

TAMIL NADU AGRICULTURAL UNIVERSITY



PBG 101: FUNDAMENTALS OF CROP BOTANY (1+1)

THEORY NOTES

Dr. S.E. NAINA MOHAMMED

**DEPARTMENT OF PLANT BREEDING AND GENETICS
ANBIL DHARMALINGAM
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
TIRUCHIRAPPALLI - 620 009**

CONTENTS

Lecture	Particulars	<u>Page no</u>
1	Introduction to field crops- Agricultural classification of field crops. Family description, economic parts, economic uses, value additions, in the following crops	1
2	Cereals :Rice	3
3	Cereals : Wheat and maize	5
4	Millets :Sorghum, Pearl millets	9
5	Finger millet, Small millet-Foxtail millet, and little millet.	12
6	Barn yard millet, Proso millet, and Kodo millet.	13
7	Pulses : Black gram, and Green Gram	14
8	Pulses: Soy bean, Cow pea, Bengal gram, Lab Lab and Dew gram	18
9	Mid Semester.	
10	Oilseeds: Groundnut, Gingelly	19
11	Oilseeds: Caster, Sunflower, Safflower	22
12	Oilseeds: Rape and Mustard, Niger and Jatropha	24
13	Fibers : cotton	26
14	Fibers : Jute, Sun hemp, Agave, and Silk cotton	29
15	Sugars : Sugar cane, Sugar palm, Sugar beet	31
16	Forage crops	33
17	Tree fodder.	36

FUNDAMENTALS OF CROP BOTANY

Introduction to field crops

Different workers classify crop plants under any one of the three groupings namely Taxonomical, Commercial and Agricultural classifications:

Taxonomical classification: The crop plants are dealt with under the natural order or family. The crop with different economic uses when brought under one family do not generally bring out the economic importance of the individual crops.

Commercial classification: The plant products, which is of commercial use is grouped under a) **food crops** b) **industrial crops** and c) **food adjuncts**. It is a broad based grouping. It is possible that a crop in one group may figure in other group.

Agricultural classification: This classification covers the salient features of the above two classification. According to the use of plants and plant products to man, the grouping is made as follows

1) Cereals: It is applicable to the fruits / grains obtained from the Poaceae family members. These form the principal sources of food for man and animals. They are Rice, Wheat, Maize, Sorghum, Ragi, Barely, Pearl millet, Oats, etc.

Grain: This term is also applied to the characteristic fruit caryopsis of Poaceae family.

Millet: It is generally used for a member of small-grained cereals, which are of main importance.

Pseudo cereals: Apart from Poaceae family many other plants, which produce small grains and are used as a source of food, are called pseudo cereals. E.g. Buckwheat

(*Fagopyrum esculentum* family chenopodiaceae) grain amaranthus (*Amaranthus* sp-family Amaranthaceae) Quinoa (*chenopodium quinoa* family Chenopodiaceae and *Zostera marina* family potamogetonaceae).

2.Pulses: Next to cereals, pulses form an important source of human food. The term pulse is generally used for the seeds of leguminaceae plants, which are used as food. Pulses supply protein. Though the seeds are generally used, the whole fruit or pod both mature and immature is utilized. Important pulse crops are Red gram (*cajanus cajan*) black gram (*Vigna mungo*) green gram (*Vigna radiata*), *Dolichos lablab* etc.

3.Vegetables fruits and nuts: They are dealt in horticulture, under Olericulture and Pomology respectively. These form a rich and valuable source of food.

4.Oil and oil seeds: Among the agricultural crops, oilseeds are important both for domestic and industrial purposes. Oils supply fat, which gives necessary energy for metabolism besides adding taste to food. The use of oil in medicines is well known. In industries, oil is used for preparation

of soaps, Cosmetics and lubrication. Castor oil and coconut oil are very important industrial oil, which figure in the export trade.

5.Sugars and starches: sugar cane is the main source for sugar and jaggery. The other sources of sugar are Palmyra, coconut and date. Starch foods are obtained from sweet potato, tapioca and sago palm. Starches are also an industrial product much needed in confectionary, textile, stationary and cosmetic industries.

6.Fibers: Cotton is the most important of the fiber crop. Linen obtained from the flax and linseed plant has been the source of fiber for clothing in temperate regions. Artificial fibers are also obtained from wood pulp. In the manufacture of gunny bags, Hessian cloth and packing material, fibers of Jute and Mesta are of importance. Twines, cordages and rope are made from fibers of Coconut, Mesta, Sunnhemp, Agaves etc. The uses of fibers in carpet, mats, brushes and for stuffing purposes are also well known.

7.Beverages: In general beverages are drinks, which form an essential part of human diet because of their liquid content. Coffee, Tea, and Coco are important beverages, which has stimulating effects. Fruit juices like lemonades, orangeades, apple juice, pineapple, and other bottles juices come under this.

8.Narcotics, fumitories and masticatories. Products from tobacco, ganja, opium and stramonium, which have a stimulating and drowsy effect in moderate doses, came under **narcotics**. When stimulating effect is produced on smoking its is termed as **fumitories** e.g. Tobacco and when chewed it called **masticatories**. E.g. areca nut, betel leaf, tobacco etc.

9.Spices and condiments: A variety of plant products are used as food adjuncts so as to add flavor, aroma and taste. Those which give aroma and flavor are called **spices** and those when give taste are **condiments**. They have some essential oils, which give taste and flavor E.g. pepper, cardamom, cloves, chillies, turmeric, ginger, onion,garlic etc.

10.Rubber: The main source of rubber is rubber tree *Hevea brasiliensis*. Other plants, which produce latex and rubber are *manihot glaziovii*, and *cryplostegia*. Rubber use in both domestic and industrial is fast growing. It plays a major role in national economy.

11.Forages: The term forages generally include both fodders and pastures. **Fodders** are harvested and fed to animals e.g. Guinea grass, Napier grass, Lucerne, Fodder cholam, Fodder maize. The grasses and legumes are grown in arable land and left for animals to graze are **pastures**. The straw of paddy, cholam and bhusa of pulse crop and groundnut form important forages.

12.Green manners and green leaf manures: The growing of special crops for adding organic matter and nitrogen to the soil and ploughing them *in situ* is called **green manure**. E.g. Dhaincha, Sunnhemp. Incorporating green lopping from shrubs and trees in fields form **green leaf manure**. eg. *Ipomea carnea*, *gliricidia* etc

Salient features of the Family:

Plants usually herbs, adventitious roots, **stem**. hallow and nodal; **Simple leaves** with sheathing bases, ligulate; **inflorescence** compound spike; **Flowers** zygomorphic, bisexual, rarely unisexual subtended by bracts (glumes). **Petals** 2, anterior minute lodicules; **stamens** 3 in a single whorl, **solitary carpel**, ovary unilocular, **stigmas** 2 feathery, **Fruit** caryopsis.

Habit: Mostly annual or perennial herbs. Rarely they are woody.

Root: Adventitious fibrous and stilt roots are also common.

Stem: Mostly hallow, sometimes solid (Maize and sugar cane) erect, branched or unbranched, prostrate or creeping. In case of perennial herbs the stem may be runner, which approaches up to considerable distance or a rootstock, which also serve for vegetative propagation.

Leaves: Simple, alternate, well-developed leaf sheaths present, sessile, ligulate, lamina ribbon shaped, leaf blade mostly hairy.

Inflorescence: It is of complex type. Compound of several spikelets, which aggregate in many ways on the main axis, called as **rachis**. Some are in compound spikes. Others are in racemes and still others are in panicles. Panicle may be loosely arranged or very much condensed. But usually the inflorescence is a spike of spikelets as in which each spikelets may consists of 1-5 flowers attached to a central stock called as **Rachilla**. At the base of each spikelet is a pair of glumes, the lower or outer one is the fertile glume and the upper or inner one is called as sterile glume. These glumes are sterile and do not bear any flowers in their axils. Above these glumes, florets are present. Each floret at its base is provided with a lemma and palea.

Flowers: sessile minute, bracteate usually bisexual but unisexual in maize. Zygomorphic and hypogynous.

Androecium usually 3 stamens, 6 in paddy and bamboo. Filaments long slender with versatile anthers.

Gynoecium Tricarpellary but only one carpel is functional, ovary superior unilocular with single basal ovule, style short, stigmas long and feathery.

Fruit mostly caryopsis, rarely a nut or berry. Seed endospermic with a straight embryo and with a single cotyledon called scutellum.

Floral formula P_0 or $(2 \text{ lodicules}) A_3$ or $3+3 G$

Grain structure. The ovule after fertilization develops into the seed with its coat completely fused together with the developing ovary wall or pericarp. The grain has the following structures.

The pericarp or fruit coat. It is made up of distinct layers of quadrangular cells, which form the pericarp followed by cells, which are much compressed. The endosperm is a single layer of tube cells.

Seed coat. Due to the pressure brought out by the developing seed on the pericarp, the testa and teguments become much compressed down and out of shape.

The aleurone layer. A prominent layer of rectangular cells, which contain protein, lies next to seed coat. This layer is known as aleurone layer.

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

Embryo. The scutellum has an upper free part which has a fleshy projection known as the ventral scale and below that there is inner ventral scale and it is peculiar to rice only. On the surface of the embryo there is plumule. The structure between these scutellum and plumule is the mesocotyl.

Economic uses. The term **paddy** is referred to the grain enclosed by the husk or the glumes. **Rice** is the grain devoid of husks. The following is the proportion in rice and other constituents of paddy under hulling

Rice – clean rice	-	48 %	Broken and points	-	16 %
Meal	-	3 %	Bran	-	13 %
Husk	-	20 %			

The husk contains 18 % silica, 35 % soluble carbohydrates, 2.5 % protein, and 0.5 % fat. The rest is fiber. It is used as manure after composting, as filler in packing cases, for insulation boards and charred husks for refining sugar.

During milling of paddy, the aleurone layer with protein and outer layers of the endosperm with carbohydrate form a fine powdery mass called the **bran**. It has the following constituents.

Carbohydrate-	40-50 %	Soft oil	-	15-20 %	
Crude oil	-	0.4-1.0 %	Protein	-	5-10 %
Fiber	-	5-15 %	Free fatty acid	-	3 %

Rice and its composition. Rice contains a large amount of starch, some protein, minerals and vitamins. The aleurone layer is rich in nutrients like fat, protein, phosphorus, and calcium. The embryo contains large portion of protein and minerals including iron and vitamins of B group.

Par boiling toughens the grain and prevents loss of nutrients. The vitamins and minerals are forced through the bran layer into the kernels. In general there is a practice to wash rice thoroughly before cooking. Washing removes minerals and vitamins. Par boiled rice retains the essential nutrients better than raw rice when washed. Rice has low protein content compared with other cereals. The mineral contents of rice are also low. Small amount of iron and fat is also present and contains vitamins E and B. All the nutrients mentioned above go to make up its quality.

Uses. Rice is the staple food. It is used in many forms. Bran oil used as salad oil. This oil is also used as carrier for insecticide, as sulphonated oil

in textile and leather treatment. It is used as lubricant for watches and scientific instruments. Poor quality oil is used in soap manufacture.

Economic parts: The grain and straw are the economic parts.

Lecturer 3

WHEAT *Triticum aestivum* (2n = 42) Poaceae **(Kothumai, khehu)**

Wheat is the leading food crop in world farming. It is main food crop of temperate zone. It is a plastic crop. It is also extended to warm regions of temperate and sub tropics to tropical low lands. It is one of the most ancient crops of the world. It was cultivated as long as 6500 years ago on the territory of present day Iraq. It is native to some regions of India, Iran and Mediterranean seacoast.

The genus *triticum* embraces 22 species. Only two of them *Triticum aestivum* (soft wheat) *Triticum durum* (hard or durum wheat, macaroni wheat) are cultivated. Of all other wheat species only *Triticum diccicum* (Emmer wheat – Tetraploid 2n=28) is occasionally grown in wheat fields.

The grain of durum wheat contains more protein up to 18 – 20 % but its gluten is not porous and not elastic, that is why bread made out of durum wheat is of low porosity. It is extremely good for manufacturing marconi and confectionaries.

Inflorescence: It is called as head, spikes or ear. Often 15-20 spikelets are borne on rachis in a zigzag shape. The spikelets have two glumes, which may end as an awn (lemma).

Fruit (grain). It is a caryopsis having more or less oval shape. The apex of the grain has tufts of hairs called **bush**. The other side has a longitudinal groove or a furrow often called the **crease**. The either sides of the furrow are called **cheeks**. The embryo is situated at the base on the dorsal side of the grains.

Structure of wheat grain: The wheat grain is a dry one seeded indehiscent fruit (caryopsis). The wheat grain has four structures. Viz1.**Grain coat**, 2 **nucellar epidermis** 3. **endosperm** 4. **embryo**.

The fused pericarp and testa surrounds both the endosperm and the embryo with the **scutellum** in direct contact with the surface of the endosperm. The axis consists of primary root, which is enclosed by **coleoryiza** and the plumule with the protecting sheath of coleoptile enclosing the primordia of two or three foliage leave and short apex. The part of the plumule is called the **mesocotyle**, which is between the scutellum representing the cotyledons and the coleoptile representing the next leaf.

Quality of wheat: The protein to carbohydrate ratio of wheat grain is approximately 1:6. The proteins contained in wheat include albumins, globulins, glutenins and gliadines. Albumin dissolves in water and coagulates in heated aqueous solution. The other protein forms are insoluble in water and are called **gluten**. It is the highest in wheat. 16-50 %. Because of gluten wheat flour is used for baking.

In wheat **milling** and **baking** qualities are the two important aspects, which are considered.

Milling quality: It depends on the hard and soft grain. The hard grains are of better quality because of the embryo being easily separated during milling. The flour is mainly obtained from endosperm.

Baking quality: In leavened bread where yeast is added to flour, carbondioxide is produced by the fermentation of carbohydrates. This results in number of bubbles, which increase the volume of dough. The ability of the dough to retain the carbon dioxide during baking helps the 'rise' in the loaf and this is called the **strength of flours**, which depend upon the **gluten** in the protein.

Composition of grains:

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

Chemical composition:

	<u>grain</u>	<u>flour</u>
Water	13.0 %	12.4 %
Protein	11.5 %	10.0%
Fat	2.0 %	1.0 %
Carbohydrate	7.0 %	7.6 %
Fiber	2.0 %	0.3 %
others	1.5 %	0.3 %

Uses of wheat

1. Staple food in the form of bread, biscuits, cookies, chapatti etc
2. Industrially starch, gluten, malt, distilled spirit are manufactured.
3. Wheat brain is rich in protein. It is valuable live stock feed.
4. Wheat straw as livestock feed
5. Corrugated board from straw.

Maize *Zea mays* (2n=20) Poaceae

Next to rice and wheat, maize is the most important cereal crop in the world. It is suited to a much wide range of climatical condition than either rice or wheat.

The maize plant is monoecious. The male inflorescence called the **tassel** is terminal on the main axis and is a much branched panicle, the spikelets are arranged both on the central axis of the panicle and the branches in pairs, one sessile and another pedicelled.

The female inflorescence is known as the '**cob**' or '**ear**'. It could be considered as a modified lateral branch derived from an axillary bud of the main stem. The internodes of this lateral branches have become short

forming a central stout axis. The modified leaves cover the inflorescence, forming the husk of the ear.

The central axis of the inflorescence is much thickened and carries the soft and succulent spikelets in longitudinal rows. The spikelets are in pairs and sessile. The fertile pistillate flowers represented by the pistil are found within the second lemma. The ovary is surmounted by a long slender style which grows rapidly and emerges from the top of the husk and these together are called as '**silk**' and are receptive throughout the length.

Structure of maize grain: The maize grains are fully exposed and naked on the flat surface of the grain, the embryo can be seen as a whitish deltoid area. The fruit coat (pericarp) is fused with the seed coat, (the testa) and together form the hull of the grain. These forms 6 % of the grain. The bulk of the grain is of endosperm. The endosperm may be starchy, floury or horny. Generally the horny types have high proportion of protein. The embryo in maize is distinct, lying on the flat side of the grain. A longitudinal section across the embryo shows the shield-like scutellum lying adjacent to the endosperm. In the upper part, is plumule covered over by coleoptile and a lower part of the radicle covered by coleorhiza. The embryo in maize popularly called **germ** has oil up to 50 % of the grain and also contains proteins, minerals and sugars.

Zea mays has numerous varieties

1) Dent Corn. (*Zea mays* var. *indentata*). It is the most widely grown type maize in USA and Mexico. There is a depression or dent in the crown of the seed. The starch at the sides of the seeds is corneous, while the soft starch extends to the narrow base or tip. Rapid drying and shrinkage of the soft starch results in the characteristic denting.

2) Flint Corn (*Zea mays* var. *indurata*). It is predominant in Europe, Asia, and America. The seeds of flint maize are hard and smooth and contain little starch. The seeds are smaller than the dent corn and therefore well adapted to poultry feedings.

3) Sweet Corn. (*Zea mays* var. *saccharata*). This type contains a sweetish starch and is characterized by a translucent horny appearance when immature and a wrinkled condition when dry. The ears are picked green for table use and canning.

4) Flour Corn (*Zea mays* var. *amylacea*.) Flour or soft maize has kernels, which are composed entirely of soft starch. They usually develop no dent.

5) Pop Corn (*Zea mays* var. *everta*). The grains are usually small and contain a higher percentage of hard starch than flint maize. The grain expands explosively on heating forming food pops.

6) Pod Corn (*Zea mays* *tunicata*). This is probably one of the earliest domesticated types. Each kernel is enclosed within the lemma and palea, which are well developed. It is not grown commercially.

7)Waxy maize.(*Zea mays ceratina*). The kernel has a waxy appearance. The starch is gummy and has some of the characteristics of tapioca. It is found in eastern Asia, N. Burma Philippines, E. China.

There is great variation among different varieties of maize in the content of protein and fat. Protein may be as high as 15 % in some and as low as 15 % in a few. In the grain 80 % of protein is found in the endosperm. Maize protein is known as **Zein** and is inadequate in lysine and tryptophan amino acid. Maize is the richest of the cereals for fat with the exceptions of oats, which is concentrated in the germplasm (80%). It is also the richest in thiamine and riboflavin.

Uses: As a food - It is used as broken grains boiled and cooked as rice meal. As Porridge. Flour is extensively used in bakery products, baby foods and chapattis. Pop corn, corn flake, corn pop, syrup etc.

Cattle feed – Grain is used as feed for poultry, pigery and cattle. Green fodder for silage and dry fodder for animals.

Industrial use – Corn starch is used in textiles.

In breweries and distilleries for alcohol. For preparation of vermicelli, Bread etc. Industrial gum. Corn oil is used in cosmetics and as edible oil.

Protein Zein – used for making ratified fiber with good tensile strength wool like quality.

Sorghum. (*sorghum bicolor*) $2n = 20$
(Great millet, Indian millet, Milo, Chola, Jowar)

Sorghum is the most important millets grown in India. It is essentially a crop of the tropics and suited to low to moderate rainfall.

Inflorescence usually compact panicle or semi compact or loose (**lax**) panicle. Inflorescence compactness varies from species to species and also within the species. Terminal peduncle erect or recurved to give on the lateral branch of the panicle. The joint of the rachis bears paired spikelets is pedicellate. Sessile fertile spikelet is comparatively large than staminate spikelet.

Fertile (perfect) or sessile spikelet. It has two glumes of approximately equal length G1 and G2 having two flowers inside. One is sterile with empty lemma (L1) and no palea (P1). The other upper floret is perfect bisexual consists of membranous lemma (L2) and a small then delicate palea (P2). Two **lodicules** present adjacent to fertile lemma. **Stamens** three and versatile, pistil with round single celled ovary and two long styles ending in a feathery stigma.

Staminate or pedicelled spikelet. Spikelets are long or short pedicel, two leathery boat shaped glumes enclose two florets. The lower floret is represented by the lemma (L1). Only the upper floret is staminate with short awned lemma (L2). Palea (P2) absent, two lodicules. Three stamens, pistil absent. **Fruit.** It is a free caryopsis between the glumes. it is commonly called the grain or seed. The pericarp or fused with the integuments of the seed coat.

The ovary as it develops into grain has the protecting glumes at the early stages only. As the size of the grain increases the major part is often exposed.

A wide range of color ranging from deep red to white and tint of yellow are met with. In the absence of color the grain is translucent and shiny and are known as pearly grains differentiating from the chalky grains. There were number of classifications for the genus sorghum. The latest one is done by Harlan (1972). It is simple and practical system of classification of the cultivated sorghum into 5 basic races and 10 hybrid races, which can be easily identified from morphological characters of the nature of head and spikelet.

Basic races are 1) **Bicolor (B)** grain large glume clasping the grain 2) **Guinea (G)** grains flattened dorso-ventrally. 3) **Caudatum (C)** grains asymmetrical, glumes 1/2 the length of the grain 4) **Kaffir (K)** grains symmetrical (spherical) glumes clasping in varying length. 5) **Durra (D)** grains rounded ovate, wedge shaped at the base and broadest slightly above

the middle. Glumes very wide. **Hybrid races** consists of all combinations of the basic races.

Wild sorghum species of Tamil Nadu.

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

S. sudanense: utilized for improvement of forage sorghum.

S. nitidum: Found in kodai Hills, possesses shoot fly resistance and dormancy.

S. staffi: Found in southern districts used for inducing dormancy.

Land races of sorghum:

- | | |
|---------------------------|-------------------------|
| 1. Periya manjal cholam | 2. Chinna manjal cholam |
| 3. Thalai virichan cholam | 4. Makkattai cholam |
| 5. Sen cholam | 6. Irungu cholam |
| 7. Vellai cholam. | |

Spontaneous races of sorghum

- 1). Arundenaceum
- 2) Aethiopium
- 3) Virgatum
- 4) Verticilliflorum
- 5) Propinquum
- 6) Shatter cane.

^Sorghum poisoning: The shoots of sorghum contain cynogenic glycoside dhurrin, which by enzyme action hydrolysis to give hydro cynic acid (**HCN**) which is highly poisonous. Nitrogenous manuring increases HCN content and also dry land cultivation. The poison is destroyed after flowering.

Uses: Flour of sorghum is used for making porridge, biscuits unleavened bread, pop corn, Edible oil, dextrose, gluten etc
Brewing beer.
Ethanol extraction.
Cattle feed – fodder, hay and silage.

Pearl millet. *Pennisetum typhoides / americanum* ($2n=14$) Poaceae

Penna – Feather Setum – Bristles.

(Indian millet, Bulrush millet, Cat tail millet, Pencillaria, Bajra)

It is one of the most important among the millets next to sorghum. The inflorescence is speciform panicle and terminal. The appearance of the **flag**

leaf or boot leaf marks the end of vegetative phase and the stem stops further elongation. The peduncle is this, cylindrical clothed with more or less woolly hair below the base of the region of the spikelets. The rachis is straight cylindrical with short hairs. Rachillae bearing clusters of spikelet are arranged spirally on the rachis. Each Rachilla bears an involucre of bristles and a cluster of one or two spikelets.

Each spikelet consists of two sterile glumes and two florets. The lower floret is usually male and the upper hermaphrodite glumes I and II are minute. Lemma 1 is broadly oblong to ovate and lodicule is absent. The stamens are three with characteristic pennicillate anthers. Lemma II is as long as the spikelets. Palea II is little longer than palea I hermaphrodite. The ovary with a single style, bifid at the tip into two non plumose stigma. The gynoecium is protogynous.

Characteristic feature of bajra: Spiklets are subtended by involucre of bristles. Lodicles are absent. Pennicillate anthers. Fused style with bifid stigma. Protogynous nature.

Uses: Flour - For preparation of cakes and unleavened bread.

Grain - Malted seed is an important source of bees, feed for poultry and other live stock

Green plant – Fodder. Straw – Feed for livestock, bedding, thatching, fencing, and fuel.

Lecture --5

Finger millet (Ragi) *Eleusine coracana*. (2n =36) Poaceae
(Kelvaragu)

It is widely cultivated crop of the tropical and subtropical regions of the world. It is grown from poor soils of hill slopes to rich soils of Indo Gangetic plains. It is grown under rain fed conditions and also under irrigation. There is wide diversity of this crop.

There are four types of finger millet, Viz, i) **Top curved** where the curved fingers are longer and have a central hollow. ii) **Incurved**. The fingers are short and curve in and practically close up the central hollow. iii) **Open**. The fingers are the longest and gape out and present a characteristic funnel shaped appearance iv) **Fisty**. It has incurved spikelets in a greater intensity of curving giving a roundish fist appearance.

The grains keep well in storage and not easily damaged by insect pests. Since the crop has tillers, all the ear head do not come to maturity at the same time 2 or 3 round are needed to pick up the head.

Fruit is urticule: Pericarp forms a thin wrinkled, papery, covering not fused with seed and may break away easily from the seed.

Uses: Ragi malt. – Food for aged and children.

Food in the form of cake. Porridge, sweet meat.

As important famine food it can be stored for longer period up to 10 ears

Using for malting and brewing

Straw - cattle feed.

SMALL MILLETS

Due to the small size of the grain of some millets they are called small millets. They are hardy and drought resistant, with little care its grows to give some yield. Mostly raised as rain fed crops.

Foxtail millet *Setaria italica* 2n = 18 (Thenai, Italian millet)

It is a hardy crop grown in low rain fall areas and adaptable to wide range of soils. It cannot tolerate water logging.

Uses. Foxtail millet can be cooked and eaten like rice either whole or broken. Flour is used for making porridge and puddings. In Russia it is used for brewing beer. It is also used as a bird feed

Little millet . *Panicum miliare* 2n = 36. Samai

Inflorescence – A panicle, contracted, much branched, erect or nodding, branches slender. Spikelets solitary or some times in two's. Glumes two. Lemma I and its palea encloses the staminate flower or sterile. Lemma II

and palea II enclose the hermaphrodite flower, stamens three ovary superior with plumose stigmas.

Fruit Caryopsis enclosed with in lemma and palea. Grain very bright, olive brown in color.

Barnyard millet. *Echinochloa frumentacea* (2n.= 36, 54) (Kuthiraivali, Sanwa.)

It is the quickest growing of all millets and produce a crop in a period of six weeks, and grown mostly in southern state. It is generally grown as a rainfed crop. At the same time the crop can be grown in partially water logged areas. In china it is grown as a substitute for rice when the rice crop fails.

Inflorescence is a panicle, contracted or pyramidal, spikes many thickened with densely crowded unawned spikelets, packed in 3 to 5 rows, glumes 2 (G1, G2) lower floret (L1, P1) sterile, upper floret (L2, P2) fertile hermaphrodite stamens 3 ovary superior style two and plumose stigma.

Fruit is a caryopsis enclosed in L2, P2 seed small smooth shining round at the base and pointed at the apex.

Uses The grains are used as food. Young shoot used as vegetables in Java. It is grown as a fodder crop and can produce as many as eight crops per year.

Proso millet *Panicum miliaceum* (2n = 36,72)

(Panivaragu Common millet, French millet, Hog millet, Broom corn millet.)

It is extensively grown in India as a cereal crop under rain fed condition. It is a very short duration crop and hence is suitable as a catch crop. It has the highest protein among all cereals.(12.5%).

Inflorescence is a lax panicle, spikelet numerous with two glumes and two lemma of which second lemma along is fertile. The outer glume is short and the second glume is as long as the spikelet. Lodicule two, stamens three ovary with bifid stigma.

Fruit is a caryopsis, globular enclosed within lemma and palea II

Uses : grain as food, as catch crop , as fodder.

Kodo millet *Paspalum scrobiculatum* (2n = 40) (Varagu)

It is a minor cereal, which is grown to a larger extent in southern states of India. The crop is remarkably drought resistant grown mostly as rainfed. This is the earliest among the food grains. The grain is easily preserved and proves as a good famine reserve and a poor man food. The husks and immature grains are poisonous. The grain is safer for use as it gets old.

It is a **panicle** with two to eight spikes on the main rachis. Each spikes having broad flat rachis with series of depressions in which the spikelets are situated arising from either side of the ridge running the entire length. Spikelets are arranged alternatively in two series, short pedicelled glume I absent. G II more or less equal to the spikelet encloses the hermaphrodite flower with two lodicules. Stamens 3, Ovary superior.

Fruit: caryopsis and is tightly enclosed by the hardened lemma II and its palea. It contains 10.6% protein and 59% carbohydrate. Immature grain and husk contains poisonous principle. Grain well dried dehusked and stored for sometime and then used.

Lecture 6

PULSES Fabaceae

(subfamily – Papilionaceae, caesalpinaceae, mimosceae.)

Pulses are seeds of leguminous plants used as food. All pulses belong to the sub family Papilionaceae under Fabaceae (leguminaceae) They are rich in proteins minerals and vitamin B and are so nearer to animal flesh in food value. All the plant parts of the pulses crop are rich in protein and so they form a valuable forage and excellent manure.

PAPILIONACEAE

Distinguishing characters: Often climbers, bisexual flowers, generally Zygomorphic, sepals 5 with odd sepal anterior, generally more or less united. 5 petals and papilionaceous, stamens mostly 10, mono or diadelphous, carpel one with ventral suture posterior. Fruit mostly a legume.

Habit: Mostly herbs, shrubs or climbers wild as well as cultivated

Root: Taproot, which are branched and bear nodules containing nitrogen-fixing bacteria.

Stem: Erect herbaceous or woody, climbing by means of tendrils.

Leaf: Leaves may be simple or compound. Mostly alternate with leafy stipules. The

leaves may be modified into tendrils.

Inflorescence: Usually racemose but may be Cymose raceme.

Flower: Bracteate, bisexual, complete, Zygomorphic, irregular papilionaceous, and hypogynous.

Calyx: Five sepals, gamosepalous, odd sepal anterior with valvate aestivation inferior.

Corolla: 5 petals, polypetalous unequal with a descending imbricate aestivation papilionaceous, the outermost (posterior) petal is largest and forms the broad free standard (vexillum). The lateral pair of the side petals, which are also free and generally long clawed, forms the wings, while the anterior pair are closely appressed and often more or less coherent and forms the keel (carina) in which essential organs are closed.

Androecium: 10 stamens, diadelphous 9+1 Anthers 2 celled dehiscence by longitudinal, inferior.

Gynoecium: Monocarpellary, superior, unilocular with marginal placentation. Style flattened and hairy with a simple stigma.

Fruit: A legume

Seeds: Usually non-endospermic

Floral formula: $k(s) c, +2+(2) A (9)+1, G1$

Characteristics of Pulses. The pulses or legume seeds from an important source of protein to vegetarian population. The characteristics features are

- They contain 17 to 40 % protein, the highest being in soyabean, and 50% carbohydrate.
- The fat content is low 1-2%
- Rich in Lygiene, typtophan and threonine but low in sulphur containing amino acids like methionine, cystine and cystene.
- Many grain legumes contain toxic substance like trypsin inhibitors, which are removed by cooking.
- The pulse crops are having root nodules, which fix up atmospheric nitrogen into the soil.
- Some crops like lima bean contain HCN, which is dissipated by boiling and changing water.
- *Lathyrus sativus* (kesari dhal) contains toxic amino acid, which causes lathyrus diseases in human being. Boiling and changing water can remove it.

Red gram *Cajanus cajan* (2n=22)
(Pigeon pea, Thuvari, Toor, Dhal.)

Fruit is a **pod**, which is variable in shape size, constriction color texture, pubescence. Pods, which have deep constriction are known as beaded while others are flatish. Seeds may be rounded or lens shaped and varying in color, size and shapes.

Uses: The green pods and green seeds are eaten as vegetables. The ripe dry seeds are boiled and eaten as pulse. Dried husk and broken pieces of seeds are used as cattle feed. Green leaf and tops of the plants is used as fodder and for making silage. Dried stake is used as fuel and as thatching materials.

Two different ways of making split pulses (dhal)

1) Wet method. By soaking seeds in water for 6-10 hours and then smearing them with red earth, drying them in sun and splitting them in mill. The dhal recovery is 80 percent.

2) Dry method. Seeds rinsed well, dried in sun and split in the mill. The recovery is 60 percent.

Bengal gram *Cicer arietinum* (2n= 16)
(Chick pea, gram, konda kadalai, channa)

In India it is one of the important pulse crop grown throughout the country. It is grown as a cold weather crop both in north and south India. It is drought resistant.

Fruit turgid pod normally containing one or two seeds which vary in size and shape and color. The seed coat may be smooth or puckered and wrinkled or roughly granulate. Cotyledons thick and yellowish.

Uses: Dried seeds are soaked in water, cooked and eaten. Dhal used in various food preparation. Popped- pottu kadalai, broken seed - kakalai parupu. Flour used in various preparations. Roasted seeds are taken as food and also in preparation of various dishes. Green pods and tender shoots used as vegetables. Dried plants as cattle feed. Seeds are also used as substitute and as adulterant of coffee. The young tops of plants are used as a pot herb. Dried plants or bhusa serves as fodder. An acidic liquid collected from the glandular hairs contains malic and oxalic acid and is medicinal.

The Phaseolus group of pulses.

A few of the important pulses and beans are from this genus and are distributed both in the tropical and temperate regions. The members of this genus are mostly herbaceous, erect, prostrate or climbing in habit. Leaves are Pinnately trifoliate and rarely unifoliate with leafy stipules. Flowers of various colors are in axillary racemes on a elongated peduncle. Bracts and bracteoles present. Calyx gamosepalous corolla exerted with a recurved standard, wings large and adnate to the keel, stamens diadelphous ovary sessile and many ovuled. Pod linear rarely oblong, and less distinctly septate between the seeds.

Green gram *Vigna radiata* (2n = 22)
(Mung pasiparyarn, serupayaru)

Green gram is indigenous to India and has been in cultivation since prehistoric times. Erect or semi erect herbaceous annual with slight tendency for twining in the upper branches. Leaves trifoliate with long petioles, stipules with basal appendage, stipels minute and leaflets entire ovate, flowers 10 – 20 crowded in axillary racemes on long pedicels, keel spirally coiled, stamens diadelphous (9+1) ovary with long bearded style. Pod longer than in black gram with short hairs. Seeds globular with many fine and wavy ridges on the surfaces, hilum flat cotyledons yellowish.

Pod seed as food for human being, green and dry plant as fodder.

Black gram *Vigna mungo* (2n = 24)
(Uzhunthu, urad, urd)

Black gram is cultivated in many tropical and subtropical countries in several parts of Asia Africa and C&S America. It is a twining herb, annual plant, densely hairy, stem slightly ridged, leaves alternate, stipulate, petiolate, Pinnately trifoliate. Inflorescence axillary raceme with flowers congested at the top of the peduncle. Flowers 5-6. shortly pedicelled bisexual, hypogynous, Zygomorphic, Complete. Sepals 5 gamosepalous, imbricate corolla papilionaceous, petals five, polypetalous keel in the form of spiral beak. Androecium diadelphous (9+1) filament alternately long and short. Gynoecium superior ovary, monocarpellary unilocular marginal placentation. Fruit – Legume densely hairy seeds, generally black.

Difference between green gram and black gram

Character	Green gram. <i>V.radiata</i>	Black gram. <i>V.mungo</i>
1. Stem	Mostly erect or sub erect.	Mostly spreading or trailing
2. Leaves	Mostly green or dark green	Mostly yellowish green
3. Hairiness	Plant sparsely hairy	Plants densely hairy
4. Hair	Colour Slightly brown	Reddish brown
5. Pods	Spreading or reflexed shatter readily have short hairs	Erect or sub erect, do not shatter much, possess long hairs.
6. Seeds	Small globose, usually green	Large oblong usually black.
7. Seed coat	Wavy ridges present, sometime very faint.	No ridges
8. Cotyledons	Yellow, when chewed pasty sensation absent.	Whitish or pale yellow when chewed it gives a pasty taste.
9. Hilum	Not concave	Concave.

Uses: As a food – Dried grain is used for making iddli vadas etc.

Flour used in bakery for preparation of bread and biscuits. Green seed and pods

are eaten as vegetables.

Dried or green plants are used as fodder. Broken grain seed coat and bhusa

(pothe) are excellent fodder.

Soybean *Glycine max.* (2n=40)

Soybean is one of the most important legume food of the people of far eastern countries like China and Japan and are chiefly used as a pulse. The seeds are rich in protein and are of high biological value. It is also rich in fat and vitamins, being good source of calcium and phosphorus. Soybean flour is being used in many foods. The importance of soybean in the recent years has been increased because of its oil content and the byproducts. Soybean oil is yellow or light brown in color and is used to a great extent as edible oil.

Since it has low carbohydrate and high protein content soybean flour is considered as an excellent food for diabetics. It is sometime used as a substitute for Black gram for preparing idli, vada etc. Soybean milk extracted from the seed is also useful for invalids and infants. Curd and cheese are also prepared. Soya sauce is also prepared. It is considered to be beneficial for patients with various disorders because of the high phosphorous content. Unripe seeds are used as vegetables.

Industrial uses: The soyameal is a good source of protein as it contains 40- 50% protein. Soybean protein is extensively used to produce the foam liquid used for extinguishing fire and also for making synthetic fibers, plastics and adhesives. It is a drying oil. It is used for mixing up with other oils, in paints and varnishes.

Soya flour is used in bakery. Soy meal is used as a manure and also as stock feed. The plants are also used as green forage in many parts of the tropics.

Cowpea. *Vigna unguiculata* (2n=22)

(Thattai payaru, Kaaramrani, Maanpayaru, Lobia chowli)

It is grown in warm parts of the world. Tender leaves are used as greens from the vegetable type cowpea. Sprouted seed as vegetables. Grain as pulses. Whole plant as green fodder. Cow pea and maize green fodder mixture is excellent for cattle.

Dolichos group of pulses:

The dolichos are twining herbs with stipellate, trifoliate leaves. Flowers are racemose or axillary, calyx tube short, corolla is much exerted petals equal in length keel is obtuse not spiral, stamens are diadelphous. Ovary nearly sessile. The pod is flat linear or oblong, recurved.

Lab-Lab: *Lablab purpureus* 2n=22,24. var (typicus)

(Hyacinth bean, Pandal avarai, molai)

Garden or pandal avarai is perennial, but cultivated as annual. The pods are long tapering. It has no oil glands and no smell. Entire pod is edible.

Dew gram *Phaseolus aconitifolius* (moth bean, mat bean)

It is widely grown throughout India, parts of Asia and in USA as a pulse crop and forage crop.

Lecture 9 Midterm examination

****Good luck****

Lecture 10.

OIL SEEDS

Chemically oils and fats are very similar and they differ only in the physical state. In liquid form it oil and in solid states it is fat at the same temperature. Oils are synthesized by plant from the simplest carbohydrates resulting from photosynthesis and occur as insoluble droplets in the tissues of the plant cell either in vacuoles or in the cell wall. They are mostly found in seeds, endosperms, mesocarp, embryo and less frequently in root, stem and foliage.

The vegetable oil are divided into two groups.

1. **Fixed or non volatile oils:** Which do not envoporate under normal condition or temperature and exposure.

2. **The essential or volatite oils:** Voltilize or evaporate in the atmospheric air on exposure. These oils have aromatic scent and of quite different composition from the fixed oil.

Fixed oils or non volatile oils can be classified as 1.Drying oils 2.Semi drying oils 3. Non drying oils 4. fats.

1) Drying oils: On exposure to these oils absorb oxygen and dry onto thin elastic film. Such oils are useful for the manufacture of varnishes, paints, soap and for illuminating purposes. The unsaturated fatty acids in drying oil include linolenic and linoleic and in their glycerides. Eg. Linseed oil (*Linum usitaticum* Linaceae) Safflower oil (*Carthamus tinctorius* Asteraceae) Soybean oil (*Glycine max* Fabaceae)

2) Semi drying oils: This oil absorb oxygen slowly and drying slowly on continuous exposure to atmospheric air. This forms only a soft film after long exposure. Eg. Gingelly oil (*Sesamum indicum* Pedalaceae) Mustard oil (*Brassica* sp Brassicaceae) Cotton seed oil (*Gossypium* sp Malvaceae) Sunflower oil (*Helianthus annus*. Asteraceae)

3) Non drying oils: These oils remain liquid at ordinary temperature and do not form film on exposure to air. They react with oxygen very slowly or not at all. They are characterized by high content of oleic acid. These are generally used for soap making and for lubrication purposes. Eg Castor oil (*Ricinus communis* Euphorbaceae,) Groundnut oil (*Arachis hypogaeae* Fabaceae) Cocount oil (*Cocos nucifera* Arecaceae) palmoil (*Eleasis guinensis*. Arecaceae) Olive oil (*Olea eyroea*. Oleaceae).

4) Fats: This include vegetable oils which remain solid or semi solid at ordinary temperature used as food and also in candle and soap manufacturing industry. E.g. Coco butter *Theobroma cacao* Sterculaceae. Palm oil and Palm Kernel oil.(*Elaesis Guinensis* Arecaceae).

Non conventional oil seeds:Eg. Jojoba – *simmondsia chinensis* Bauxaceae Jatropa – *Jatropha* sp. Euphorbiaceae.

Uses of oil: As source of energy, Medicinal value,

Industrial oil soap cosmetics, lubricants.

Oil cake as animal feed, Green and dried plant as fodder.

Ground nut *Arachis hypogaea*. $2n=40$. Fabaceae.

(Pea nut, Monkey nut, Nilakadalai, Vaeer kadalai, Moongfali.)

Distinguishing features: The genus *Arachis* consists of a **hypanthium** (long calyx tube) pinnate leaves, stipule adnate, monodelphous stamens (8+2 staminode) didynamous-4 short filaments with elongated anther, dimorphic, straight embryo, a **geocarpic peg**, (carpophore/Gynophore) an underground fruiting habit and produces most of its flowers at the lower nodes.

Sub species

Cultivated *Arachis* is sub divided into subspecies. Again these subspecies are divided into two varieties each (after Karpovikas 1969)

- I i *A. hypogaea* subspecies *hypogaea* var. *hypogaea* (Virginia type)
- ii *A. hypogaea* subspecies *hypogaea* var *hirsute* (Peruvians)
- II i *A. hypogaea* subspecies *fastigata* var *fastigata* (Valencia bunch)
- ii *A. hypogaea* subspecies *fastigata* var *Vulgaris* (Spanish bunch)

Difference between spreading and non spreading (bunch)

Spreading (Virginia/ Peruvian)	Bunch (Spanish/Valentia)
1 Central axis erect, lateral branches prostrate. Lateral branches exceed the length of central axis.	central axis erect but it will not exceed the length of central axis.
2. Main axis is vegetative.	Nodes on main axis above primary laterals are productive for the first 6 nodes.
3 Alternate branching in the laterals i.e. vegetative branches followed by reproductive branches. More or less growth indeterminate in growth habit.	Sequential branching. Primary laterals usually reproductive for the first 6 nodes followed by sterile axis. Determinate growth.
4. Comparatively high oil content	Comparatively less oil content
5. Larger duration (120-130 days)	Short duration (90-105 days)
6. Seed dormancy present	No dormancy
7. Leaf dark green, small in size	Pale green larger in size
8. Perennial tendency	Annual.

Ground nut flower is sessile, yellow in color and carried on the fairly long calyx tube, which gives the false appearance of a pedicel, a single bract and two bracteoles are present for each flower, the calyx is tubular slender ending in five lobes of which three are united into one big structure and the two linear lanceolate. Corolla papilionaceous. Stamens monodelphous eight fertile and two sterile staminate, the eight stamens are dimorphic with four having long anther lobes and four with rounded anther lobes. The Gynoecium

with a superior ovary arises at the very base of the flower at the bottom of the calyx tube. Ovary Monocarpellary unilocular with one to three ovules on marginal placenta. Fruit is a indehiscent pod, carried on a long stalk which is the gynophore.

Pod development. After fertilization thalamus develops into peg or gynophore (to more specific carpophore) The gynophore is positively geotropic and after reaching certain depth the carpels develop into pod attaining a horizontal position.

Uses: The nuts are eaten raw or after roasting. Table varieties -extra large kernels with low oil content are preferred. Kernel is a rich source of phosphorous and vitamins. Protein 26% and oil.45 to 50%

Oil is a cooking media

Hydrogenated oil – for preparation of vanaspathi, vegetable ghee.

Manufacture of margarine- butter like substance. Pea nut butter.

Oil cake as cattle fed.

Moist oil cake for production of aflotoxin from *Aspergillus flavus*.

Oil – Non drying – Pharmaceutical industry Soap industry, Lubrication.

New textile fiber- **Adril**- manufactured from peanut protein.

Economic characters. In the groundnut the farmers and traders consider the following characters of economic importance and crop improvement has to be based in these characters. 1) Shelling percentage, 2) number of kernels per kilogram,3) Natural test weight of pods and kernels, 4) Oil content,5) Free fatty acid content 6) Depth of pod formation,7) Dormancy,8) Pest and disease resistance.

Gingelly *Sesame indicum* (2n=) Pedaliaceae.

Gingelly is a source of the much valued edible or salad oil and the oilcake is very good as cattle food. It is also termed sesame or til. Due to its synergistic action its use in insecticides is becoming popular. The oil is of great importance in medicine.

Distinguishing characters Stem quadrangular in shape, Basal leaf opposite, upper leaf alternate. Presence of extra floral nectary gland as peduncle base. Corolla bell shaped, biliped and five lobed. Androecium-epipetalous didynamous stamens. Ovary bicarpellary, by presence of false septa appear as four loculed. Seed color varies from pure white to various shades of brown and gray to black. Seed coat may be rough or smooth.

Uses: Seeds mixed with jaggery and eaten. Good source of cooking oil. 85% unsaturated fatty acid. Manufacture of margarine. Low grade of oil is used in soap, paint illuminant, base for scented oil. Carrier for antibiotics, vitamins and hormones.

Oilcake –rich in calcium, phosphorous and the vitamin niacin, used as cattle feed.

Seed and green plant have medicinal value Oil is used as laxative.

Used in insecticidal preparation.

Lecture 11

**Castor *Ricinus communis* (2n=20) Euphorbiaceae.
(Amanakku, kota muthu, Arend)****Distinguishing characters.**

Presence of bloom –Ashy coating on the leaves and stem of the plant.

Monoecious condition- unisexual flowers, male at the bottom and female at the 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.

Fruits and seeds. Four distinct size groups of fruits namely very small fruits are found in ornamental types and in some of the wild perennial types. Small and medium types are preferred for cultivation since they fairly high oil content varying from 45 to 57 %. Big seeds have generally low oil content of less than 40%. Very small seeds are preferred for medicinal purposes.

On the fruit the epicarp may be either smooth or warty or spiny. Attractively colored types of horticultural value with colored inflorescences and fruits have been evolved. The seeds color ranges from white to gray deep chocolate, purple and red. Mottling is also much varying. The seed has no dormancy.

Uses. Oil content varies from 48 to 56 % in different varieties. The larger seeds are usually low in oil content. The wild types are also considered to be low in oil content. Endosperm alone contains 58 to 66%.

Alkaloids are vegetable bases contains nitrogen. They are the decomposing products of protein. They have marked physiological effect on animals. They have much value in medicine and drugs. It is not used in cooking for it has low (PUFA) poly unsaturated fatty acid and less of linoleic acid. The castor cake cannot be fed to cattle due to the toxicity of endosperm protein viz ricin. The oil is stored in endosperm. Castor seed contain a unique hydroxy fatty acid called ricinoleic acid.

Uses. Oil is used for manufacturing paints varnishes.

For illumination.

Lubricant for aero engines. Hydraulic brake fluid.

In the manufacture of soap, printing ink, wax, and polish.

Used in nylon fiber and plastic industry.

Rilson a polyamide nylon type fiber manufactured.

Oil cake as fertilizer.

Stem as fuel, making paperboard.

Decomposed castor oil is the raw material for perfumery and for the manufacture of bactericide and fungicide.

Used as laxative in pharmacy.

Oil extraction. The castor seed contain 50% 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 the surface is skimmed off. By boiling the toxic principles are neutralized. Chemical composition. The oil is nearly colorless or very pale greenish yellow viscous fluid. The typical fatty acid composition of castor oil is ricinoleic acid.91-95%, linoleic acid 4.5% Palmitic and stearic acid 1.2% and negligible amount of oleic acid.

Sunflower *Helianthus annus* (2n= 34) Asteraceae

Sunflower is an important oilseed crop after soybean and oil palm in the world and accounts for about 12.8% of the world production of edible oils. Sunflower seed oil production is more in temperate regions but it is adapted to tropical condition also.

Uses. Seeds are nonedospermic, major source of semi frying oils.

Seed flour is highly nutritive and used in bakery.

Seeds are consumed raw, roasted or salted.

Seeds are used in medicine as diuretic.

Oil is used as cooking media (90% poly unsaturated fatty acid (PUFA) and 10% saturated fatty acid.) It has noncholesterol and anti cholesterol properties.

Used in paints, varnishes, soap, cosmetics.

Oil cake as cattle feed.

Sunflower also produces excellent honey and wax

In woolen fabric making.

Sulphonated sunflower oil is used in high coefficient liquid disinfectant

Stalks are used as fuel.

Bast fiber from stem is used for cordage and textile purpose.

Safflower *Carthamus tinctorius* (2n = 24) Asteraceae (Kusumba, Senthooragm)

Safflower is an important oilseed crop in India. It is slowly becoming of increasing importance as an oil crop for the drier parts of tropics and subtropic. In India it is cultivated for both oil and reddish dye called safflower dye (cathamin) from florets.

Uses. The seed /fruit is **achene**.

It is fairly good drying oil contains high percentage of linoleic acid but little or no linolenic acid.

It is best used for patients suffering from heart and artery disease.

Oil- Cooking media. (saffola)

For paints and varnishes

Dye purpose. Oil has medicinal values

Oil cake – cattle feed. Good manure.

It is used as adulterant in ghee.

Rape and Mustard *Brassica* sp. ($2n=16, 18, 20, 22, 36$) Cruciferae

The group rape and mustard includes the oil yielding species of *Brassica*. The commercial Indian rape seed and mustard are often mixture of rape seed, mustard and colza in varying proportion. The seeds go by different name in different parts of the country. Generally both colza (sarson) and rape (toria) are called together rape seed. Rai is mustard. Cultivated *Brassica* can be broadly divided into two distinct types.

1. Vegetable type-cabbage, (*Brassica oleraceae* - var capitata.) cauliflower (*Brassica oleraceae* var botrytis). Turnip (*Brassica oleraceae* var rapa)

2. Oil seed type. 1) Rape seed *Brassica campestris* and 2) Mustard *Brassica nigra*.

Rape seed a) *Brassica campestris* ($2n=20$)

Indian rape seed is self sterile in nature. Important oilseed crop of N. India. There are three cultivated types. *Brassica campestris* var. **brown sarson**
Brassica campestris var. **Yellow sarson**
Brassica campestris var. **toria**

b) *Brassica napus* $2n=38$ European rape seed.

Self fertile grown in Europe for green fodder as well as oilseed.

Mustard. a) *B. nigra* ($2n=16$) Black or true mustard. Banarasi rai contains 28% of fixed oil used as medicine. Oil is pungent due to presence of glucoside sinigrin mostly used as condiments.

b) *B. alba* $2n=24$. White mustard or ujli sarson. Young seedlings used as salads. Seeds yellowish in color contains 30% oil.

c) *B. juncea* $2n=36$ Indian mustard. (Brown sarson). Popularly known as rai contains 35% oil. Leaves are used as herbal medicines. Most pungent among cultivated oil seeds. It contains glucoside sinigrin.

The oil producing species of *Brassica* are all cross fertilized.

Key characters. Leaves two types 1) stem leaves bigger, lance shaped and serrated. Flower leaf small smooth margin. Androecium tetradynamous. Fruit siliqua.

The oil content of the seed varies from 30-45% depending on the variety. Yellow seeds contain more oil than brown seeds. The seeds also

contain 20% protein and high % of total fatty acid 40-50% (erucic acid) oleic acid 20-30% and other saturated acid such as palmitic stearic, lignoceric are present in small quantities. Edible purpose mustard oil must contain less of erucic acid.

Uses. Seed as condiments

Oil as cooking oil

Oil as illuminant, lubricant, soap industry, fertilizer, tannery and plastic industry.

Green plant as fodder.

It has medicinal uses.

Leaves of young plants are used as green or leafy vegetables.

Niger *Guizotia abyssinica* (2n= 30) Asteraceae
(Peyyellu. Ram til)

India is the chief niger producing country in the world. The oil is edible, pale yellow, or bluish green in color and has pleasant smell. The seed contain 30-45% of drying oil with high linoleic acid and has little taste or smell.

Uses.

Edible oil.

Used for soap making, lubricants and illumination.

Oil cake as cattle feed.

Fibers

The fiber are obtained from the sclerenchymatous cells found in the plant body and these fiber cells occur either in groups or bundles. Chemically the fiber cell consists chiefly of cellulose with lignin or semi cellulose or any other substances. The commercial term fiber includes generally all thin and slender substances, which can be spun or made use of as fine stuffing material.

Fiber cells are non-living structures, when mature and serve as a purely mechanical function, i.e. they impart strength and rigidity to the plant body.

Classification of fiber. The fiber may be grouped into two broad categories, viz. **1) natural fiber and 2) synthetic fiber or artificial fiber.**

Natural fiber includes fiber obtained from plants and animals. eg. Wool, hair of animals and silk. **Synthetic fiber.** The development of this fiber in the recent years has been very phenomenal. Synthetic cellulose, glass filaments, rayon, nylons and orions have entered textile industry to a great extent. The use of synthetic fiber in industrial purpose as in asbestos and glass wool is well known. However the role of natural fiber in supplying the needs of man and the industry cannot be completely displaced by synthetic.

Natural fiber or Plant fiber or vegetable fiber are classified based on their morphological nature and the position in the plant and the uses to which they are put.

Based on their botanical origin.

a) Stem or Bast fiber. These are the fiber found in the stems of plant. The sclerenchymatous tissues associated with the phloem and the pericycle are included in this group. These fiber are botanically the true fiber. Each fiber is complete cell by itself. Many cells are grouped together and often cemented together by the pectic substances into fiber strands. These cells have cellulose walls and vary in amount of lignifications. Bast fiber is also called **soft fiber, stem fiber or phloem fiber.** Fibers are separated usually by the process of **retting**.

b) Leaf fiber. (Structural fiber, hard fiber) The fibers are obtained from the leaves of Agave, Manila hemp, Sansevera etc. Sclerenchymatous fiber and vascular tissues in the leaves forms the fiber. Strands of small short lignified schlerenchymatous tissues ensheathing both xylem and phloem are scattered in the leaves of the monocotyledonous plants. These fibers are highly lignified. Usually separated by **scrapping**.

Seed fiber, or fruit fiber, or Surface fiber. These fibers are obtained from fruits and seeds of plants are mostly cellular hairs. These cells may be from the wall of the fruit or from the wall of the seed. In case of cotton the sub epidermal layers of the seed give rise to the long soft hair, which form the important fiber of commerce. In kapok, the hairs from the inner carpellary wall

of the fruit make **floss**. Since these fiber cells are found on the surface they are called **surface fiber**.

In coconut the fruit have sclerenchymatous fiber, which are due to high lignification. Though this forms the surface fiber the tissue of schlernchyma differs from cellulalr growth of cotton and kapok. The fibers are usually separated by **ginning**.

Cotton *Gossypium* sp. (2n=26,52) Malvaceae
(Paruthi, Kapas)

Cotton is the most ancient crop of the tropical and subtropical. It is one of the most important items of export in the developing countries. Cotton fiber is unchallenged natural textile fiber even today. The genus gossypium consists of diploid and tetraploid cultivated cotton.

Old world cotton or Desi cotton or diploid cotton 2n=26 are **G. herbaceum** (upmam cotton) and **G. arboreum** (Karunkanni cotton)

New world cotton or American cotton or Tetraploid cotton 2n=52 are **G.hirsutum**.

(Combodia or upland cotton) and **G. barbadense**.(sea Island cotton)

Cotton fiber is epidermal prolongation of seed coat cells. Certain of the epidermal cells of seeds (epidermis of the outer integument of the ovule bulge out and the protoplasm and nucleus enter it. The longer out growth make **lint** and the shorter one make **fuzz**. In diploid cotton and upland cotton both lint and fuzz are present where as Sea island cotton (**G.barbadense**) only lint are present and such seeds are called **naked seed**.

Structure of fiber. 1) The integument or outer layer is also called **cuticle or waxy layer**.

2) Outer cellulose –original cell wall.

3) Layers of secondary deposits – pure cellulose in numerous concentric layers.

4) Walls of the lumen—wall around the lumen.

5) Substance in lumen –more of entrogenous in nature.

I Classification of fiber based on use. (commercial classification)

1) Textile fiber: Manufacture of fabrics and netting of fiber are twisted together into threads or yarn and then woven. e.g. cotton jute.

2) Brush fiber: Manufacture of brushes and brooms e.g. palm, sisal.

3) Filling fiber:Used in upholstery and for stuffing cushions, etc. e.g.cotton kapok,jute.

4) Cordon fiber: Used for making twines, ropes, cables e.g. Hemp, jute, agave.

5) Plaiting fiber: Flat fibrous strands which are pliable and can be folded into plaits as in hats matting thatties, screens or baskets. Part of the stem or whole branch or root may be used e.g. Korai, bamboo, vetiver etc.

- 6) Wicker work: For baskets, chair and other furniture of wickers work . Splints of branches or the whole branch of many plants are used. e.g. bamboo, cane, palm, willows etc.

Terminologies.

Seed cotton: (kapas) cotton along with seed removed from locks of the boll.

Lint: ginned cotton or cotton with out seed. It is the fiber developed on the epidermal layer of the seed. It is removable by ginning.

Fuzz: Fiber developed from the sub epidermal layer of the seed. Short in nature, not removable by ginning. Acid defuzzing is done to destroy pathogens before sowing.

Ginning . The process of separation of lint from seed by machine known as gin.

Ginning percent. The ratio between lint and seed. Expressed in percentage. $G.P. = \text{weight of lint} / \text{weight of seed cotton} \times 100$.

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 fiber / seed and weight of the individual fiber. This depends on fiber length, thickness and specific gravity of fiber wall. Smaller seeds raise the ginning out turn, but not necessarily increase lint production.

Count. Ability of the individual fiber to stretch while spinning. Lower count- low spinning quality, high count- higher spinning quality.

Lint Index. Weight of lint per seed or per 100 seeds. It represents the absolute weight of lint production per seed and its is more useful in breeding than ginning percent. $LI = \text{weight of 100 seeds} / 100 G.P. \times G.P.$

Fiber length or Halo length or staple length. Most important among fiber properties. This character is determined by 1) **Pulling method.** Professionals estimate based on eyes and hand. 2) **By combing** the fiber with brass comb and measuring the combed fiber by celluloid disc scale (Halo card Halo disc Halo butterfly.) 3) Use of fiber sorting instruments like Ballsorter or Baer's sorter. 4) Use of **photo electric instruments** viz. Fiber graph.

Commercial cotton can be **classified on the length of fiber** as **Long staple** > 2 inches length, e.g. G. barbadence. **Medium staple** 0.5—2.0" length.e.g. B. hirsutum. **Short staple** <0.5" length. e.g. G.herbaceum and G. arboreum

Uses. Cotton lint is a valuable textile fiber. Varies plant parts are useful.

In Lint Textile, absorbant cotton, wiping , polishing material.

In industries for making tyre cord and machinery belt.

Cotton seed,-- Cattle feed, cotton seed oil (20% semi drying oil)

Root bark—Ergot like drug is prepared.

Stalk – Fuel, paper pulp, bast fiber extracted.

Leaves—manure and fodder.

Lecture 14 Jute ***Corchorus capsularis*, *C. olitorius***. (2n=14) Tiliaceae.

Jute is a leading crop among all bast fiber (Stem fiber) plants. It is a typical plant of humid tropics and subtropics. Jute is chiefly raised for the sake of its fiber, which develops in the external part of the stem (in the bark). Individual fibrils are from 5 to 40 mm long. The surface of the jute fiber is smooth and brown in color. Commercial jute fiber is obtained from two species viz. *Corchorus capsularis* (white or bitter jute) and *C. olitorius* (Tossa jute). Mainly grown in W. Benga, Bangla Desh.

Fiber extraction. The ideal phase of harvest is when the plants are in small pods. Harvested plants are bundled and staked for the withering of leaves. After 2 to 4 days the leaves shed and the bundles are then steeped in water.

Steeping is a process of immersing the bundles in water. After 2 to 4 days the tissues and cells rupture. This facilitates the entry of micro organism into stem.

Retting: It is a process by which the fiber in the stem get loosened and separated from the woody stalk due to the removal of protein, gums and other mucilaginous substances by the micro organisms. Fiber yield is 6% of the fresh stem weight.

Fiber Quality: Jute fiber is fine and silky but less stronger than many other fiber.

Uses. Jute is used chiefly for rough weaving. The thick cloth made from jute is used for making gunny bags, sails for country boats. It is used in the manufacture of carpets, curtains, strings, twines and ropes. Jutes butts (short fiber) are used for paper making.

Mesta ***Hibiscus cannabinus*** (2n = 36) Malvaceae
(Kneaf, Deccan hemp, Java jute, Bimplipatam jute, Pulichai Kanchava, Gogu.)

Mesta fiber is a valuable fiber probably next to jute. This crop is successfully grown throughout tropics and subtropics. Bast fiber is obtained from the stem similar to jute.

Uses. Fiber is mixed with jute for manufacturing of bags, nettings and ropes. Also used in the manufacture of sand paper and abrasives. The seed contain about 20 % oil which is some time extracted and used as a lubricant and for illumination, soap. Linoleum. paints and varnishes are also manufactured from this oil.

Sun hemp. *Crotalaria juncea*. 2n=16 Fabaceae
(Chanappai Bombay hemp)

Sunnhemp is another source of bast fiber, grown in tropical countries. It is also grown as fodder and green manure. The fibers are stronger than the jute but lighter in color and more enduring than jute. They are long strands of fiber of about 4 to 5 feet in length and yellow to green in color. Fiber is obtained by retting.

Uses: Cordage fiber, marine cordage, manufacture of sail cloth, canvas, matting, rope, sole of shoes and sandals, used for making cigarette papers, tissue paper, and fishing nets.

Agave (*Agave silsalana*) (2n+138) Amaryllidaceae.

Agave produces hard fiber. *A. vera* cruz is a common species planted along the railway embankments and around villages. This is popularly called as Railway aloe and wrongly termed as *A. Americana*. *A. wightii* is a smaller species with profuse suckering found commonly in S. India. *A. cantala* is found in N. India. *A. sisalana* is a most valuable and potential source of fiber production. The plant is xerophyte and comes up well under limited rainfall. The plant grows under partial shade and is quick in growth with big leaves.

The leaves form a rosette and are regularly arranged in the form of spiral. It is estimated that the sisal plant produces on an average 300 leaves during its life time. Harvest of leaves for fiber production is generally done after 3 years of planting. By this time the plant will have over 100 leaves. Thirty to forty leaves are left on the plant and the lower leaves are harvested,

Extraction: This involves beating, scrapping and washing the product.

Uses: The fiber is to a great extent used for ropes, cordages and twines. Used in the manufacture of mats and as a filling material. It is also used in the form of textile fiber required for wagon covers, linoleum. The short fibers are used for making brushes, horse hair substitute, sisal kraft paper and paper boards.

Kapok *Ceiba pentandra* 2n=72 Bombaceae (white silk, cotton tree, Elavam, kapik silk cotton.)

The fiber is obtained from the inner wall of the fruit. The fiber is single celled with a bullous base. The individual fibers are thin walled with wide air filled lumen. Kapok fibers are light. These fibers cannot be spun into yarn due to their soft short untwisted and brittle natures. **Uses:** The fiber is ideally suited for filling mattresses, pillows, cushions and other upholstery articles. The fiber has a high degree of buoyancy; therefore it is used in making life belts, life jackets, life buoys and other naval life saving appliances. It is a good sound absorber and used as an insulating material in aeroplane cockpit, theatres and hospitals. Also in ice boxes as it is a

poor conductor. **Kapok seed oil** (20-25%) non drying oil used as lubricant, soap making, cake as cattle feed. Fiber used in fires work manufacture.

Lecture 15

Sugars

(Sugar cane *Saccharum officinarum* (2n=80) Poaceae.)

Sugar cane is a perennial gigantic grassy plant of Poaceae family. It is extensively grown in India, Cuba, Hawaii W.Indies. There are 5 species of sugarcane of which three are cultivated and two are wild species.

1 ***Saccharum officinarum***. Noble cane (2n=80). Large barreled low fiber, high sugar content, susceptible to diseases and pests.

2 ***S. barberi***. Indian cane (2n=82-124) Intermediate between noble and wild canes. Small barrel, internodes spindle shaped, high fiber content, resistant to diseases.

3 ***S. sinense***. Chinese cane (2n=118) Vigorous thin grassy form virtually, no sucrose, resistant to drought, pest and diseases. Fair amount of sucrose content.

4 ***S. spontaneum***. Wild cane (2n=40-128). Vigorous than grassy form. Virtually no sucrose, resistant to drought, pest and diseases.

5 ***S. Robustum***. Wild cane (2n=60-194) Thick stock low sugar content, disease resistant.

The above 5 species are important for the improvement of sugar cane. They all inter cross freely.

Nobilization. Back crossing of F1 with ***S. officinarum*** (noble cane)

Manufacture of cane sugar.

The following are the process.

1. **Extraction** . The cane is crushed well with waters to extract 90-95% of juice and is sent for clarification.

2 **Clarification of juice.** The juice contain 15% of sucrose, vegetable protein, mineral salts, organic acid, gums and fine particle of baggasse. Clarification involves sulphitation i.e. adding of milk of lime and treating with

sulphurdioxide and carbondioxide. A current of carbondioxide followed by sulphurdioxide is passed through the defacted juice to remove excess lime and to bleach the juice. Sulphitation prevents formation of brown mass by oxidation.

3 Concentration and crystallization. The clear juice is concentrated in multiple effect. Cooled and crystallized in open tank. The left over is molasses.

4 Refining and drying of crystals. The raw sugar is dissolved in hot water and the suspended impurities removed by filtration. Concentrated under reduced pressure and crystallized. The solution if discolored, is treated with carbon black. Then the clear liquid is centrifuged to get pure sugar crystals.

Uses. Alcholic beverages, soft drink, confectionary, ice cream, chocholate, sweetening agent. Other industrial uses like drug industry and for preservation.

Bye products. 1 **Mollases.** Mainly for preparation of chemicals like vinegars glycerol, latic acid, chloroform etc. Also for biogas plant. Livestock feed and alcholic drinks. 2) **Beggasse.** Mainly for boiler fed fuel, manufacture of paper, insulating wall board, plastics etc. 3) **cane wax.** For polishing 4) **Press mud** Used as fertilizer. 5) **Trash,** Organic manure.

Palm Sugar *Borassus Flabellifer* (2n=36) Arecaceae

Extraction of sugar. The tip of the inflorescence is cut and the sap is collected in containers. The sap possesses 14% sugar. This is boiled down to a syrupy consistency and pressed into leaves to cool and harden into crude sugar known as jaggery.

Uses. Jaggery, toddy, leaf is used for making brushes brooms baskets mat, timber for rafters, pillar, posts and fuel.

Sugar Beet. *Beta vulgaris* (2n=18) Chenopodiaceae.

The cultivated *Beta vulgaris* includes, sugar beet, vegetable beetroot and forage beet root. **Bolting** of sugar beet. Sugar beet is biennial. It develops large succulent root in the first year and 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. Sugar beet contains about 12 to 18 % sugar. The root are cut into small pieces and treated 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 carbondioxide which

precipitates calcium carbonate. The juice is filtered and concentrated, crystallized and centrifuged. The beet sugar is identical in composition and appearance to cane sugar.

Uses. Sugar, leaf-cattle feed, manure, molasses- stock feed and ethanol preparation

Lesson 16

Forage Crops.

The term **forages** is used broadly to mean all the plant constituents that are eaten by herbivores, including those that are grazed (pastures) and those that are cut before fed such as fodder. Crop residues such as straw and the foliage of trees and shrubs also fall within the broad definition.

Fodders. Plants, which are, cultivated as forage crops and they are cut and fed to animals in stalls. Pastures, grasses and legumes are grown in pasture lands where the animals are led to graze,.

Forages can broadly be classified into three groups .viz. **grasses, legumes and non legumes.**

Grasses. Annual grass – Maize, sorghum, andumbu.

Perennial grass.—B.N. and N.B, hybrids.

Legumes Annual –Cowpea, cluster bean.

Perennial Lucerne, Siratro, Desmanthus

Non legumes. – Fodder beet, Fodder radish.

Grasses.

Napier grass. *Pennisetum purpureum*. It is a tall perennial grass forming very thick clumps, tillering is heavy. It comes up well in both under tropical and temperate regions. It comes well in any soil condition and also responds

to sewage irrigation 6-8 harvests can be taken in a year. The grass with stands drought for short spell and regenerate with rains.

Pearl millet. Napier (Cumbu- Napier). They are very vigorous in their growth and adopted for varying climatic and soil conditions. They give heavy yield higher than Napier. They are more nutritious, palatable, succulent, juicy and less fibrous. They tiller profusely have luxuriant growth and responds to higher level of nitrogen.

Guinea grass. *Panicum maximum*. It is the most popular grass with heavy tillering, forming big clumps with long internodes, slender and glabrous. It cones up well in tropical condition with moist climates. Under cultivation it can be grown in any soil. It requires sufficient moisture but cannot withstand water logging. It responds to sewage irrigation. It can be harvested once in 25 to 30 days interval. The crop can be allowed in the field for several years. Dry matter content is 15- 20% Protein 6-8% free from all toxic principles.

Buffel grass. *Cenchrus ciliaris* (Kolulottai grass). It is an important perennial pasture grass and grows well in a great variety of soil and climate. It is a perennial grass with underground rhizomes. They are hardy and drought resistant and have quick regeneration capacity. It gives the highest forage yield among the grasses grown under rainfed condition. Aerial branches tufted, leaf sheath compressed with hairs raceme of spikes sessile spikelets, no lodicules.

Johnson grass.

CEREAL FODDER.

Sorghum (**Sorghum bicolor**) is grown mainly for pastures and hay. Irungu cholam (*S. dochna*) is mainly fodder type grown extensively in dry areas in the southern districts of Tamil Nadu. Young seedlings contain HCN and decreases as it matures. Side tillers and axillary branches contain high percentage of the acid as compared to the main stem.

Pearl millet. (**Pennisetum American**) It is quick growing, tillering very freely and in the case of some varieties the stem are very thin and succulent. It also lends itself to cutting more than once. It is heat and drought tolerant, high photosynthetic efficiency. It has high dry matter production, high protein content.

Maize. (*Zea mays*) It is almost an ideal cereal forage crop because of its quick growing, high yielding, palatable and nutritious qualities. It can be safely fed at any stage of growth. Mostly useful crop for making silages.

Minor Millets.

LEGUME FODDER.

Lucerne./ alfalfa (*Medicago sativa*) It is also called as **queen of fodder or green gold**. Lucerne is grown for pasturage, hay, dehydrated meal and medicinal purpose. It is an important leguminaceous fodder grown as a perennial crop in drier regions and as an annual crop in hot humid regions. It is heat and drought resistant.

Cow pea. *Vigna unguiculata*.

It is the most important leguminous fodder crop during summer and rainy seasons mainly due to its quick growing habit, high yielding ability and high protein content.

Desmodium. It is a tropical legume. It grows well in acid soils.

Stylosanthes guianensis. It is a summer growing perennial pasture fodder legume. *S.hamata* found to thrive in alkaline soils. *S.fruiticosa* is from India. It is an herb and small shrub. It thrives in light soils due to its deep rooting system.

Desmodium. *D. tortuosum/ intortum* is commonly known as green leaf desmodium, is a large trailing and climbing perennial rooting at nodes and having a deep tap root. It can be harvested 2-3 times. Shade tolerant green manure cum fodder produces profuse seed. Protein 22%.

Clitoria ternate. (Sangu puspam.) Suited to dry land pastures highly self sown crop. Grows well with chenchrus seeds and roots have medicinal value. Protein 16-28%.

Sirato. *Macroptilum atropurpureum*. Drought resistant, twiner legume, component in pasture, grows well with kolukattai grass, suitable in coconut garden. Protein 15%.

TREE FODDER.

Subabul. *Leucaena leucocephala*. Among the browsing leguminous trees it lops the best. It provides economic nutritious and highly palatable forage to livestock and poultry.

Glyricidia sepium. It is a medium tall tree grown in tea coffee and coca plantation for shade. It is pruned for green manure purpose.

Agathi

Erythin

Acacia

GREEN MANURE AND GREEN LEAF MANURE.

Green manure is generally a leguminous crop raised in a field and incorporated in situ. E.g. Sunnhemp, daincha.

Green leaf manure. It is a practice of cutting and applying them to the dields and ploughing them e.g. Neem, calotropis, glyricidia.

Sunnhemp. *Crotalaria juncea*. Erect herbaceous shrub. Cylindrical stem silky appearance pods oblong inflated and hairy.

Sesbania speciosa.

Daincha.

Tephrosia noctiflora.

Neem. *Azadirachta indica*. Evergreen tree with plenty of foliage. Loppings once or twice a year.

Pungam. *Pongamia glabra*. A leguminous ever green tree. Lopping is done once or twice a year.