 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 wheats, 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**

*T.vulgare* x *Secale cereale*

Wheat
disease
AABB(*2n=28*)

Rye (Winter hardiness
and pest resistance.)
RR(*2n=14*)

F1

ABR

Doubled

**Tricale**
(*2n =42* - Hexaploid)

# MAIZE

Maize is the most important cereal in the world after wheat and rice; it is 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** : Poacea
**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 crosses readily with maize and the hybrids are fertile with normal meiosis. Used as fodder.

***Tripsacum dactyloides (2n=36,72)* Gama grass :**

A perennial grass which is used as fodder. Distributed in tropical and subtropical North America.

**ORIGIN AND PUTATIVE PARENT**

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.
2) Another theory is that maize originated from a wild pod corn
3) Another theory is that teosinte, tripsacum and maize, all descended from a common ancestor by divergent evolution but the ancestor would have been lost.

**Classification**:

Maize which is a cross pollinated 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 transluscent, horny appearance when immature and wrinkled at maturity. Baby corn is obtained from the sweet corn. Green cobs on 40th 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. *everrata*- 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 type. The kernel is enclosed by husk. It is mainly grown for breeding experiments.

**XENIA**

Xenia effect occurs in maize kernal, 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 *Opaque - 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 per cent of the total protein present.

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

**UTILIZATION OF MAIZE**

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. Industrial uses:

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 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** : Angeosperms
**Class** : Monocotyledon
**Series** : Glumacea
**Sub class** : Glumiflorae
**Family** : Poaceae
**Sub family** : Poaideae
**Tribe** : Andropoganae
**Sub tribe** : Sorgastrum

## ORIGIN

**Place of origin** : Africa 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 16$^{th}$ century there were number of classification for the genus sorghum. The famous among them is **Snowden's** classification (1936) later refined by Garber (1950) and Dogget (1970).

## SORGHUM

Section I

**Sorghum** (True Sorghum)

Section II

**Para sorghum** (other sorghum)

*S.versicolor*
*S.introns*
*S.nitidum*
*S.plumosum*

Section I

**Sorghum** (True Sorghum)

Sub section

**Arundinaceae** (2n = 20)

Sub section
**Halepensia** (2n = 20)

*S.halepense*
*S.miliaceum*
*S.almum*
*S.propinquum*
*S.radolphianum*

Series Series

***Spontanea***(grass) ***Sativa*** (grain)
*S.sudanense* *S.vulgare*
*S.aethiopicum* *S.subglabaesence* *S.virgatum* *S.dochna*
*S.verticicifolium*
*S.stapfii*

The latest classification was done by **Harlan** and **de Wet** (1972).

***1. Bicolor* (B):** Grain elongate,glumes clasping the grain which may be completely covered or ¼ exposed.
***2. Guinea* (G):** Grains flattened dorso-ventrally.
***3. Caudatum* (C):** Grains asymetrical, glumes 1/2 the length of the grain.
***4. Kaffir* (K):** Grains symmetrical ( spherical), glumes clasping in varying length.
***5. Durra* (D):** Grains rounded obovate, wedge shaped at the base and broadest slightly above the middle; glumes very wide.

According to them, the cultivated sorghum *Sorghum bicolor* is divided in to five basic races based on the coverage of glume the grain (Fig 1).

**HYBRID RACES :**

This consists of all combinations of the basic races.

| | | | | | |
|---|---|---|---|---|---|
| 1. | Guinea bicolor | (GB) | 6. | Guinea kaffir | (GK) |
| 2. | Caudatum bicolor | (CB) | 7. | Guinea durra | (GD) |
| 3. | Kaffir bicolor | (KB) | 8. | Kaffir caudatum | (KC) |
| 4. | Durra bicolor | (DB) | 9. | Kaffir durra | (KD) |
| 5. | Guinea 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. Processes 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% |
| Carbohy drate | 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 increases 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.

**USES**:

Flour of sorghum is used for making porridge, biscuits or unleavened bread. Pop 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, are 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.

**BOTANY**

***Habitat*** : Tropical and subtropical
***Habit*** : Annual herbaceous, erect, single stalked or with tillers.

**ROOTS** :

Fibrous root system. The first seminal root lasts till the end of crop growth period. At lower nodes of stem stilt roots a appearing as a circle. The seminal root which develops from the radicle with its lateral roots may persist throughout the life of the plant. Along with the main seminal root, the roots arising from the mesocoty1 region of the germinating seed, also called seminal roots, behave like the main seminal root. But the main adventitious fibrous roots developing from the lower nodes of the stem below ground level are the effective and active roots of the plant.

**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 shrot at the base and longer above. At basal nodes stilt roots will be seen. Colour of stem may be green or with purple wash.

**LEAVES :**

Simple, alternate, glabrous, long, lanceolate, leaf blade is ribbon like with an acute apex, midrib prominent; ligule is short, membraneous and fringed, present at the junction of leaf sheath and the leaf blade. Below the leaf surface waxy coating will be there which prevents evaporation of water. Boot leaf will not open completely till the panicle come out.

**INFLORESCENCE :**

Usually compact panicle or semi compact or loose (lax) panicle. Infloresence compactness varies from species to species and also within the species.

The classification of infloresence based on compactness and shape, is given (Fig.2)

1. Very lax panicle - typical of wild sorghum
2. Very loose erect primary branches
3. Very loose drooping primary branches
4. Loose erect primary branches
5. Loose drooping primary branches
6. Semi- loose erect primary branches
7. Semi-loose drooping primary branches
8. Semi-compact elliptic
9. Compact elliptic
10. Compact oval
11. Half broom corn
12. Broom corn

Terminal peduncle erect or recurved to give on the lateral branches of the panicle. The joints of the rachis bears paired spikelets. One is sessile while the other spikelet is pedicellate. Sessile spikelet is bisexual or hermaphrodite, pedicelled one is male or sterile. Sessile fertile spikelet is comparatively larger than staminate spikelet.

**FERTILE (PERFECT) (OR) SESSILE SPIKELET :**

It has two glumes of approximately equal length ($G_1$ and $G_2$) having two flowers inside; lower one is sterile with empty lemma ($L_1$) and no palea ($P_1$ absent); upper floret is perfect, bisexual consists of membraneous lemma ($L_2$) two cleft at apex and with long or short arm, a small thin delicate palea ($P_2$). 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 enclose two florets. The lower floret is represented by the lemma ($L_1$) only and the upper floret is staminate with short awned lemma ($L_2$); palea ($P_2$) absent; two lodicules; three stamens; pistil absent (Fig.3).

**Fruit :**

The sorghum grain is a caryopsis with the pericarp fused with the integuments of the seed coat inside. The pericarp consists of the epidermis, hypodermis and a very small tissue of the mesocarp and ube cells. The integuments found below the epicarp are generally two and brownish in colour. The mesocarp is rarely coloured. The colour of the grain is evidenced in the epidermis, hypodermis and the tube cells (Fig.4).

The grain of sorghum has about two-thirds of its volume made up of the endosperm and about one- third by the embryo. The embryo consists of the scutellum carrying the plumule and radicle enclosed by the coleoptile and coleorhiza respectively.

The epidermis of the pericarp consists of elongated or rectangular thick walled cells with varying degrees of cuticular thickening. Below the epidermis is the hypodermis. The hypodermis is generally single layered and the cells are usually small and much thickened so that the lumen of the cell becomes very small. The mesocarp has numerous thin walled small cells. However, five to six-layered types with ten to fourteen layers of cells are also found. Following the mesocarp there is a layer of tube cells which are thick walled, cylindrical and in transverse section appear as rings though they are narrow and long. Very often this layer is fused with the inner integuments. Though the tube cells are generally one-layered, two to three layers may also be found in some types, sometimes coloured brown. These are developed as the inner layer of the pericarp.

Though the integuments are two in the ovule and the young grain, as the grain matures, the testa is the only prominent layer beneath the pericarp. Its thickness varies in the different varieties. The outer and radial walls of the cells of the testa are thin whereas the inner walls are thickened. The aleurone layer is a single layer with cells which are small and regular in shape. The aleurone grains are globular and smaller than the endosperm starch grains. Following the aleurone layer there are cells of the endosperm which contain plenty of starch grains. Starch grains are polygonal with a distinct hilum and radiating fissures. Very often the outer layers of the endosperm are horny while the inner region is soft and mealy.

# **PEARL MILLET** (BAJRA)

***Pennisetum glaucum* (2n: 14)**

**Family: Poaceae**

**Introduction**

Bajra is the staple food in the drier parts of tropical Africa particularly in West Africa and India. In India it is the fourth most important cereal after rice, sorghum and wheat. Bajra can be grown on poor sandy soil in low rainfall areas; unfortunately it is very susceptible to bird damage. It is also called bulrush millet, spiked millet, cattail millet, pearl millet and bajra in India.

**Habitat:** Grown as a rain fed crop in semi-arid re.g.ion, but also as an irrigated crop in India. High temperatures are required during maturity periods.

**Habit:** Tall erect annual herbaceous grass, 0.5 to 4.0 m tall with moderate tillering.

**Roots:** Primarily seminal root replaced by adventitious root produced from lowest node of stem; prop roots from nodes just above ground.

**Stem:** Solid, slender or stout; sparsely tillering ability; nodes with ring of silky hairs.

**Leaves:** Alternate, sheathed; long leaf sheath, open at top; clasping below, lamina lanceolate, glabrous or variously hairy; mid rib prominent preventing blade from dropping; tip acute; ligulate; ligule short, densely ciliate.

**Inflorescence:** Contracted panicle or false spike, terminally produced, resembling a bulrush, greenish yellow, cylindrical throughout its length or tapering at ends; central rachis bearing densely packed clusters of spikelets usually borne in pairs but 1-4 or more per cluster may occur, subtended by 25-90 bristles collectively called involucre of bristles.

**Spikelets:** Each spikelet contains two florets with a short membranous outer glume and a longer inner glume. Lower floret staminate with only lemma and three stamens; palea and lodicules absent, occasionally sterile or almost suppressed; upper floret with lemma, palea, three stamens with long filaments and bilobed, dorsifixed versatile anthers and ovary with two styles jointed at base.

**Fruit:** Caryopsis; well exerted from lemma and palea from which it easily separate; variable in shape, size and colour, embryo elliptic, about half length of grain; hilum marked by a black dot.

**Pollination:** Pearl millet is protogyny and hence cross-pollination normally occurs. However there is some overlapping of the female and male phases in the same inflorescence or in different inflorescence on the same plant leading to some amount of self-pollination.

**Origin of Pearl millet**

**Center of origin:** West Tropical Africa

The west tropical Africa is the home of Pearl millet, where the greatest number of wild and cultivated forms occur (Chevalier, 1934).

**Putative parent**

***P. glaucum*** and its wild species from which it originated is not known with certainty.

**Wild relatives**

Pearl millet are derived from two sources, one being the tall widely spread *P. purpureum* and the other the xerophytic group of smaller species of the section *Penicillaria* to which *P. glaucum* belongs. *P. purpureum* is a tetraploid (Stapf and Hubbard, 1934). Other species include *P. spicatum* (India) *P. nigritarum* and *P. cinereum*.

**Uses of pearl millet**

1. It can be cooked in the same way as rice
2. It may be ground into flour and made into a thin or thick porridge in the same way as finger millet.
3. The flour may be made into cakes or unleavened bread.
4. Parched grains is eaten in India
5. Used to produce malt and in Africa the malted grain is an important source of beer.
6. The grain may be fed to poultry and other livestock.
7. The green plant provides a useful fodder. The straw which is inferior to that of most other cereals, may be fed to livestock, but it is coarse and pithy
8. The straw is used for bedding, thatching, fencing and fuel.

**Description of Pearl millet grain**

The seed is the fruit called caryopsis. Usually exerts from lemma and palea, from which the seeds can be easily separated; small variable in shape, size and colour, usually obovoid or elliptic, about 4 mm long, white, yellow, grey or light blue; embryo elliptic, about half length of grain; hilum marked by a black dot.

Chemical composition:

| | |
|---|---|
| Water | 12.4% |
| Carbohydrate | 67% |
| Protein | 11% |
| Fat | 5% |
| Fibre | 1.2% |
| Ash | 2.7%. |

Pearl millet is high in tryptophane and cystine and low in lysine and methionine.

# FINGER MILLET (RAGI)

***Eleusine corocana* (2n: 36)**

**Family: Poaceae**

**Introduction**

Ragi is important staple food in parts of East and Central Africa and India, particularly in Karnataka. It is the principal cereal grain in northern parts of Western Uganda and N.E. Zambia. Ragi is also known as African millet or Finger millet.

**Habitat:** Grown mainly in the tropics; requires a well distributed rainfall during the growing season with an absence of prolonged drought; being a short day plant, the time to maturity is influenced by temperature as well as photoperiod.

**Habit:** Robust, free tillering tufted annual grass; 40-100 cm tall.

**Roots:** Seminal roots replaced by branched, shallow, fibrous adventitious root system from base of main stem and tillers.

**Stem:** Lower nodes of stem usually semi-procumbent, upper part erect, stout, compressed and smooth.

**Leaves:** Distichous, sheath flattened, overlapping, split along entire length, glabrous, ligule thin fringed; lamina linear; often folded with strong midrib, glabrous, tip acute.

**Inflorescence:** Terminal, digitate, usually 4-6 dense sessile spikes (digits); straight or incurved; compact or spreading; additional 1-2 short spikes carried 2-4 cm below terminal whorl.

**Spikelets:** About 60-80 spikelet per spike, densely crowned, arranged alternately on rachis in two overlapping rows along outer sides of spike; each spikelet with 6-12 florets arranged in two parallel rows on a zigzag rachilla with two basal glumes.

**Florets:** Hermaphrodite, but terminal floret may be sterile or staminate; lemma boat shaped with one strong median nerve forming keel; palea about three quarters of the length of lemma; lodicules two; stamens three; ovary with plumose stigma.

**Fruit:** Utricle, globose, smooth; colour varying from red, reddish brown, dark brown to nearly black; pericarp remain distinct during development and at maturity appears as a papery structure surrounding the seed.

**Pollination:** Pollen is shed during the emergence of the stigmas and anthers, hence normally self-pollinated. However one per cent cross pollination by wind takes place.

**Origin and Wild relatives**

**Centre of origin:** Uganda

The two closely related species of Eleusine are *E. indica* and *E. africana*,. *Eleusine indica* is a diploid having 2n: 18, while *E. africana* is an allopolyploid 2n: 36, derived from a cross in which *E. indica* is one of its parents *E. coracana* was selected from large grain mutants of *E. africana* in North Eastern tropical Africa. According to Mehra, 1963, it is believed that the cultivated *E. coracana* was derived from *E. africana* because of its ploidy level (2n: 36) and close resemblance to the African high landforms.

**Classification of cultivated ragi**

The cultivars of *E. coracana* differ from the wild species *E. indica* and *E. africana* in having larger seeds and the spikelets do not shatter at maturity. Mehra (1963) recognizes two groups of *E. coracana* as noted below.

**1. African high land types:**

Bearing resemblance to *E. africana*, with long spikelets, long glumes, and long lemmas with grain enclosed within the florets.

**2. Afro-Asiatic types**

With close resemblance to *E. indica*, short spikelets, short glume, short lemmas, and the mature grains exposed out of the florets.

**Uses of Ragi**

1. Finger millet is an important staple food in parts of East and Central Africa and India particularly in Karnataka.
2. It is used for malting and brewing
3. The grain is ground into a flour and malt into a stiff mush or porridge by adding to boiling water and stirring during heating until it attains the right consistency.
4. Malted grain dried, roasted and ground
5. Finger millet can be stored for long periods of up to ten years or more without deterioration or weevil damage.
6. The straw can be used as fodder and the fields are often grazed after the ears have been harvested.

**Chemical composition**

| | |
|---|---|
| Water | 13 % |
| Carbohydrate | 72% |
| Protein | 8% |
| Fat | 1.3% |
| Fibre | 3% |
| Ash | 2.7% |

The prolamine of Ragi Eleusinin has high biological value with a good content of cystine, tyrosine, tryptophane and methionine, which are important in the prevention of Kwashiorkor, but low in lysine. The grain is a rich source of calcium phosphorus and iron,

.

# MINOR MILLETS

# FOX TAIL MILLET (THENAI)

***Setaria italica* (2n:18)**

**Family: Poaceae**

**Introduction**

Foxtail millet is the most important millet in India especially in Tamil Nadu, Karnataka and parts of Maharastra. It is next in importance to Sorghum and finger millet.

**BOTANY**

Annual grass; seminal roots three followed by numerous thin adventitious roots, culms erect, slender, internodes hollow, tillering; leaf sheath longer than internodes, ligulate; leaf blade linear; tip acuminate; mid rib prominent. Inflorescence spike like panicle, carrying 6-12 two flowered sub sessile spikelets each subtended by 1-3 bristles; stamens three; ovary with two long styles ending in plumose stigma; fruit caryopsis tightly enclosed by lemma and palea.

**Center of origin:** East Asia

**Wild relatives**

*Setaria italica* was probably derived from *S. viridis* a common weed in the old world. It seems that *S. italica* and *Panicum miliaceum* were among the first crops to be domesticated in central eastern Asia. They were widely spread throughout Asia and Eastern Europe in pre historic times.

**Uses**

1. It is used as human food in Asia, Europe, North Africa and Japan.
2. Foxtail millet may be cooked and eaten like rice either entire or broken
3. It may be ground and made into porridge and puddings.
4. In Russia it is weed for brewing bear.
5. It is a well known bird seed for feeding to case birds
6. It is an important fodder crop and is grown in United States for hay and silage.

# BARN YARD MILLET (KUDURAIVALI)

***Echinochola frumentosa* (2n: 36 and 54)**

**Family: Poaceae**

**Introduction**

It is also called Japanese Barnyard millet and Sanwa Millet. This is the quickest growing of all millets and will produce a crop in about six weeks. It is grown in the Orient and India.

**BOTANY**

A robust tufted annual grass; seminal roots followed by adventitious roots; stem smooth, glabrous, producing tillers; internodes hollow; leaf blade linear, lanceolate; tip acute; margin finely toothed. Inflorescence a panicle; spikelet two flowered, awnless, pedicellate, subtended by bristles, two glumes; lower floret sterile with lemma and palea; upper floret hermaphrodite, five nerved lemma and five nerved palea, two lodicules, three stamens, two distinct style with plumose stigma. Fruit a caryopsis enclosed in white shining hardened lemma and palea.

**Center of origin:** E.Asia

Barnyard millet originated either from *E. colona* or *E. crusgalli* and possesses characters intermediate between the two.

**Uses of Barnyard millet**

1. In China and Japan it may be grown as a substitute for rice when the paddy fails.
2. It is grown as forage crops in the united states and can produce as many as eight crop per year
3. It is cooked in water like rice or parched and boiled with milk and sugar by the poor classes
4. It is sometimes mixed with rice and fermented to make beer
5. The grain is used for feeding cage birds.

# PROSO MILLET (COMMON MILLET/PANIVARAGU)

***Panicum milliaceum* (2n: 36 & 72)**

**Family: Poaceae**

## Introduction

Common millet is usually grown as a rain fed crop. It might be useful in the drier regions of Africa to give a quick maturing crop for the hunger gap, before the main crops of other cereals are harvested. Also known as Proso millet, Hog millet, Brown corn millet and Russian millet.

## BOTANY

A shallow rooted erect annual grass, free tillering, internodes hollow, cylindrical; leaf lamina linear lanceolate. Inflorescence a slender panicle; spikelet with two florets with two glumes; lower floret sterile; upper floret fertile with lemma, palea, two lodicules, three stamens and two styles with plumose stigmas; fruit a caryopsis enclosed by persistent lemma and palea.

**Center of origin:** Central Asia

This millet is not known in a wild state. *P. spontanum* which occurs as weed in Central Asia is probably a derivative of *P. miliacum* rather than its progenitor.

## Uses of Proso millet

1. The husked grain has slightly nutty flavour, is eaten whole and may be boiled and cooled like rice.
2. It is ground into flour for making mush, porridge or chapatti
3. Mixed with wheat flour for making bread
4. The green plant may be used as fodder, but the straw is poor.

# LITTLE MILLET (SAMAI)

***Panicum sumatranse (P. miliare)* (2n: 36)**

**Family: Poaceae**

**Introduction**

This minor millet in grown throughout India to a limited extent.

An annual tufted grass with slender culms, soft leaves, inflorescence a panicle with erect hairy branches; spikelets in pairs with two glumes; floret with two lemmas, two lodicules, three stamens and ovary with plumose stigma; fruit a caryopsis.

**Centre of origin:** W. Africa

**Wild relatives:** *P. psilopodium*

**Uses of Little millet**

1. Husked grain may be cooked in the same way as rice
2. It can be made into flour
3. The soft straw is palatable to cattle and the green plant has potentialities as a quick growing fodder.

# KODO MILLET (VARAGU)

***Paspalum scrobiculatum* (2n: 40)**

**Family: Poaceae**

## Introduction

Kodo millet is a minor crop throughout India. It is hardy and drought resistant and often grown on poor gravelly soils requiring little attention.

## BOTANY

An annual tufted grass; leaves in two ranks, stiff, erect. Inflorescence a panicle; 2-8 spikelets in flattened rachis; spikelets usually in two rows; each spikelet has two florets; lower floret sterile, upper bisexual with lemma, palea, two lodicules, three stamens and plumose stigma; grain enclosed in hard horny persistent husk which is difficult to remove.

**Center of origin:** India

**Wild relatives:** Wild form is *P. scrobiculatum* var. commersonii compared to the cultivated *P. scrobiculatum* var. scrobiculatum.

## Uses of Kodo millet

1. Usually eaten by the very poor

Light red grains are said to be sweet tasting and dark grey grains to be bitter. Some forms have been reported to be poisonous to men and animals.

# PULSES
# RED GRAM (PIGEON PEA)
***Cajanus cajan* (2n: 22)**
**Family: Fabaceae**

**Introduction**

Red gram or pigeon pea ranks highest amongst the pulse crops of India, consumed by large population of the country. *Cajanus cajan* is certainly one of the oldest cultivated plants in the world. Ancient traders on the route between Zanzibar, India and Sri Lanka introduced the plant into India. In India it is mainly grown in U.P, M.P, Bihar, Maharastra, A.P and Tamil.Nadu.

**Habitat:** Widely adaptable with re.g.ard 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 or perennial shrub grown as annual.

**Roots:** Pronounced deep tap root with long laterals.

**Stem:** Cylindrical, angled and hairy.

**Leaves:** Phyllotaxy spiral; trifoliate; petiole grooved, long; stipules small, ovate hairy; stiples small; pulvinus at the base of the petiole and at base of leaflets. Leaflets lanceolate to narrow elliptic, acute at both ends, entire, hairy on both surface, long stalked; terminal leaflet larger than short stalked laterals.

**Inflorescence:** Terminal or axillary raceme.

**Flowers:** Bisexual, irregular, zygomorphic, pentamerous, yellow in colour.

**Calyx:** Gamosepalous, four lobed, two lobes being united.

**Corolla:** Papilionaceous; standard petal auricled, yellow or dorsal side red or purple or yellow with red or purple veins; wings and keel yellow of equal length; keel incurved at apex.

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

**Gynoecium:** Monocarpellary, superior; 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, flattened 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; grayish, red brown, purplish or speckled; hilum white.

**Pollination:** Pigeon pea is an often cross-pollinated crop. The filaments of the stamens elongate in the bud and pollen in shed over the stigma on the day before the flowers open. Hence self-pollination is the rule, however bees visit the flowers and other insects and about 20 per cent cross-pollination occur.

**Origin of Red gram**

**Centre of origin:** Africa

It is probably a native of Africa. Where it is sometimes found wild or naturalized seeds have been found in Egyptian tombs of the XII Dynasty (2000 B.C.). It appears that they were taken to India in prehistoric times and this region now constitutes a center of diversity with the greatest number of pigeon pea cultivars are now widely spread throughout the tropics and subtropics.

**Types of cultivated forms**

Two botanical varieties have been recognized.

| *C. cajan* var. *flavus* | *C. cajan* var. *bicolor* |
|---|---|
| Early maturing | Late maturing perennials |
| Shorter plants | Large bushy plants |
| Standard petal yellow | Yellow with dorsal side of standard red or purple or streaked |
| Green glabrous pods and light coloured when ripe | Hairy pods blotched with maroon or darkly coloured |
| Usually 3 seeded | 4-5 seeded |
| Tur cultivars of India | Arhar cultivars of India |

**Uses of red gram**

1. The young green seeds are eaten as a vegetable
2. In India, these are split and made into dhal, which may be prepared either by a dry or wet method.
3. The dried husks, seeds and broken dhal are used as cattle feed in India.
4. The green pods are sometimes used as a vegetable
5. The tops of the plants with fruits provide excellent fodder and are also made into hay and silage.
6. Used as green manures and cover crops
7. Used as temporary shade in young cocoa and other crops.
8. Used as windbreaks and for anti erosion work.
9. Dried stalks are used for firewood, thatching and baskets in India

**Dhal preparation**

**Dry method**

Dry seeds are placed in the sun for 3-4 days and are split in a mill and dehusking process is repeated 3-4 times by separating the unsplit seeds, treated with oil, dried in the sum and milled again when a further grain is split and dehusked. The grain and dhal Outturn is 66 per cent and fetch better price.

**Wet method**

The seeds are first soaked in water for 6-10 hours. They are mixed with sieved red earth (@ 2.5 kg per 45 kg of seeds), heaped up and left overnight. The seeds are spread out and dried in the sun, sieved and winnowed to remove the earth, and finally split into dhal in a hand mill. Out turn is 80 per cent but fetches lower price.

**Chemical composition**

Dry ripe pigeon pea contains

| | |
|---|---|
| Water | 10% |
| Carbohydrate | 57% |
| Protein | 19% |
| Fat | 1.5% |
| Fibre | 8% |
| Ash | 3.8% |

Split dhal contains

| | |
|---|---|
| Water | 15% |
| Carbohydrate | 57% |
| Protein | 22% |
| Fat | 1.7% |
| Fibre | 8% |
| Ash | 3.6% |

# BLACK GRAM (URD)

***Vigna mungo* (2n: 22 & 24)**

**Family: Fabaceae**

**Introduction**

Black gram is one of the most highly prized pulses of India, more particularly in the ve.g.etarian diet. It is of very ancient cultivation in India. It is grown both as a summer and winter crop. It is often grown in rotation with rice and sometimes in mixed cultivation. Black gram is greatly cultivated in India for local consumption, where large acreage is grown, being particularly important in Karnataka.

**Habitat:** Drought resistant; grown in areas with a rainfall of not more than 35 inches per year; suited to clay soils and is often grown on black cotton soils in India.

**Habit:** Erect or sub erect, diffusely branched herbaceous annual.

**Roots:** Tap root and branched

**Stem:** Grows up to 1.5 m height; provided with reddish brown hairs.

**Leaves:** Trifoliate, petiolate, stipules ovate; stiples falcate (sickle shaped); leaflets ovate to lanceolate, entire.

**Inflorescence:** Axillary raceme; 2-3 branched.

**Flowers:** Five to six clustered at top of short peduncle; bracteoles longer than calyx.

**Calyx:** Gamosepalous; lobes linear.

**Corolla:** Pale yellow; standard wide, keel spirally coiled with horn like appendage.

**Androecium:** Diadelphous (9+1), filaments alternately long and short.

**Gynoecium:** Ovary superior, ovules few in marginal placentation; style spirally twisted; stigma oblique and introrse.

**Fruit:** Pod; erect or sub erect; buff to dark, brown; when mature, rounded, very hairy; 6-10 seeded with short hooked beak.

**Seed:** Oblong with square ends; 4 mm long; mostly black; testa smooth without ridges, hilum white, concave.

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

**Origin of Black gram**

*Vigna mungo* is of very ancient cultivation in India and is not known in a wild state. It probably originated from *P. trinervius* or *P. sublobatus*, which occur wild in India. It has been introduced in recent times elsewhere in the tropics, mainly by Indian immigrants and in some countries as a green manure.

**Cultivated types**

| | |
|---|---|
| Early cultivars | - large black seeded |
| **Lack cultivars** | - small olive green seeds usually grown as green manures in West Indies. |

**Economic importance**

1. It is boiled and eaten whole or after splitting into dhal
2. Parched and ground into flour which is made into balls with spices eaten as porridge or baked into bread and biscuits.
3. The green pods are eaten as vegetables
4. Used as green manure and cover crop and as a short lived forage
5. Hulls and straw are used as cattle feed.

**Chemical composition:**

Dried pulse contains

| | |
|---|---|
| Water | 9.7 % |
| Protein | 23 % |
| Fat | 1 % |
| Carbohydrate | 57 % |
| Fiber | 3.8 % |
| Ash | 4.8 % |

# GREEN GRAM (MUNG)

***Vigna radiata* (2n: 22)**

**Family: Fabaceae**

**Introduction**

Green gram is an important crop in India, where it is esteemed as the most wholesome among the pulses, free from the heaviness and tendency to flatulence that is associated with other pulses. Large area is grown in India for local consumption usually as a dry land crop following rice. Also called Golden gram, Mung bean

**Habitat:** Dry land crop; grown on good loam; requires well-distributed rainfall, drought resistant; susceptible to water logging.

**Habit:** Erect or sub erect herbaceous annual.

**Roots:** Deep tap root

**Stem:** Hairy; much branched; 0.5 to 1.3 m tall.

**Leaves:** Alternate, trifoliate, dark or medium green; petiolate stipulate; leaflet ovate.

**Inflorescence:** Axillary raceme; 10-12 flowers clustered at top.

**Flowers:** Zygomorphic, pentamerous, complete, bisexual, bracts ovate, as long as calyx.

**Calyx:** Gamosepalous, five lobed.

**Corolla:** Yellow, papilionaceous.

**Androecium:** Stamens diadelphous (9+1)

**Gynoecium:** Ovary superior; ovules few; stigma oblique and introrse.

**Fruit:** Pod; grey or brownish when mature; long and slender with short hairs.

**Seeds:** Small, globular; usually green, hilum round, white testa with fine wavy ridges.

**Pollination:** Self-pollination; pollen shed in the previous day evening and flowers open in the next morning.

**Origin of Green gram**

The crop is of ancient cultivation in India and the plant is not found in a wild state. It is supposed to have originated from *P. frinervius*, *P. sublobatus* a common origin of black gram and green gram.

**Cultivated types**

The cultivation can be divided into two main types depending on the colour of seeds.

**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, more commonly planted for the production of pulses.

**Uses of Green gram**

1. It is the pulses free from the heaviness and tendency to flatulence which is associated with other pulses
2. The dried bean are boiled and are eaten whole or after splitting into dhal
3. They are parched and ground into flour after removal of the testa and the flour being used in various Indian and Chinese dishes.
4. The green pods are eaten as a vegetable
5. In USA and China green gram is used as bean sprout.
6. The haulms are used as fodder and the husks of the split beans are a useful livestock feed.
7. The crop is grown for hay, green manure and as a cover crop.

**Chemical composition of green gram**

Dry seeds contain

| | |
|---|---|
| Water | 9.7% |
| Protein | 23.6% |
| Fat | 1.2% |
| Carbohydrate | 58% |
| Fibre | 3.3% |
| Ash | 4% |

Differentiation between Black gram and Green gram

| Black gram | Green gram |
|---|---|
| Reddish brown hairs on the stem and leaves | sparsely hairy on stem and leaves |
| Leaves mostly yellowish green | Leaves mostly green or dark green |
| Petals pale yellow | Yellow |
| Pod erect or sub erect buff to dark brown. When mature rounded very hairy. | Pod grey or brownish when mature long and slender with short hairs. |
| Seed oblong with square end. Mostly black testa smooth without ridges | Seeds small, globular, usually green. Testa with wavy ridge |
| Hilum white and concave | Hilum round white |
| Cotyledon white | Cotyledons yellow |

# COWPEA

***Vigna unguiculata* (2n: 22 & 24)**

**Family: Fabaceae**

**Introduction**

Cowpea is grown for the dry seeds and also for their long immature pods. These are less important than some of the indigenous pulses such as red gram, black gram, and green gram. It is also known as black eye pea, black eye bean, marble pea etc. The pods are variously known as Yard long bean, Asparagus bean, Bodi bean or Snake bean.

**Habitat:** Grown under wide range of conditions; sensitive to cold and frost; tolerate heat and relatively dry conditions with less rainfall.

**Habit:** Spreading, sub erect or erect annual herb.

**Roots:** Taproot, stout with numerous spreading laterals; nodules large globular, about the size of small peas.

**Stem:** Erect or sub erect or procumbent.

**Leaves:** Trifoliate, petiolate, petiole long, stout, grooved, stiples inconspicuous, leaflets ovate, rhomboid, usually entire but sometimes slightly lobed; apex acute; lateral leaflet oblique.

**Inflorescence:** Axillary raceme; few flowers crowed near tip in alternate pairs on thickened nodes; peduncle stout; grooved often exceeding the length of leaf; cushion like nectarines between each pairs of flowers.

**Flowers:** Pedicellate, zygomorphic, hypogynous.

**Calyx:** Gamosepalous; companulate with triangular teeth of which the upper two are usually connate and longer than the rest.

**Corolla:** Dirty white, yellow or violet; standard petal 2-3 cm in diameter; keel truncate.

**Androecium:** Stamens diadelphous (9+1); anthers uniform

**Gynoecium:** Ovary sessile; with many ovules; style bent; stigma bearded and oblique.

**Fruit:** Pod, 7.5 to 12 cm long; erect or ascending (*V. unguiculata*); very long (*V. sesquipedalis*; yard long bean) pendent; more or less inflated and flabby when young.

**Seed:** Long, globular or kidney shaped; smooth or wrinkled; white green, buff, red, brown or black and variously speckled; hilum white surrounded by a dark ring.

**Pollination:** Self-pollination is the rule. Pollen shed before flower opening (cleistogamy); nectarines at base of the flower attract ants, flies and bees, but a heavy

insect is required to depress the wings and expose the stamens and stigma. Only small extent of cross-pollination occurs.

**Origin of Cowpea**

**Centre of origin:** Tropical Africa

Cowpea spread from Tropical Africa through Egypt or Arabia to Asia and the Mediterranean in very remote days.

**Related species**

Three distinct sub species have been recognized.

1. *Vigna unguiculata* sub sp. *cylindrica*: This catjung cowpea is the most primitive among the cultivars cultivated in Africa and Asia.
2. *Vigna unguiculata* sub sp. u*ngiculata*: The common cowpea, more highly specialized in Africa
3. *Vigna unguiculata* sub sp. *sesquipedalis*: Asparagus pea or yard long bean, mostly grown for its immature pods, most widely cultivated in the Far East.

**Cultivated types**

Brittingham (1946) classified cultivated types as follows.

1. Asparagus bean group: yard long bean or long white- Trinidad and Hong Kong.
   Divided into
   a) Green podded forms 1½ - 3 ft long
   b) White podded forms up to 1½ ft length.

2. Catjang group - Puerto Rico
3. Cowpea group:Sub divided into
   a) Crowder – cultivars with seeds crowded brown or brown eyed in colour. Puerto Rica
   b) Black eye: Seeds not crowded in the pods and are white with a black eye pattern round the hilum – California and Puerto Rico.
   c) Cream cultivars: seeds not crowded in the pods and cream in colour.
   d) Intermediate between Crowder and Black eye: Seeds spaced intermediate between Crowder and Black eye. Mature pods deep purple and seeds with a buff or maroon eye.
   e) Forage cultivars: useful for forage.

**Uses of cowpea**

1. The dried seeds are an important pulse crop in the tropics and subtropics
2. The dried pulse may be ground into meal which is used in a number of ways
3. The fresh seeds and immature pods and eaten and they may be frozen or canned and exported
4. The young shoots and leaves are eat as spinach and pod herbs
5. Cowpea is often dried and stored for dry season use.
6. Fodder plant for hay, silage or pasture,
7. The seeds are sometimes used as a coffee substitute

8. Used as green manure and cover crop.

**Chemical composition**

| | |
|---|---|
| Water | 11% |
| Protein | 23.4% |
| Fat | 1.3% |
| Carbohydrate | 57% |
| Fibre | 4% |
| Ash | 3.6% |

# SOYBEAN

***Glycine max* (2n: 40)**

**Family: Fabaceae**

**Introduction**

Soybean is an oilseed as well as a pulse crop. It is the most important source of ve.g.etable oil. The production of high proteineceous meal as a livestock-feed is gaining in importance at the expense of oil. The US has been the largest producer of soybeans. The second largest producer is China followed by Indonesia, Japan, Korea, Nigeria, and Tanzania. In India it is a recent crop and gaining momentum as an oil seed crop.

**Habitat:** Grown in areas where the summer is hot and rather damp; withstand excessive heat or severe winters; grown on a wide range of soils.

**Habit:** Erect, bushy pubescent annual with grey hairs on all parts of the plants; some are prostate and twining, a tendency which increases with shade; determinate cultivars develop terminal inflorescence; indeterminate cultivars shows axillary inflorescence.

**Roots:** Taproot, nodules small spherical sometimes lobed.

**Stem:** Branched; buds in axils of cotyledons. The primary leaves do not normally develop unless tip damaged.

**Leaves:** Alternate, trifoliate, rarely five foliage; petiole long narrow, cylindrical; stipules, small lanceolate, stipels minute; leaflets ovate to lanceolate, usually palea green in colour, base rounded; apex acute or obtuse; lateral leaflets often slightly oblique; most cultivars drop leaves when pods begin to mature.

**Inflorescence:** Short clustered axillary raceme; terminal if determine type.

**Flowers:** Small, bracteoles two, ovate, acute.

**Calyx:** Hairy, persistent, united for half-length with two upper and three lower lobes.

**Corolla:** White or lilac; standard ovate, emarginated (notched at the extremity); wings narrow, obovate; keel shorter that wings, not fused along upper surface.

**Androecium:** Stamens monadelphous; vexillary stamens free at the base; anthers uniform, globose.

**Gynoecium:** Hairy sessile, few ovuled, style curved, glabrous, stigma capitate.

**Fruit:** Pod; borne is cluster on short stalks; pale yellow, grey or black; slightly curved.

**Seed:** Globose; testa straw yellow; green, brown or black or blotched and mottled in combination of these colours, hilum small; cotyledon yellow or green.

**Pollination:** Self-pollination is the rule. Flowers open in the early morning and pollen is shed just before or at the time of opening and is shed directly onto the stigma. Bees and other insects visit flowers so that cross-pollination can take place, but is usually less than one per cent.

**Origin of Soybean**

**Centre of origin: China (Manchuria)**

Soybean is found wild throughout Eastern Asia.

**Wild relatives**

The cultivated *G. max* is derived from *G. ussuriensis* of eastern Asia and possibly in hybridization with *G. tomentosa* found in S. China.

**Cultivated types**

| | |
|---|---|
| 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. |

**Uses of soybean**

1. Most important source of oil and protein
2. Unripe seeds are eaten as vegetable
3. Dried seeds are eaten whole, split or sprouted
4. Soya milk – a processes product from soy seed, is a valuable protein supplement in infant feeding.
5. Soya curd and cheese and also made
6. Soya sauce made from mature fermented bean forms a favorite sauces of E. Asia
7. In Indonesia boiled beans are fermented by *Aspergillus* and made into cakes (Tempe)
8. The seed yield edible, semi drying oil used in food preparation.
9. Soybean oil is used industrially in the manufacture of paints. Linoleum, oilcloth, printing inks, soap, insecticides, disinfections etc.
10. Lecithin, phospholipids obtained as a by products of the oil industry is used as a wetting and stabilizing agent in food, cosmetic, pharmaceutical, leather, paint, plastic, soap and detergent industries.

11. Soya meal: The residue after the extraction of this is very rich in protein, a feeding stuff for livestock.
12. Soya flour is used in bakery and other food product as additives and extenders to cereal flour and meat products in health foods etc.
13. Important pasture and fodder crop.  Made into hay and silage.
14. Used as a green manure and cover crop.

# BENGAL GRAM (CHICK PEA)

***Cicer arietinum* (2n: 16)**

**Family: Fabaceae**

**Introduction**

Bengal gram is the most important pulse of India. In India it is grown as a winter crop and it must have cold or cool night with dew for successful cultivation. It cannot tolerate heavy rains and so unsuited to the wet hot tropics where it often fails to flower. In India, it is grown in northern Indian in the upper Ganges basin and the central provinces.

**Habitat:** Drought resistant; requires a cool dry climate and light well aerated soil; grown as a winter crop in India and must have cold or cool night with dew for successful cultivation.

**Habit:** Erect or spreading much branched annual herb; all parts covered with clavate glandular hairs.

**Roots:** Taproot with lateral roots and numerous large nodules; more extensive in late maturing cultivars.

**Stem:** Cylindrical; erect or spreading branches with grayish hairs.

**Leaves:** Imparipinnate, yellowish green to dark; bluish green; stipules ovate, notched; leaflets ovate, elliptic or obovate serrate margin; 9-17 leaflets; mid rib terminating with a leaflet.

**Inflorescence:** Axillary solitary raceme borne or peduncle; white green, pink or blue.

**Flowers:** Bisexual, zygomorphic.

**Calyx:** Gamosepalous, five lobed.

**Corolla:** Standard broad and clawed; wings free; keel incurved.
**Fruit:** Pod; swollen and oblong; contain only one or two seeds.
**Seeds:** Angular, beak, pointed; hilum small; testa smooth, wrinkled or rough; colour white, yellow, red, brown to nearly black.
**Pollination:** Anthers grouped above stigma before flower opens; usually self-pollinated; flowers are visited by bees and occasional natural cross-pollination occurs.

**Origin:** Tropical Asia

*C. arietinum* is not known in wild states. It appears to have originated in Western Asia and to have spread at a very early date for India and Europe. Related species are *C. chorossanicum, C. montbrelli, C. bijugum, C. anatolicum, C. cuneatum, C. pinnatifidum*.

**Cultivated types**

There are two broad groups

| | |
|---|---|
| Brown or Desi | White or kabuli |
| Most widely grown | Sparsely grown |
| Dark reddish brown or even black | White seeded |
| Not bold | Bold seeded |
| Gives comparatively higher yield | Gives comparatively poor yield. |

**Uses of Bengal gram**

1. The whole seeds are eaten cooked or boiled
2. Dhal is prepared by splitting the seeds in a mill and separating the husk. Outturn 80%
3. Flour (basin) is made by grinding the seeds and is one of the chief ingredients with ghee and sugar for many forms of Indian confectionery.
4. Green pods and tender shoots are used as vegetable
5. The dry stems and leaves after threshing, the husks and broken pieces from the dhal making are fed to livestock.
6. An acrid liquid from the glandular hairs is collected by spreading a cloth over the crop at night, which absorbs the exudation with the dew. It contains about 94 per cent malic acid and 6 per cent oxalic acid that are used medicinally and as vinegar.

**Chemical composition**

Dried seeds give

| | |
|---|---|
| Water | 9.8% |
| Protein | 17% |
| Fat | 5.3% |
| Fiber | 3.9% |
| Ash | 2.7% |

**LAB LAB** *Lab lab purpureus* (2n=22, 24)

*Lab lab purpureus* var. *typicus:* Garden bean
'Pandal avarai'

*Lab lab purpueus* var. *lignosus* : Field bean
"Mochai".

Origin : India

***Lablab purpureus* var. *typicus:* Garden bean 'Pandal avarai'**

- Perennial. Twining herb. Cultivated as an annual.
- pods long, tapering.
- long axis of seeds parallel to suture.
- With out oilglands and 'Mochai' smell.
- Entire pod is edible as vegetable.

***Lablab purpueus* var. *lignosus*: Field bean "Mochai".**

- Semi erect bushy, perennial annual.
- pods shorter, oblong and fibrous
- seeds, 4 to 6 round.
- vertical to the suture
- 'mochai' odour.
- Ripe seeds of lignosus
- Protein 24.9 per cent

**Avarai and Mochai**

| | **Avarai** | **Mochai** |
|---|---|---|
| Habit | Perennial Twining herb requires support | Semi erect bushy perennial, cultivated as annual |
| Plant part | No 'Mochai' odour | 'Mochai' odour present |
| Pod | Immatured pod as vegetable. Matured green seeds As vegetable | Immature seeds alone as vegetable pericarp tough, dried seed as pulse. |
| Seed arrangement | Parallel to length of suture | Vertical to length of suture |
| Photosensitivity | Photosensitive | Photosensitive |

# OILSEEDS

In some plant species the metabolic activity leads to the production of reserve food substances in the form of oils or fals. Oil is in liquid form under ordinary temperature and fat is in solid state in ordinary temperature. The oils are synthesized 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 of 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 quiet 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* | Linacea |
| 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* | Pedaliaceae |
| 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. The react with oxygen very slowly or not at all. They are characterized 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 | *Arhis 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* | Sterculiaceae |
| Palm oil & palm Kernel oil | *Elaeis guineensis* | Arecaceae |

**Oilseeds are also classified as**

1. Major oilseeds – 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 oilseeds:**

- Source of energy
- Medicinal value
- Industrial oil – soap making cosmetics, lubricants.
- Oilcake 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<br>Castor<br>Coconut<br>Oilpalm | Groundnut<br>Sunflower<br>Safflower | Olive,<br>Oil Palm | Cereals | Sandal wood<br>Eucalyptus<br>Pepper Mint<br>Lemon grass |

**Extraction of oil:**

**i. Mechanical extraction:**

Normally by mechanical pressure of either heated or unheated seed. Pressure is applied gradually and the extracted oil is refined to improve the quality by removing impurities such as water, dirt and vegetable matter. The residue remaining after the extraction process has been completed is known as the seed cake, which is rich in protein. Many seed cakes are used as feed to cattle and some as nitrogenous fertilizer.

ii. Solvent extraction:

This process involves a solvent to leach out the oil. By this method even the last traces of oil from press cake or plant tissues can be extracted. Soybean oil is extracted using this method and oil are freed from solvents by fractional distillation. This process is expensive but extraction is perfect.

## Groundnut – Arachis hypogaea (2n = 40)
## (Peanut/ Monkeynut/ Nila Kadalai/ Moongphallee)

Groundnut is extensively cultivated in tropical and sub-tropical regions all over the world. All the species of Arachis are geocarpic ripening their fruits underground. Groundnut was introduced in India by Portuguese travelers through Kerala. Later in Tamil nadu, spread by East India company.

**Systematic position:**

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

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.

**Classification:**

(Classification based on habit) Agronomically there are three types.

| | |
|---|---|
| Spreading | - Virginia runner |
| Semi spreading | - Virginia bunch |
| Bunch | - Spanish Bunch. Valencia |

**Botanical classification:**

Gregory and Gregory (1973) has divided the genus Archia into 7 sections.

1. Arachis
2. Erectoides
3. Rhizomatasae
4. Extranervosae
5. Ambinervosae
6. Triseminale
7. Cauliorhizae

The cultivated groundnut comes under section Arachis. This section includes two series (Annuae and Perennes) and 12 species which includes both diploid and tetraploid 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 |

**Putative parent:**

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

**Seeds:**

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

**Pod development**

After fertilization thalamus develops into peg or gynophore (to be more specific – Carpophore). The gynophore is positively geotrophic and after reaching certain depth the carpels develop into pod attaining a horizontal position.

**Uses:**

- The nuts are eaten raw of after roasting. For this purpose bunch types with extra large kernels are preferred since they contain relatively low oil content than Virginia type.
- Kernel rich source of phosphorus and vitamin – 26 per cent protein 45 to 50 per cent oil.
- Oil as a cooking media.
- Hydrogenated oil – for preparation of vanaspathi / vegetable ghee.
- Manufacture of margarine – butter like substance.
- Peanut butter.
- Oil cake as cattle feed
- Moist oil cake for production of aflotoxin from Aspergilus flavus.
- Oil – Non drying
  Pharmaceutical industry
  Soap industry
  Lubrication
- New textile fibre Ardil – manufacture from peanut protein.

**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, Afric, China, Burma, Sudan
In India : U.P., Rajasthan, M.P., A.P., Tamil Nadu, Maharastra, Gujarat.

**Classification**

Morinaga et. Al., (1929) classified the species of Sesamum based on the chromosome number into three groups.

**Related wild species:**

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.malbaricum, 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.

**Seeds:**

Seed colour various from pure white, various shades of brown and grey to black. Seed coat may be rough or smooth.

**Uses:**

- Seed mixed with jaggery and eaten – Chikki
- Good source of cooking oil – (85% unsaturated fatty acid).
- 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.

**Castor – *Ricinus communis* L (2n = 20)**
**(Amanakku/ Kottamuthu/ Arend)**

Castor is a plant which grows wild in tropical and sub-tropical 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 | : | Dicotyledon |
| Sub-class | : | Monochlamydeae |
| Series | : | Unisexuals |
| Family | : | Euphorbiaceae |

| | | |
|---|---|---|
| Place of Origin | : | Ethiopia |
| Distribution | : | India, China, Eqypt, 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 | - | Crimson castor |
| *R.communis* subsp. africanus | - | African castor |
| *R.communis* subsp. mexicansu | - | Mexican castor |
| *R.communis* subsp. gibsoni | - | Red castor |
| *R.communis* subsp. cambogenisis | - | Red castor |

**Distinguishing 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 pressure 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 neutralized.

**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 negligible amount of oleic acid.

**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 manufacture.
- Oil cake as fertilizer.
- Stem as fuel, making paper board.

**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 : Inferae
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* : Jerusalam Artichoke (hexaploid, 2n = 104) – Cultivated for its tubers.

**Wild species:**

*H. hirsutus, H. rigidus, H.Petriolaris*.

**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%).

**Seeds:**

Seeds are nonendospermic major source of semi-drying oil. Seeds are also consumed raw, roasted or salted.

**Chemical composition:**

| Moisture | Protein | Fatty oil | Fibre |
|---|---|---|---|
| 3.5% | 13% | 25% | 27% |

**Uses:**

Oil as cooking media (90% poly unsaturated fatty acid (PUFA) and 10% Saturated Fatty acid. It has non cholesterol and anti cholesterol properties. Used in cooking and for salads. Used in paints, varnishes, soap, cosmetics. Oil cake as cattle feed. From dried stalk paper is made. Sunflower also produce excellent honey and wax.

## SAFFLOWER – *Carthamum tinctorius* 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 Midle 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
Sib-division : Angiosperms
Class : Dicotyledon
Sub-class : Gamopetalae
Series : Inferae
Family : Asterales
Order : Asteraceae
Place of origin : Africa

**Seed:**

The fruit is an achene and is usually refered to as the seed. 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 linolenic acid.

**Uses:**

- Cooking media (Saffola)
- Good drying oil
- Corolla used in dyeing industry
- Oil cake – stock feed
- Preparation of paints and varnishes.

## NIGER – *Guizotia abyssinica* (L.f.) Cass. (2n = 30)
## (Peyyellu/ Vilis/ Ram-til)

Niger is cultivated in India, where the oil is used for cooking and illumination purposes. The seeds contain 35 to 45 per cent of light yellow drying oil with high linoleic acid content having little taste or smell.

**Systematic position**

Division : Phanerogams
Sub-division : Angiosperms
Class : Dicotyledon
Sub-class : Gamopetalae
Series : Inferae
Order : Asterales
Family : Asteracea
Place of origin : Abyssinia.
India is the chief producer of Niger oil.

**Uses:**

Edible oil – Oil with pleasant smell. Poor quality oil – for making soaps, lubricants and for illumination. Oil cake – cattle feed.

## RAPE SEED AND MUSTARD
## *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 tones 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 : Thalmiflorae
Order : Parietals
Family : brassicaceae

**Cultivated brassicas can be broadly divided into two distinct types.**

1. Vegetable type – cabbage (*B. oleracea* var. capitata). Cauliflower (B.o. var. botrytis). Turnip (*B. oleracea* var. rapa)
2. Oilseed type – Rape seed and mustard

**Key characters:**

**Leaves two types:**

i. Stem leaf bigger, lance shaped, serrate and

ii. Flower leaf small, smooth margin.

Androecium : Tetradynamous stamen,

Fruit : Siliqua.

**Rape seed**

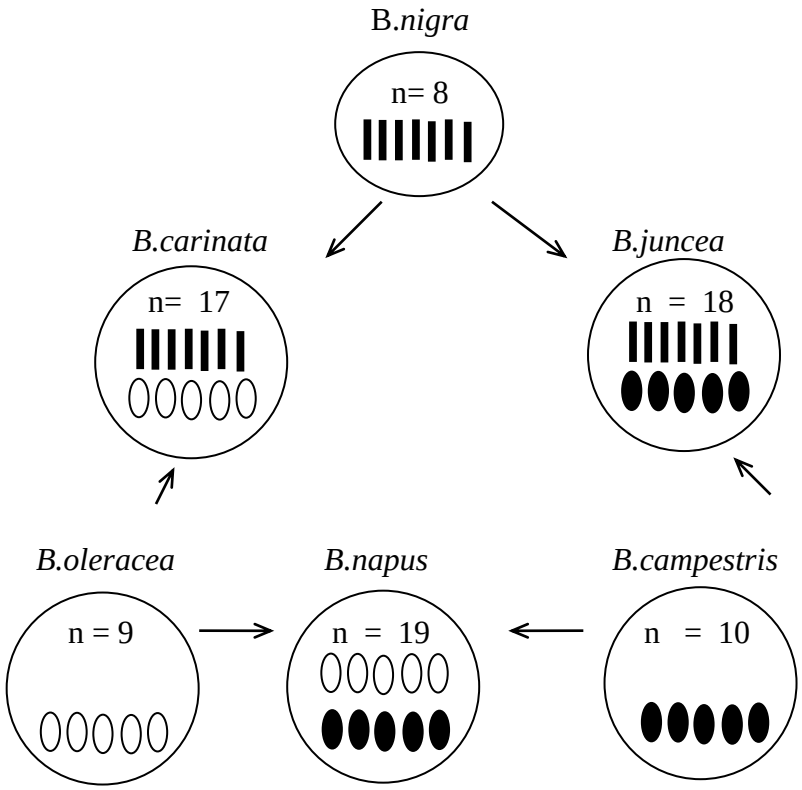
1. B. campestris: (2n = 20)
   Indian Rape seed. Self sterile in nature. Important oilseed crop of North Indi. There are three cultivated types.
   B.campestris var. brown sarson – (Brown sarson)
   B.campestris var. yellow sarson – (Yellow sarson)
   B.campestris var. toria - (Toria)

2. B. napus : (2n = 38)
   Europen rape seed. Self fertile grown in Europe for green fodder as wel as oilseed.

**Mustard:**

1. ***B.nigra*: (2n = 16)**
   Black or true mustard or Banarsi rai. Native of Eurasia. Countair 28 per cent fixed oil used as medioine. Oil is pungent due to presence of glucoside sinlgin mostly used as condiment.
2. ***B.alba*: (2n = 24)**
   White mustard or Ujli sarson. Young seedlings used as salad. Seeds are yellowish in colour. Contains 30 percent oil. Native of Medierrannean region.
3. ***B.juncea*: (2n = 36)**
   Indian mustard 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.

The oil producing species of Brassica are all cross fertilized. The genetical relationship of oilseed Brassicas is illustrated below.




This triangle is known as the triangle of U, after Nagaharu u (1935).

**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 of total fatty acids); oleic 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 mist contain les erucic acid and for industrial purpose high erucic acid content is preferred.

**Uses:**

- Seed as condiment
- Oil as cooking oil
- Oil-illuminant, 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 plant used as green or leafy vegetable.

# JATROPHA – From the periphery to the centre

## Jatropha cucus

Jatropha is a wild growing plant native to tropical America. It has become naturalized in semi ardi Asia and Africa. It is quick growing, non browsed by animals and has a remarkable adaptability to a variety of climate and soils. In India it is believed to have been introduced by Portugase navigators in the 16$^{th}$ century. Seeds of Jatropha contain 30% oil by weight of air dried seed and once the production of biodiesel start it will fetch a good income.

Jatropha oil can be used as bio-diesel after transesterification. Among all tree borne oil seed cocas oil has the closest physiochemical traits of diesel. Jatropha removes carbon from atmosphere and stores in its woody trees and assists in carbon sequestration. For India, conversion of 175 million hectares of our waste land and baren agricultural lands into green oil fields of jatropha could indeed prove a boon because of its multiple uses in industry, agricultural and commerce.

## Conversion of vegetable oil into bio-diesel

Traditionally, raw vegetable oil produced from jatropha and several other crops ahs been used as such with out any modification as fuel in rural areas for lighting purpose. It was also used for running tractors. For use of jatropha oil as biodiesel by mixing it with petroleum diesel, raw jatropha oil cannot be used.

The impediment in using vegetable oil as fuel is their high viscosity, low volatilities and / or cold flow properties compared to diesel. So the raw oil has to be converted into biodiesel. In France which is a leading producer of biodiesel commercial diesel contains upto 5% of biodiesel where as in USA blends upto 20% are sued. Biodiesel i.e. Methyl esters of vegetable oil are prepared by transesterification also called alcoholysis, is the displacement of alcohol from an ester by another alcohol.

## To the field

Coimbatore district takes a lead in the mass cultivation and production of Jatropha based bio-diesel. The District Rural Development Agency (DRDA) plans to set up a bio-diesel plant at a cost of Rs.7.5 lakhs under SGRY scheme in Anaikatty 30 km away from Coimbatore town. The tribal self help group had already pioneered by planting about 7 lakhs saplings in 585 acres in areas like Thondamuthur, Periyanickenpalayam, Karaimadal and Jambukandi tribal village in Anaikatty. Various voluntary organizations are also helping governmental agencies in brightening up the poor tribal lives.

## Cultivation methods

The saplings are planted in pits of 1 foot length and breadth. 1200 saplings were planted per acre. The distance between the plants is about 6 feet. DRDA plans to plant

75 lakh seedings in 7,500 acres of waste land in Coimbatore district in the next two years. With in 18 months trees will bear flowers and fruits. It is estimated that 3 to 4 kg of seeds can be harvested from a tree annually. The expected cost of 1 kg seed is about 5 Rs. From 4 kgs of seed we can get 1 kg oil and 3 kg oil cake.

Farmers have to wait 1½ to 2 years for the yield. To get an income during this period the farmers are advised to go for intercropping such as pulses and vegetables like ash gourd, tomato and bitter gourd. Cuttings can provide yield from $6^{th}$ month on wards but non availability of cuttings for bulk planting is the constraint.

**Advantages**

1. Vegetable oil based diesel offer lesser damage to the environment as against fossil diesel.
2. Jatropha cultivation makes an ideal choice for the ecological reclamation of waste land in the tropical and sub tropical regions.
3. There are lot of employment opportunities for unskilled, semiskilled and qualified labourers.
4. The oil cakes can be use for biogas production.
5. Biofuels are also in great demand in industries like thin film coatings on metals, solvent cleaning of metals and printing ink for newspapers.

**Apprehensions**

1. Glycerine formed as a byproduct may cause a glut in the market but as glycerin has may need uses in cosmetics and toiletries this apprehension is ruled out.
2. The oil cakes are toxic and cannot be used as food for cattle. The toxic component is curcin.

**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 enters our daily life in a variety of ways.

The genus Gossypium consists of diploid and tetraploid cultivated cottons.

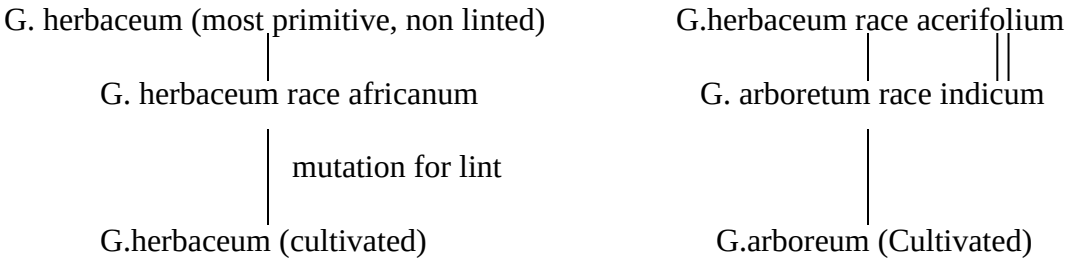
| **Diploid (2n = 26) Old World cotton (Desi cotton)** | | | |
|---|---|---|---|
| **Botanical name** | **Common name** | **Place of origin** | **Distribution** |
| *G.herbaceum* | Uppam cotton | Africa | India, China, Africa, |
| *G.arboreum* | Karunkanni cotton | Indochina | Burm, Malaysia |

| **Teraploid (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)



Origin of cultivated tetraploid cottons (2n = 52) – according in Philips

G.barbadense = Old world Linted cotton (A genome) x G.raimondii (D genome)

G.hirsutum = Old world Linted cotton (A genome) x G.thruberi (D genome)

Origin of G.barbadense

G.herbaceum x G.raimondii

A genome (2n = 26) | D genome (2n = 26)

F1

D genome-Sterile

(2n = 26) Natural doubling

AA DD genome

G.barbadense (2n = 52)

Tetraploid fertile cotton

Origin of G.barbadense

G. arboretum x G. thurberi

A genome (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 males sterility

**Cotton fibre:**

Fibre are epidermal prolongation of seed coat cells. Certain of the epidermal cells of seeds (epidermis of the outer integument of the ovule) bulge out the 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 unseperable.

In diploid cotton and upland cotton both lint 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 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.

Fertilization & attain full length (25 days) + Thickening and maturity (25 days) = 50 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 fire:**

Five different parts are seen in matured fibre.

i) The integument or outer layer also called cuticle or waxy layer.
ii) Outer cellulose layer-original cell wall.
iii) Layer of secondary deposits-pure 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 sed. Short in nature not removable by ginning acid defuzzing is done to destroy pathogens before sowing.

**Ginning:**

The process 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 judgment.
- By combing the fibre with brass comb and measuring the combed fibre by celluloid disc scale (Halodisc / Halp – butterfly).
- Use of fibre sorting instruments like Ball sorter or Baer's sorter.
- Use of photoelectric instruments viz. Fibre 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.

**Uses:**

Cotton lint is a valuable textile fibre. Various plant parts are useful.

| | | |
|---|---|---|
| Lint | - | Textile, absorbent cotton, wiping, polishing material, clothing, house hold articles, industrial articles, twines, cellulose, plastic for making type cord 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. |

**Jute – Corchorus sp. (2n = 14)**
**(Chanal/ Singinjanascha/paat)**

The commercial fibre jute is obtained from two species viz., C.capsularis and C.olitorius. mainly grown in West Bengal, Bangladesh and Calcutta.

Place of Origin: C.capsularis – Indo Burma; C.olitorius – Africa.

The genus Corchorus includes 40 species. In India only 8 species occur. The two cultivated species are C.capsularis (White jute/ bitter jute) and C.olitorius (Tossa jute). Both the species are not crossable.

***C.capsularis:***

This species contains a bitter glycoside "Corchorin" which gives a bitter taste. The fibre is also inferior to C.olitorius.

***C.olitorius***

Yields more fibre per unit area (Fibre finet, soft, lustrous occupies 25 percent of jute area in India. The only disadvantage in this species is premature flowering if sown earlier (out of season). This premature flowering leads to branching which reduces the fibre quality.

**Fibre extraction procedure:**

**Harvesting:**

The ideal phase of harest is when the plants are in small pods.

**Bunding:**

Harvested plants are immediately made into bundles and are laid on the ground in long narrow lines or staked for the withering of leaves. After 2 to 4 days the leaves shed and the bundles are then taken for steeping in water.

**Steeping:**

Steeping is the process of immersing the bundles in water. After 2 to 4 days the tissues shrink and cell rupture. This facilitates the entry of micro organisms into the stems when steeped in water.

**Retting:**

Retting is a process by which the fibres in the bundle get loosened and separated from the woody stalk due to the removal of pectins, gums and other mucilagenous substances. This is usually effected by the combined action of water and micro organisms. Fibre yield is six percent of fresh stem weight.

**Fibre quality:**

Jute fibre is fine and silky, but is less strong than many other Indian fibre C.capsularis broke with a weight of 164 lb: whereas C.olitorius gave way with 125lb weight, expressing the fact that fibre of capsularis is superior than olitorius. The defect of jute fibre is the difficulty to spin the higher counts. 20 being the finest made commercially.

**Uses:**

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 carpels, curtains, shirtings and twine and ropes. Jute butts (shorts fibres) are used for making paper.

## Mesta – Hibiscus cannabinus (2n = 36)
## (Kenaf/ Deccan hemp/ Bimplipatam jute/ Java jute/ pulichai/ Kanchava/ Gogu/ Patsan/ Ambari)

This fibre crop is successfully grown in many countries throughout the tropics and subtropics as a commercial crop. The bast fibre obtained form 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 | : | Andra Predesh, Tamil Nadu, Karnataka. |

The fibre strands are 1.5 to 3.5 m long and are comparable to jute in luster. They are somewhat coarser but are tougher and stronger and resistant to rotting.

**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 toil which is sometimes extracted and used as a lubricant and for illumination for manufacture of soap, linoleum and in paints and varnishes.

## Sunn hemp – Crotalaria juncea L. (2n = 16)
## (Channapai/ Sunn / San)

Sunn hemp is a source of bast fibre grown in torpical countires. It is also grown as a fodder and green manure. India exports this fibre to Untie Kindom, Belgium and United States.

**In India :** Uttar Prdesh is the largest producer. Other major producing areas are Bihar, Andhra Pradesh Tamil Nadu and Madhya Pradesh.

**Place of Origin :** Asia

**Uses:**

Cordage fibre marine cordage manufacture of sail cloth, canvas, matting rope, soles of shoes and sandals, used for making cigarette papers tissue paper fishing net.

**Sisal – Agave sisalana Perrine (2n = 138)**
**(Kathazhai/ Kaith/ Kattalae / Sisal hemp)**

Native of tropical America, South America and Mexico. Hard structural fibres obtained from the large fleshy leave. The plant is made up of a short very thick stem which gives rise to a close rosette of leaves. T eh leaves are long, straight, thick, dark green pointed structure often with spiny margins and covered with waxy bloom, reaching a length of four feet or more and upto six inches wide.

| | | |
|---|---|---|
| Place of origin | : | MEXICO |
| Distribution | : | Mexico, Africa, Germany, India, China. |
| In India | : | Karnataka, Kerala, Orissa. |

**Harvesting:**

Harvesting is done after two and a half to three years after planting. The leaves are cut al the base by hand with a machete. At least 25 leaves should be left in the plant. Agave sisalana fibre is the chief source of structural fibre.

**Extraction:**

This involves beating, scrapping washing the product. Beating and scrapping involves removal the green pulp: beating is done by using a wodden mallet called “Raspadors” and scrapping by a knife and then washing. Now decordicaters are available.

Sisal fibre has a high percentage of cellulose (72 per cent) and high proportion of lignin (14.5 per cent).

**Uses:**

For carpet-backing, bags, industrial fabrics, matting, twines and ropes. Pulp for paper making. Sap from inflorescence may be fermented to produce alchoholic drinks.

**Kapok – Cieba pentandra (L.) Gaertn. (2n = 72)**
**(White silk-cotton tree / Elavam/ Poolamavu/ Buruga/ Biliboora/ Huttian)**

| | | |
|---|---|---|
| Place of Origin | : | America |
| Distribution | : | USA, Indonesia, Thailand, Cambodia, Africa, India. |
| In India | : | West Bengal, Tamil Nadu, Bihar, Assam and Uttra Predesh. |

**Extraction of fibre:**

Beating the pod, splitting it open, then seeds are removed by hand or by using a cross shaped stick the fibre is stirred and seeds will drop. Gin can also be used.

**Harvesting:**

The fruits are harvested when turns brown. The fruit are broken open with a mallet and the fibres and seeds are removed by hand. These are dried I cages covered wit net to prevent them from being blown away. Fibres are separated from seed by stirred with a cross shaped stick.

**Fibres:**

Kapok fibres are derived from the inner wall of the fruit of the kapok tree. The fibres are single celled white a bullous base. Individual fibres are 0.8 to 3 cm long. Thin walled with a wide air-filled lumen. Kapak fibres are very light. Only about one sixth the weight of cotton. These fibres cannot be spun into yarn due to their soft, short, untwisted and brittle nature.

**Uses:**

The fibre is ideally suited for filling mattresses, pillows, cushions and other upholsterly articles. The fibre has degree of buoyancy (about 4 times that of cork), the fibres are used in making life-belts, life jackets, life buoys and other naval life saving appliances. For transporting heavy vehicles across the water ways compressed fibre is used as rafts. It can transport about 36 times its own weight in water. It is a good sound absorbed and used as an insulating material in aeroplane cock pits, theatres and hospitals and also in ice boxes as it is a poor conductor.

Kapok seed oil (20-25 per cent) non drying oil used as lubricant, soap making. Cake as cattle feed. Fibre used in fire works manufacture.

**SUGARCANE**
**Saccharum Sp. (2n = 12, 16, 20)**

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, Punjan, 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 disease and pests.

2. S.barberi – Indian cane (2n = 82-124)
   Intermediate between noble cane and wild cane, internodes cylindrical.
   Small barreled, internodes spindle shaped.
   High fibre content.
   Resistant to disease.

3. S.sinense – Chinese cane (2n = 118)
   Hard, small barreled
   Mainly used as fodder.
   Resistant to disease
   Fair amount of sucrose.

4. S.spontaneum – Wild cane (2n = 40-128)
   Vigorous, thin, grassy forms.
   Virtually no sucrose.
   Resistant to drought, pest and disease.

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 sugarcane. All theses species intercross freely.

**Nobilisation of sugarcane:**

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

S.barberi x S.officianrum
Unproductive Productive
Comes up well but does not grow at
In N. India N. India

$F_1$ x S.spontaneum

I Nobilization — Grassy from, resistant to pest and Diseses.

$F_1$ x S. officinarum

II Nobilization

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 (L. 2 present)
Pedicellate spikelet blooms first. Culms green grayish green, or white

Lodicules cillate
long subterranean
runner present
Growing wild
S.spontaneum

lodicules noticiliate Runner short

Cultivated

Leaves broad long canes

Internodes spindle shaped
S.sinense

Leaves narrow short
Canes Ligular process prominent
Internodes Cylindrical S.barberi

AA. Main axis of inflorescence glabrous L.2 usually absent. Sessile spikelet opens first culms dark green, dark red, violet, dark yellow. Lodicules not ciliate. Cultivated: S.officinarum.

**Uses:**

1. **Sugar**

   Alcoholoic bevarages, soft drinks, confectionary, ice cream, Choclate, sweetening agent other industrial uses like drug industry and for preservation.

2. **By products:**

   There are five by products of sugar industry.

   i. Mollases:

      Mainly for preparation of chemicals, like vinergar, glycerol, lactic and citric acid, aconitic acid, power alchohol, chloroform, plastics, etc. also for iogas 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 calclum nitrogen and phosphorus.

   v. Trash:

      Treated with fungi and sued as organic manure.

**Manufacture of cane sugar:**

The following process are involved in the manufacture of cane sugar.

**i) 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.

**ii) Clarification of juice:**

the dark juice is opaque liquid containing about 15 per cent sucrose and small quantities of glucose, fructose, vegetable proteins, mineral slats, 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 followed by sulphurdioxide is passed through the defecated 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.

**iii) Concentration and crystallization:**

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

**iv) Refining and drying of crystals:**

The raw sugar is redisolved in hot water and the suspended impurities removed by filtration, concentration under reduced pressure and crystallization as usual.

The solution is decoloured by treating with carbon black. Then the clear liquid is centrifuged to get pure sugar crystals.

**Sugar beet – Beta vulgaris (2n = 18)**

| | |
|---|---|
| Family | : Chenopodiaceae |
| Place of origin | : Northern Europe |
| Distribution | : Russia, Europe, USA. |
| Putative parent | : Beta maritime – perennial in habit. |

**Classification:**

The genus beta includes 13 species which were grouped in the 4 sections. The cultivated sugar beet comes under section Vulgaris.

The cultivated Beta vulgaris includes sugar beet, vegetable beet root and forage beet root. All of them cross freely.

**Bolting in sugar beet:**

Sugar beet is biennial it develops a large succulent root in the first year and a seed stalk in the second year. Occasionally some plants produce a seed stalk in the first year itself which is known as bolting.

**Extraction of sugar:**

The sugar is stored in enlarged tap root. Sugar content 12 to 18 per cent. The roots are cut into small pieces, treated repeatedly with hot water and sugar is extracted by diffusion process. The extracted juice is treated with lime to coagulate some of the non sugars, and then with carbon dioxide which precipitaes calcium carbonate. The juice is filtered and the resulting clear liquid is concentrated, crystallized and centrifuged. The beet sugar is identical in composition and appearance to the usual sugar obtained from sugarcane.

**Uses:**

| | |
|---|---|
| Sugar | |
| Leaf | - Cattle feed |
| Filter cake | - manure |
| Molasses | - stock feed preparation of ethanol. |

**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 oozing but and is collected in containers. The yield of neera amounts to 3 or 4 qt. a day for several months. The sap possesses 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.

**Uses:**

Neera contains 14 per cent sucrose
Toddy - Fermented neera.
Palm jaggery - By boiling neera.
Leaf - For burshes and brooms
Leaf - Baskets, mat etc.
Timber - Rafters, pillar, posts, fuel.

# FORAGE CROPS

The term forages means the plants used for feeding domestic animals. This includes both fodder plants and pasture plants.

**Fodders:**

Plants which are cultivated as forage crops and they are cut and fed to animals in the stalls. E.g. Guinea grass, Fodder maize, Lucerne.

**Pastures:**

Grasses and legumes were grown in pasture lands where the animals are led to graze them. E.g. Cenchrus, marvel grass, spear grass, clitorie, cowpea.

Forages can be broadly classified in the two groups viz.

a) Annual Grasses – maize, sorghum, cumbu.
   Perennial Guinea grass B.N. hybrids

b) Annual Legumes – cowpea, cluster bean, Desmodium
   Perennial – Lucerne, Siratro, Desmanthus

## GRASSES
## NAPIER GRASS
## Pennisetum purpureum (Elephant grass)

Perennial grass, protein, 6-8%, good for hay making comes up well in sewage water.

## CUMBU NAPIER HYBRID

(Bajra x Napier) – BN hybrids

(Napier x Bajra) – NB hybrids
Pannisetum glaucum x P. purpureum
2n = 14 2n = 28

2n = 21
Sterile but vigorous

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, poultry feed.

## Guinea Grass
## Panicum maximum

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

**Uses:**

Highly palatable grass, with high dry matter content (15-20%), free from all toxic principles. Protein 6-8% with well balanced calcium and phosphorus. Good soil binder. Harvest can be done once in 30-40 days. Can be grazed, cut and fed, used for hay of silage making. Ideal for sewage farming.

## BUFFEL GRASS
## *Cenchrus setigerus*
## (2n: 32, 36, 40 and 54)

Family: Poaceae

Centre of Origin: Tropical Africa

A perennial grass grown in drier areas; palatable only when young, but persists well under grazing and can be plated by seeds. It is one of the available species in the drier areas for ley or permanent pasture and for legume mixtures.

## JOHNSON GRASS
## *Sorghum halapense* (2n = 40)

Family: Poaceae
Centre of origin: Mediterranean

A stout perennial tetraploid grass with extensive creeping rhizomes; widely distributed round the Mediterranean and extents eastwards to western Pakistan. It seems to have evolved from natural hybridization of a wild Arundinacea sorghum and a diploid rhizomatous Halepensia sorghum followed by the doubling of the chromosomes. It may contain dangerous amounts of HCN.

## LEGUME FODDER

### Lucerne (Alfalfa)
### Medicago sativa (2n: 16,32 and 64)

**Family:** Fabaceae
Centre of origin: Mediterranean

A most productive perennial legume, native of S.W. Asia. It has purple flowers, an erect growth habit with average crown width, and a distinctive taproot. Most cultivars of Lucerne are tetraploids with 32 chromosomes. Leaves are alternate and pinnately trifoliate. Flowers are in short clusters coloured from blue to violet. Fruit is a spirally twisted pod containing 1-8 small kidney shaped seeds. The plants contain five times as much protein as sorghum fodder and high vitamin A content.

## FODDER COWPEA

Highly palatable, nutritious, good for hay making, can be grown in dry lands mixed with sorghum cumbu or maize.

## DESMODIUM
### Desmodium tortuosum

Annual crop, can be harvested 2-3 times. Shade tolerant, green manure cum fodder crop. Produces profuse seeds. Protein 22%.

## DESMANTHUS
### Desmanthus virgatus
### Veli masal

Shrub, leaves used as fodder, protein 18-20%, can be grown as a border plant, since leaves shed soon after harvest it is to be fed immediately. Can be grown with guinea grass and BN hybrid as intercrop.

## MUYAL MASAL
### Stylosanthus scabr, S.bamata, S.guanensis.

Drought resistant, suitable for pastures to grow along with grasses. Comes up in acidic soils. Self sowing crop.

## CLITORIA
## Clitoria ternatea
## Sangu pushpam

Suited to dry land pastures, highly self sown crop grows well with cenchrus seeds and roots have medicinal value, protein 16-18%.

## SIRATRO
## Macroptilum atropurpurem

Drough resistant twiner. Legume component in pasture, grows well with kolukattai. Suitable in coconut garden, Protein 15%.

## TREE FODDER (Subabul, savundal)
## Leucaena leucocephala (or) L.glauca

3F tree – feed, fertilizer, fuel

Can be maintained as a bush and leaves can be clipped and used as forage. Leaves have high protein 29%. Has an amino acid mimosin excess feeding leads to falling or hairs, thyroid gland swelling and stunted growth. Drought resistant. Green pod can also be fed to animals.

## AGATHI
## Sesbania grandiflora

Family : Fabaceae
Centre of origin : Tropics

Widely cultivated in the tropics; small tree or shrub with rather stout branchlets; pubescent when young; flowers very large, few, pink, red or cream white; leaves contain 10 per cent moisture, 10.46 per cent ash, 42.30 per cent carbohydrates, 30.13 per cent crude protein, 5.10 per cent crude fibre and 2.01 per cent fat.

## GLYRICIDIA (Madare)
## Gliricidia sepium

Family : Fabaceae
Centre of origin : Tropical America

A quick growing deciduous tree of about 10 meter high with pinnate leaves. It has long arching leafy branches, which are deciduous in the dry season and then produce along the greater part of their length, a mass of purplish pink flowers on short racemes at each node. The rapid growth and leafy branches command this tree as a shade tree for

crops such as coffee and cocoa and young branches can be used as fodder and green manure. Propagation is by large cuttings of 2 to 2.5 m long and from seeds.

## KALYANA MURUNGAI (Coral tree)
## Erythrina indica (2n: 42 and 44)

Family : Fabaceae
Centre of origin: India

Planted in hedges and as a support for pepper; a striagling tree with flowers; bark yellowish, smooth, shining, papery, wood very soft and white, but fairely durable and used for making boxes; leaves pinnately trifoliate; flowers large and showy, scrlet to white.

## SUBABUL
## Leuecaena leucocephala

Family : Mimosoideae
Centre of origin : Tropical America

Small tree; leaves bipinnate, in 4 to 9 pairs on a rachis of 15-20 cm long; inflorescence capitate or globose, solitary axillary; flowers white; pods this and flat; seeds elliptic compressed, brown; has a very deep root system; persist well in drought but may defoliate; tolerance to flooding is very poor.

## ACACIA
## Acacid dealbata (Silver wattle)

Family : Mimosoideae

Centre of origin: Australia

A small evergreen tree with fine pinnate leaves distinguished by silvery white underside to the leaflets; excellent wind belts.

## Acacia albid (White wattle)

One of the largest to the Acacia trees; bark grey, fissured and scaly; remains leafless during the rains and assumes new foliage and flowers after the commencement of the dry season.

## Acacia decurens (Wattle)

Centre of origin : Australia

Bears profusely fragrant yellow flowers in the dry season. A quick growing unarmed tree, 15-20 m tall with rounded crown; dense surface feeding roots; all parts except flowers pubescent or puberulous; young shoots rigid, angled, with golden-yellow tomentum; leaves leathery, bipinnate; petiole decurrent; flowers minute, pale yellow, fragrant, in globose head; pods dark borwn when ripe with golden-brown or grey pubescent, constricted and contracted between seeds; seeds black, smooth, elliptic, compressed with copious caruncel.

## Acacia nilotica (Babul)

Centre of origin: Africa

A tree of 8m or more high; stems and branchlets usually dark coloured; spines straight, pinnae usually 3 to 12 pairs, leaflets 10 to 30 pairs, flowers yellow; pods grey thick soft tomentose, straight or slightly curved, giving a necklace appearance, fleshy when young, becoming black and hard at maturity.

# GREEN AND GREEN LEAF MANURES:

## DAINCHA
## Sesbania aculeate

Family : Fabaceae
Centre of origin : India

A soft wooded prickly shrub with long leave and very many small leaflets and pale yellow flowers; stem and leaf rachis prickly; standard without appendages; pod long linear, straight narrow, flattened; seeds transversely oblong, root nodules are produced; whole plant used as green manure.

## MANILA AGATHI
## Sesbania rostrata

Family : Fabaceae

A soft wooded herb; leaves pinnate, long narrow, leaflets, numerous; stem bears stem nodules a characteristics feature of this species; flowers yellow; whole plant used as green manure.

## KOLINGI
## Tephrosia purpurea

Family : Fabaceae
Centre of origin : India

An erect perennial undershurb with small red flowers said to give a blue dye resembling indigo; found along the rodsides and the whole plant used as green manure.

## NEEM
## Azadirachta indica

Family : Meliaceae

A profusely branching large deciduous tree; leaves alternate, imparipinnate; leaflets sub opposite, serrate; flowers hermaphrodite; fruits one seeded drupe; endocarp woody; seed ellipsoid; cotyledons thick and fleshy; bark, leaves, flowers, seeds and the oil of this tree are all in use for food, medicinal and insecticidal purposes.

## PUNGAM
*P.pinnata Pierre syn. P. glabra Vent*

A medium-sized glabrous tree. Bark grayish green or brown, smooth or covered with tubercles leaves imparipinnate; leaflets 5-7, ovate or elliptic; flowers lilac or white tinged with pink or violet, fragrant, in axillary racemes; pods compressed, woody, indehiscent, yellowish grey.

The tree is used for afforestation, especially in water sheds, in the drier parts of the country. Natural reproduction is through seed or by root suckers. The seeds are said to retain viability for a year.

The tree starts bearing at the age of 4-7 years. November-December to May-June. The pods are collected and the shells removed by hand. The yield of seed is said t range from 9 to 90 kg. per tree.

Seeds: The mature seed. The seeds contain a mucilage (13.5%), traces of an essential oil, and a complex amino acid named glabrin.

The seeds are mainly valued for the oil obtained from them which has many industrial and medicinal uses. Powdered seed is valued as a febrifuge and tonic and used also in bronchitis and whooping cough. The seed crusied to paste are used for leprous sores, skin disease and painful rheumatic joints.

**Pongam oil** – The seeds contain 27-39 per cent of a fatty oil which is used for leather dressing, soap making, lubrication, illumination, and for medicinal purposes.

# FUMITORIES AND MASTICATORIES

## TOBACCO : (Puhai ellai)
## Nicotiana sp. (2n = 18/20, 24, 32, 48)

Family : Solanaceae
Place of origin : South America
Distribution : USA, Africa, Asia, Europe, USSR, China, Japan, Indonesia, Turkey. Tamil Nadu, Karnataka, orissa, Andhra Pradesh, West Bengal, Uttar Pradesh, Maharastra, Bihar, Assam.

**Classification:**

There are two cultivated types of Tobacco.

N.tabacum (2n = 48)

Nearly 90% of worlds acreage is covered by this species. Used in cigarette, cigar or cheroot. Low in nicotine content (4 to 6%).

N. rustica (2n = 48)

Used in Hookah, chewing and snuff. More nicotine content (12%)

**Origin of N. TABACUM**

N. sylvestris x N.otophora
|
$F_1$ sterile
|
| Doubling
N.tabaccum

**Origin of N.RUSTICA**

N. undulata x N. paniculata
|
$F_1$ sterile
|
| Doubling
N.rustica

**Topping and desuckering:**

When the flower buds begin to appear, the inflorescence and top most leaves are plucked and removed. Soon after topping suckers will appear in side shoots. These are also removed. Chemicals like maleic hydrazide is used for descukering.

**Curing of tobacco:**

It is oxidation or dry fermentation process by which water from leaves are removed. The green colour is lost and the leaves undergo chemical changes. There are different methods of curing of tobacco. By curing leaves become pliable so that it can be easily transported.

**Different types of curing:**

**Flue curing:**

Done in brick barns where temperature and humidity are controlled. Here the barns are having a series of metal pipes (Flues). Through the metal pipes heat is supplied from a furnace kept out side the barn. Humidity provided by sprinkling water. Curing in done in 4 to 6 days, the process starts with low temperature and high humidity and ends with high temp and low humidity. Leaves have elasticity, mildly aromatic used for cigarette, pipe tobacco, chewing.

**Air curing:**

Slow process carried in barns. Good circulation of air is maintained. Takes 6 to 8 weeks used for cigarettes, pipe, cigars.

**Sun curing:**

Drying frames are used. Leaves are hung. Cured in direct sun light. Period 1 to 11/2 months. Hookah, and beedi.

**Fire curing:**

Oldest method. Fire is provided in the barn during day time only, jaggery solution is sprinkled on leaves. During night leaves are softned. Period 3 to 4 weeks used in Cheroot making chewing, snuff.

**Commercial classification:**

1. Cigarette of flue cured tobacco:
   Otherwise known as Virginia tobacco. N. tabacum widely spaced leaves.

2. Beedi tobacco. N.tabacum, N. rustrica:
   Thick in texture, strong in flavour. Green to yellowish brown in colour.

3. Cigar and Cheroot types:
   Mostly grown in Tamil Nadu and west Bengal.
   Leaf will be dark brown in colour. Thin in texture.

4. Hookan type:
   Both N.tabcum andN. Rustica. Medium in texture higher in nicotine content.

5. Chewing and snuff types:
   Thick in texture has pungent smell.

6. Wrapper type:
   Mainly grown in West Bengal. Used for wrapping cheroot, and cigar, Thin texture.

**Nicotine Content**

| | | |
|---|---|---|
| Cigarette | - | 1.2 to 3% |
| Cigar | - | 0.5 to 1.5% |
| Cheroot | - | 5.5% |
| Beedi | - | 2.5 to 5.5% |
| Hookah | - | 3 to 7% |
| Chewing | - | 2.5 to 5.5% |

**Uses of Tobacco**

Smoking, chewing, snuff, alkaloid nicotine from stem, leaf midrib as contact insecticide tobacco seeds contain oil substitute for groundnut oil, medicine sedative, vermifuge, treatment of gastro intestinal disordess.

**TAMIL NADU AGRICULTURAL UNIVERSITY**
**Centre for Plant Breeding and Genetics**
**PBG 101 Fundamentals of Crop Botany (1 + 1)**
**Mid semester Examination**

**I B.Sc. (Ag.)** **Time: 1 hr.**
**I Semester** **Max. Marks: 20**

## PART - A

**Answer any TEN questions.** ***0.5 x 10 = 5***

1. The fruit of family poaceae is a _____
2. Green revolution in Rice started after the discovery of _____
3. The related genera of zea is _____
4. Protein found in endosperm of Maize is _____
5. Place of origin for sorghum is _____
6. Botanical name of Thenai is _____

**Say true or false**

7. The toxic substance found in legume is HCN.
8. Region of diversity for green gram is India.
9. Two races of Bengalgram are Desi & Kabuli.
10. An important – crop which is a source of oil and protein is Ragi
11. Poor man's pulse crop is Horsegram.
12. The cereal having high keeping quality is Maize.

## PART – B

**Answer any TEN questions.** ***0.5 x 10 = 5***

1. Differentiate Polyphyletic and Monopheletic origin
2. What is the quality difference between Hard wheat and soft wheat.
3. Define xenia. What is its impact on Maize.
4. Differentiate Bicolour and Guinea.
5. What are the main difference between Arhar and Tur.
6. Write the distinguishing features of Pandal avarai and Mochai.
7. Bring out the difference between Indian Ragi and African Ragi.
8. Maize is
   a) Monoecious b) dioecious c) Tree d) climber
9. Sorghum poising is due to
   a) HCL b) HCN c) $H_2So4$ d) None
10. Pearlmillet is
    a) Protogynous b) Protandrous c) Unisexual d) None
11. The Botanical name of Kuthiraivali is
    a) Hibiscus rosa sinensis b)Thespesia populnea
    c) Lycopersicon esculentum d) None
12. Presence of Penicillate anther is specific to the crop
    a) Rice B) Sorghum c) Pearlmillet d) Samai

## PART – C

**Answer any FOUR questions** ***2.5 x 4 = 10***

1. How will you make split Pulse.
2. From which plant natural vinegar is extracted and how?
3. List wild species of sorghum.
4. Enumerate the importance of Green revolution in wheat.
5. List the constituents of Bran in Rice and its importance.
6. Name two minor millets.
   Give their Botanical name.