DEPARTMENT OF AGRONOMY

AGRO.301(N/S) CROP PRODUCTION II

Lecture No.1:-

Importance of oilseed crops - edible and non – edible oils – nutritional value– importance in Indian economy – constraints in oilseed production – need for improvement of productivity and production.

The crops that are cultivated for the production of oils are known as OILSEED CROPS. Oilseeds are the raw materials for vegetable oils and they are energy rich crops. Oilseed crops are the most important commercial crops in India. Edible oils are next to food grains in Indian diet. The Rapeseed and Mustard, Sesamum, Sunflower, Safflower, Linseed, Soybean, Niger, Ground-nut and Castor are the most important oil seed crops of India.

Classification:-

The oilseed crops are classified according to the nature of oil produced as follows:

1) EDIBLE OILSEED CROPS:-

The most important source of supply of edible oils are the seeds known as edible oil seeds and the crops belong to this category are known as edible oil seed crops.
E.g., Rapeseed & mustard, sesamum, groundnut, niger, sunflower, safflower, soybean etc.

2) NON-EDIBLE OIL SEED CROPS:-

The most important source of supply of non-edible oils are the seeds known as non-edible oil seeds and the crops belong to this category are known as non-edible oil seed crops.
E.g., Castor, Linseed etc.

Nutritional Value of Oilseeds:-

The bio-chemical composition and quality of the oilseeds and their products are important for the food and feed purposes.

- Edible oils are the concentrated sources of energy. The energy content of oil is much higher (39.80 MJ/kg) than protein (23.88 MJ/kg) or carbohydrate (16.76 MJ/kg).
- They contain useful carbohydrates, essential fatty acids and vitamins A,D,E and K. and provide essential fatty acids.
- Oil cakes/ oil meals are rich sources of protein (40-60%) to human and animals. They can also be used as organic manures.
- Oil quality for food purpose can be described in terms of Saturated Fatty Acid (SFA), Mono-unsaturated Fatty Acid (MUFA) and Poly Unsaturated Fatty Acid (PUFA) .

Saturated Fatty Acid (SFA) - Palmitic and Stearic acid

They have direct relation with blood cholesterol and coronary heart diseases as it increases low density lipoprotein that is harmful .

Unsaturated Fatty Acid (SFA) - Oleic, Linoleic , Linolenic and Erucic acids.

Linoleic & Linolenic acids (Poly Unsatutated Fatty Acids – PUFA) are Essential fatty acids (not synthesized by human body and are to supplied from outside) and if they are absent, it leads to physiological disorders.They increase high density lipoprotein, which is beneficial.

- Groundnut, coconut, sesame and sunflower oils have moderate amounts of saturated fatty acid but lack in one essential fatty acid i.e. linolenic acid.
- Soybean, safflower and mustard oils have both essential fatty acids as Linoleic and Linolenic acids.
- Rapeseed and mustard oil have high amount of erucic acid, an anti nutritional factor and leads to coronary diseases.

Keeping Quality of Oils :

The ratio of oleic to linoleic acid affects the storage ability of edible oil and hence affects the nutritional quality. It shuld be greater than 1.6 for longer shelf life.

- Sunflower and safflower oils cannot be stored for longer periods.
- Soybean oil looses its original flavour after once deep frying.
- Groundnut oil has very good stability due to the presence of tocopherols (vit E) and can be stored at room temperature even upto 18 months without any quality deterioration.
- Sesamum oil – highly stable due to the presence of ' Sesimol', anti-oxidant
- Mustard oil is also rich in vit.E and has good stability at high temperature also.

IMPORTANCE OF OIL SEED IN INDIAN ECONOMY :

1) In terms of vegetable oils, India is the fourth largest oil economy in the World after USA, China and Brazil.
2) India is one of the major oilseed producing countries in the world accounting for about 16% of the area and 10% of world oilseed production.
3) In India oil seeds occupy nearly 14% of country's gross cropped area and contributes to 5% of the GNP and 10% of the value of the agricultural products.
4) The oil seeds contain 20 – 60 % oil, which is chiefly consumed as food and energy source. They are energy rich and cash value crops.
5) The edible oils are used as cooking oil, vanaspati and proteins.
6) The oil seed crop earn lot of foreign exchange of 1,300 crores of rupees is saved during 2008-09 by exporting oil seed.
7) The oil seed cultivation also provides employment to rural people. It is estimated that in India 35 million people are engaged in oilseed production and one million in their processing.
8) The oldest non-food use in lamp oil and as a lubricant which are used in textile and leather industries.
9) Vegetable oils and its derivatives are biodegradable and eco-friendly thus they can be used as diesel substitutes.
10) Vegetable oils have a number of industrial uses such as plastic films, metallic foils, Soaps, Detergents, Condiments, Cosmetics, Plastic, Polymers, Organic coatings, Printing ink, Oiled cloth, linoleum, rubber additive as substitutes to hydraulic & brake oil & chemical intermediates.
11) Oil seeds contain useful carbohydrates, essential fatty acids, vitamins like A, D, E and K and also contain 18 essential aminoacids & trace elements.
12) Oil seed crops can serve as pasture, cover and green manure crops. They are also used as fodder and for silage.
13) The oil seed cake which has 40-60% protein is worth while as animal feed and organic manure.
14) In India, direct export of cakes has earned foreign exchange of INR 2,200 crores but can be upgrade as valued human food.
15) Vegetable oils have medicinal and therapeutic value and also used as laxatives. E.g., Castor, Safflower & Sunflower oil.

Safflower tea – prevents cardiovascular diseases and gynecological disorders
- if consumed daily, it reduces blood pressure

16) Oil seeds are energy rich crops and in terms of energy equation.
1Kg of oil = 1.66 g of proteins =2.37g of CHO
17) Certain oil seed cakes have vermicidal action & it is used for pest control purposes.
E.g., Mustard, Castor
18) Lecithin is a co-product in oil industry which is used as emulsifier in pharmaceutical products, bakery products & other food stuffs.

Thus, oilseed crops can be viewed as producers of high quality edible oils and at the same time they are efficient low polluting chemical factors that can be metamorphosed to produce value added products, including the substitute for fossil fuel.

CONSTRAINTS IN OIL SEED PRODUCTION:-

There is an imbalance between demand and supply in edible oils due to low productivity of oil seeds. The constraints in oil seed production are:-

1. Oil seeds are energy rich crops, but are grown in energy starved conditions. More than 85% of the area under oilseeds is rainfed, often cultivated with low input and poor management practices.
2. Most of the oil seed crops are raised in marginal and sub marginal lands which are having poor fertility status.
3. Oil seeds are subjected to the vagaries of the monsoon resulting in lower yields as compared to irrigated crops.
4. Lack of suitable HYV or hybrids which are having higher levels of oil content.
5. Most of the cultivars of oil seed crops are drought susceptible and HYV are generally long duration (> 100 days).
6. Small and marginal farmers generally cultivate the oil seed crops which are still not well adapted to new farm technologies.
7. In India, most of the soil seed crops are grown as monocropping in traditional areas without crop rotation which results in perpetuation & development of inoculum of pests and diseases, without crop rotations. Yield losses due to diseases and pests accounts for 40%. The attack of insect pest mainly aphid is one of main causes of low yield of oil seed crops, particularly rapeseed & mustard.
8. Inadequate supply of best quality seeds to the farmers when compared to cereal crops.
9. Failure of hybridization and seed multiplication programmes in oil seed crops compared to cereals.
10. Seed multiplication ratio is very very low in case of oil seed crops.
11. The progress in respect of oil seeds has not been substantial, mainly because food grains were given first priority in research & development.
12. Supply of desired inputs and transfer of technology from farm institutions to the farmer is very very poor.
13. Lack of farm implements and machinery for sowing and post harvest processing
14. Lack of suitable post harvest technology to prevent post harvest losses & also to avoid the deterioration of quality of oil seed.
15. Lack of storage, grading and marketing facilities in rural areas mainly due to future trading.
16. The efficiency of oil extraction units or expellers is very poor.
17. Scarcity of short, high yielding input responsive drought/insect/pest resistant crop varieties.

NEED FOR IMPROVEMENT OF PRODUCTIVITY AND PRODUCTION :

In India edible oil consumption is growing at the rate of 6-8% annually due to the rapid economic growth and increasing consumption.
The country,s demand for vegetable oils is expected to increase to 18.3 M.t and 21.8 M.t by 2015 and 2020 respectively. This is roughly equivalent to about 55 and 66 M.t of oilseeds

The Indian Central Oilseed Committee (ICOC) was established in 1947 to increase the oilseed production through co-ordiated research effort.

All India co-ordinated Research Project on Oilseeds (AICRPO) was set up in 1967 to carry out location specific research o different oil seed crops.

Directorate of Oilseed Research (DOR) was established in Hyderabad on 1st August,1977 to guide the research & development in nine mandate crops.

The oilseed scenario in India had undergone dramatic change with the initiation of TMO (Technology Mission on Oilseeds) in 1986. The highest oilseed production was achieved by 24.75 M.t during 1994-95 against 11.0 M.t during 1986-87. This dramatic change of Indian oilseed production from a net importer to a status of self sufficiency and net imported during early nineties has been popularly known as **Yellow Revolution**.

In post WTO regime, there is a great need to adopt multifaceted strategy for improving oilseed production through increase in area (38%) and productivity improvement (62%) including processing facility. There is a great scope for increasing the yields of oil seed crops.

A no. of oil seed de velopment projects such as NODP (National Oilseed Development Project) (1984-85) , Oilseed Technology Mission etc., have been in operation & they are essentially an extension of intensive oil seed development programme. The GOI launched ISOPOM (Integrated Scheme for Oilseeds, Oilpalm, Pulses and Maize Development Programme) to provide flexibility to the states in implementation based on regionally differentiated approach to promote crop diversification.

STRATEGIES FOR INCREASING THE OIL SEED PRODUCTION IN INDIA:-

Following measures/strategies should be taken for increasing the yield of oil seed crops:

1. Bringing more area under irrigation. (as drip & sprinkler irrigation)
2. The good quality seed of recommended varieties for the specific area & situations should be chosen and cultivated.
3. The seed should be treated with fungicide, bactericide etc. as recommended before sowing of seed in the field.
4. It is most important to select a levelled field as far as possible and good drainage should be provided for the oil seed crops, especially for the kharif crop. Water logging condition is harmful for these crops.
5. A fine seed bed free from weeds and clods should be prepared to facilitate good germination & stand.
6. The sowing of the seed should be done at appropriate time with proper row spacing in case of line sowing crop and the optimum plant population should be maintained by

thinning at 15-20 days after sowing. Early sowing escapes the attack of many diseases and pests. Under Paira cropping, sowing should be done at the dough stage of paddy.

7. The suitable variety for each crop must be chosen for the tract and season.
8. Adoption of improved crop production technologies.
9. The recommended doses of fertilizer for the specific crop should be applied at appropriate time.
10. The field should be kept free from weeds particularly during first 20 – 30 DAS.
11. The protective irrigation should be provided wherever possible during kharif season and irrigation should be applied at critical stages for rabi / summer crop.
12. The plant protection measures should be under taken, if needed.
13. Harvesting should be done at right time to avoid capsule shattering and reduction in oil content of seed.
14. The seed should be cleaned and dried well before storage.
15. Oil extraction from sources such as rice bran, cotton seed and corn apart from flora under utilized plants of forest.
16. Introduction of oil seed crop as intercrops along with cereals in non-traditional areas and also in double/multiple cropping sequences.
17. Extending oilseed cultivation ie safflower, sunflower, seasame etc to under utilized situations like rice fallows.
18. Strengthening of research and extension system.
19. Strengthening of processing facilities as crushing, solvent extraction, oil refining and hydrogenation for value addition to products in the context of WTO.
20. Provision of favourable Govt. policies such as price and credit policies etc. strenghthening of farmers support system through supply of all inputs.

India (2009-10) - Total oilseeds

Area – 26.11 M.ha Production – 24.93 M.t Productivity -- 955 kg/ha

On Global basis, India ranks first in the production of castor, safflower, sesame and niger, second in groundnut, rapeseed and mustard, third in linseed, fifth in soybean and sunflower.

* **The major oilseed growing states in India are :**

Madhya Pradesh (20.3%)
Rajasthan (18.9%)
Maharashtra (13.3%)
Gujarat (12.6%)
Andhra Pradesh (10.5%)
Karnataka (10.3%)
Uttar Pradesh (3.9%)
Tamil Nadu (2.5%)
Others (9.7%) of the total oilseed area of the country.

- **Rajasthan** produces 21.3% of total annual oil seed crops followed by **Madhya Pradesh** (20.5%) , **Gujarat** (16.7%) and **Andhra Pradesh**(7.3%).
- India per capita consumption of oil is **11.6 kg/head/year** considerably lower than in developed countries as 17.8 kg/head/year. ICMR recommendation is 14 kg/head/year or 35 - 40 g/head/day.
- Indian edible oil market is the largest after China & European Union. Each year India consumes around 10 mt of edible oils.
- Consumer oil preferences in India

North India -- Mustard, Rapeseed
East India -- Mustard, Rapeseed
West India -- Groundnut
South India -- Groundnut & Coconut

- The expected demand of oilseeds production is 44, 55 and 65 mt by 2010,2015 and 2020 respectively.

* **Supplementary sources of vegetable oils** – Rice bran is highly nutritive value & cotton seed oil having 18% oil .

- **Tree Based Oils** are Jatropha, Karanj, Pongamia, Neem,Mahua, Sal etc.
- Among the major tree crops, Oil palm forms another high potential, prospective and cheaper source of edible oil in International market.

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Lecture No.2 : **GROUNDNUT**

Botanical name : *Arachis hypogaea*
Family : Leguminosae
Common name : Groundnut, Peanut, Monkey nut, Earth nut, Manila nut,moong fali (Hindi).

In Greek language ***'Arachis'* means legume** and ***'hypogaea'* means below ground**, referring to formation of pods in the soil.

Groundnut is an important oil and protein source to a large portion of the population in Asia, Africa and the America. It is a self-pollinated, annual, herbaceous legume. Groundnut, **KING OF VEGETABLE OIL SEEDS** in India, occupies pre-eminent position in national edible oil economy.

Economic uses :

1. Groundnut oil is the cooking media for preparing different food items. It is the primary source of vegetable oil requirement to the Asian people.
2. The groundnut seed contain 47-53% oil and 26% protein and 11.5% starch.
3. The groundnut kernels are good source of all B-vitamins except B_{12} and vitamin E.
4. Groundnut kernels are rich in P, Ca & Mg including micronutrients like Fe, Zn.
5. Nearly 81% of the kernels are used for oil extraction
   12% used for seed purpose
   6% - raw materials
   1% - exported in terms of Hand picked selections (HPS).
6. Groundnut kernels are also used for the preparation of food products like chikkis, G.nut milk, G.nut butter, curd including diff. bakery products
7. G.nut oil is a major source of edible oil in India. The inferior quality oil is used for making soaps, detergents, Cosmetics, paints, candles, Lubricants and some of the medicines.
8. G.nut oil is used for medicinal purposes especially for massaging polio patients & it is also used as a substitute for olive oil and also for preparation of glycerin.
9. The oil cakes are used as valuable organic manures & feeding material for live stock. It consists of 7.3% N; 1.5% P_2O_5 & 1.3% K_2O.
10. The peanut haulms contain crude protein 8–5% lipids 1–3% and minerals 9– 10%. These are used as cattle feed either in fresh or in dried stage or preparing hay or silage.
11. The peanut shells or pod walls which constitute nearly about 25% of total pod weight are used as bedding material for poultry or as mulching material during summer season to reduce the evaporative losses.
12. Shell material is also used as filler material for making mixed fertilizers and as insulation material for buildings or as fuel in boilers.
13. G.nut crop add sufficient quantity of organic matter to the soil as most of the leaves are shed just before harvesting. In some areas, G.nut is used as a green manure crop.
14. G.nut is able to fix atmospheric nitrogen @ 60 – 100 kg N /ha within 1 season.

ORIGIN:

Center of origin of G.nut is South America i.e., Matograsso a place in Brazil. It appears that Portuguese introduced the groundnut plant from Brazil into Africa. At the beginning of 16^{th} century, groundnut was introduced into India by Jesuit fathers who followed Vasco De Gama shortly after his first landing in India.

AREA AND PRODUCTION:-

Major groundnut producing countries are China, India, Nigeria, USA, Indonesia, Argentina, Sudan, Senegal and Myanmar. India ranks first in area and production contributing to 40% of the area 36% of the world production.

	Area	Production	Productivity
India(2008-09)	**6.0 M.ha**	**5.5 M.t**	**920 kg/ha**
A.P.(2008-09)	**13.01L.ha**	**10.07 L.t**	**774 kg/ha**

G.nut accounts for 28% of the total area & 36% of total oilseed production in the country.

The major G.nut producing states are Gujarat, A.P., T.N., Karnataka & Maharashtra. as per 2008 – 2009 statistics

	Area	Production Mt	Productivity (t/ha)
1st	Gujarat	Gujarat	T.N
2nd	A.P	A.P.	Gujarat

CLASSIFICATION:-

Groundnut (*Arachis hypogaea*) consists of two sub – species each containing two botanical varieties

Subspecies **hypogaea**
- Variety hypogaea (Virginia type)
- Variety hirsuta

Subspecies **fastigiata**
- Variety fastigata (Valencia type)
- Variety vulgaris (Spanish type).

COMPARATIVE CHARACTERS OF VIRGINIA & SPANISH/VALENCIA :-

CHARACTER	Virginia	Valencia/Spanish
Seed size	Medium to very large	Small to medium
Seed per pod	Usually 2, occasionally 3	Usually 2-4, rarely 3
Seed dormancy	Moderatly present	Little to none
Branching	Moderate to profuse	Sparse to moderate
Flower bud on main axis	Present	Absent
Flowering pattern	Alternate	Sequential
1^0 – lateral branches	Longer than main stem	Shorter than main stem
Growth habit	Spreading to semi-spreading	Bunch
Growth period	Long (130-175 days)	Short (90 – 105 days)
Peak flowering	8-12 weeks	6 – 10 weeks
Leaf color Leaflet size	Dark green Small	Pale green Large
Leaflet apex	Pointed	Rounded
Pod distribution	Scattered	Close to the base
Ability to growth after seed setting	Retains growing point if pods are detached	Usually dies
Linoleic acid	Low	High

COMPARATIVE CHARACTERS OF VALENCIA AND SPANISH TYPES:-

Characters	Valencia	Spanish
2^0 – lateral branches	Absent	Present irregularly to 1^0 –branches
Stem and petiole color	Purple	Green
Hairiness	Less	More
Leaflet color	Dark green	Light green
Inflorescence Seeds per pod	Single Usually 3 -4	Compound Usually 2
Constriction, reticulation & beak on the pod	Less prominent	More prominent
Shell thickness	Thick	Thin
Testa color	Red to purple	Rose
Maturity	90 – 95 days	100 -105days

VARIETIES:-

Groundnut var. now under cultivation fall under

Three botanical groups: Spanish, Valencia, Virginia.
Three habitat groups: bunch (Spanish/ Valencia)
Semi spreading (Virginia bunch)
& spreading (Virginia runner)

The recommended var. of groundnut are JL – 24 (Phule pragathi), TAG -24, Greeshma, Prasuna, Abhaya,Apoorva,ICGV-86590,K – 134, TPT-2, TPT -3, ICGV 86325, DRG 12, Kadiri 4,5,6, Jcc-88, ICGS 11,ICGS - 44 ICGS – 76, Kalahasti, Narayani, TG 26, TMV 2, J-11, Gaug – 1 etc.

Lecture No. 3 **CLIMATE AND SOILS**

Climate:

Groundnut is predominantly a crop of the tropics. The approximate limits of present commercial production are between latitudes **40^{0}N and 40^{0}S** and up to an attitude of **1065 m**, where **rainfall during the growing se ason exceeds 500 mm.**

Rainfall:

The crop can be grown successfully in places receiving a minimum of 500 mm and a maximum of 1250 mm. From the productivity of groundnut in several countries, it is evident that semi – arid and arid regions with 500 – 700 mm rainfall during crop period are ideal for groundnut production.

- Rainfall should be adequate during flowering and pegging stages.
- Ideal RF for successful groundnut crop would be
  - 80 – 120 mm ? during summer to facilitate preparatory cultivation
  - 100 – 120 mm ? at sowing
  - 200 mm ? from flowering to peg penetration
  - 200 mm ? early pod development to pod maturity
- Rainfall is the most important factor limiting the productivity of rainfed groundnut due to variability in amount and distribution of RF.
- Continuous rains leads to excessive vegetative growth resulting in poor pod yield.
- Rains at harvest cause germination of kernels in non-dormant Spanish and Valencia cultivars besides problem in pod drying.

Temperature:

Soil temperature <18^{0}c delays emergence of seedlings. The embryo is killed above 54^{0}c.

- G.nut performs well in dry temperature range b/n 24^{0}c & 33^{0}c. but it can s urvive up to 45^{0}c.
- Ideal temperature for reproductive stage is b/n 24 – 27^{0}c
- Rate of pod growth will be maximum b/n 30^{0}c & 34^{0}c.

Light :

- ✓ Groundnut is day length insensitive plant.
- ✓ About 60% solar radiation for 60 days after emergence appears to be critical.
- ✓ Low light intensity
  - Prior to flowering ? slow down the vegetative growth and increases the plant height.
  - At early flowering ? leads to flower abortion.
  - At pegging ? reduces peg and pod number & pod weight.

Flowering phase is more sensitive to reduced light intensities.

In the absence of soil moisture stress, clear days have greatest potential for opt. growth and development leading to high pod yield.

SOILS :

Groundnut can be grown on all types of soils such as sandy, sandy loam & heavy black soils. It thrives best on sandy loams.

- ❖ Most suitable soils for groundnut production are well-drained light sandy loams with an ample supply of calcium and moderate organic matter.
- ❖ Heavy and stiff clay soils are not desirable as they tend to become hard during dry weather thereby interfering with peg penetration into the soil and also makes the harvest extremely difficult.
- ❖ Groundnut is one of the most acid tolerant crops with a critical P^H range of 5 – 5.5.
- ❖ It is moderately sensitive to soil salinity & highly susceptible to waterlogging.

Gujarat, Southern Rajasthan (Chitorgarh, Udaipur & Jhawar)

TILLAGE:-

Land preparation for groundnut depends on the soil type and onset of monsoon for rainfed crop and on the previous crop grown for irrigated crop.

- ❖ Light red soils are usually ploughed twice with the summer rains followed by 2 – 3 harrowings.
- ❖ In general, deep ploughing of light soil once or twice results in higher pod yield than repeated shallow ploughings for rainy season crop as deep ploughing aids in higher rainwater storage in root zone to minimize the adverse effect of drought during the crop season.
- ❖ In A.P. , black soils are only harrowed (4 – 5 times) several times without any ploughing.
- ❖ For irrigated crop, one light ploughing (even at high soil moisture content to hasten soil drying) followed by harrowing for 3 – 4 times at 2 – 3 days interval.
- ❖ Optimum depth of ploughing is 15-20 cm. If too deep ploughing is done, it leads to development of pods in deeper layers which makes the harvesting difficult.

SEASONS:-

The crop growing season should be ideal for growth and development of crop for opt. yield.

Kharif :- 90% area is under groundnut is during kharif under rainfed conditions.
Average yields are comparatively low due to erratic behaviour of monsoon i.e late onset of monsoon, dryspell during critical crop growth stages, heavy rains at later stages or early withdrawl of monsoon. Pest & disease incidence is also high in kharif. The climate will be cloudy with lesser sunshine.

- season extend from April to August.
- In black soils, sowings may be delayed even upto August/September to avoid heavy rains effect on germination.
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Rabi :- G.nut cropping during rabi is limited to areas where winter is not severe & temp. do not grow below 15^0c. It is confined to states of T.N, A.P, Karnataka, Orissa, Maharashtra and Gujarat.
It is grown under irrigated on uplands or with supplemental irrigation in rice fallows.

- Sowing period extend from October to December.
- Second half of November is the ideal sowing time.

Summer :-

G.nut yields are three times higher during summer than kharif due to ideal climate as clear sky, good light intensity and less incidence of pest and diseases. It is also grow completely under irrigation althrough the crop period.

Drymatter production is nearly 25.7 g/day as against 14.8 g/day in kharif.

- sowing period: mid – Dec. to mid-Jan is ideal for higher yield.

Optimum time of seeding:-

In A.P.

	Kharif	Rabi	Summer
North coastal	I F.N. of June	II F.N. of November	15 Dec. to 15 Jan.
Telangana	I F.N. of June	II F.N. of November	15 Dec to 15 Jan.
Rayalaseema	15 June to 7 July	II F.N. of November	!5 Dec to 15 Jan.

SEEDS AND SOWING

Seed selection:-

- ✓ Germination < 85% is not considered satisfactory.
- ✓ Selected pods are thoroughly cleaned, dried, packed preferably in gunny bags & stored in a well ventilated place.
- ✓ G. nut pods for seed purpose are usually hand shelled about a week in advance of sowing. The viability of seed will be lost if shelled long before seeding .
- ✓ Shellers are also used for shelling the pods to minimize the cost of groundnut production.
- ✓ After shelling, shrivelled and damaged seeds are rejected by hand picking.
- ✓ Seeds retained on 5mm sieve (100 Kernel wt. above 27g) germinates early and produce vigorous plants for high pod yield.

Seed treatment:-

Seed treatment against seed and soil born diseases is essential for stand establishment by preventing damage to seeds and seedlings emerging from soil.

Seed treatment with Thiram @ 3g/kg,

Bavistin (2g/kg) or DM – 45 (3g/kg)is effective for about 20days from sowing.

Most of the chemicals used for seed treatment against fungal & bacterial diseases also affect Rhizobium, thus rendering the inoculation in effective for a short time.

- o When both seed treatment & inoculation are essential, seeds may be treated with fungicides & rhizobium culture is sprayed into seed rows & covered with soil.
- o Rhizobium strains for kharif - NC – 92 Tal -1000& THA -205

  Rabi – IGR – 6

  Summer – IGR – 40
- o Granulated Rhizobium strain can also be sown with seed in the furrows.

SEED RATE AND SPACING:-

Cost of seed constitutes 37-50% of total cost of cultivation. Hence, it is essential to follow good seeding practices.

	Seed rate (kg/ha)		Spacing	
	Bunch type	**Semi-spreading & spreading**	**Bunch type**	**Semi spreading & spreading**
Kharif (rainfed)	120	150	30 x 10 cm	30 x 15 cm
Rabi (irrigated)	150	180	22.5 x 10 cm	30 x 10 cm
Summer (irrigated)	150	180	22.5 x 10cm	30 x10 cm

- Gap filling, if necessary, should be completed within a week taking advantage of moisture at the time of sowing the seed.

Method and depth of sowing:

Groundnut seed can sown either by using mechanical or bullock drawn seed drill or by dropping the seed in plough furrow behind the country plough. Hand dibbling is also adapted to a limited extent.

Kharif:- drilling or dropping seed in plough furrows at 5 -7 cm soil depth.

Rabi & summer: - Dropping seed in plough furrow at 4 – 5 cm soil depth.

Depth:- In light, soils, the seeds are sown to a depth of 5 -7 cm and in heavier soils to a depth of 4 -5 cm

Lecture.No. 4 **NUTRIENT MANAGEMENT**

For every tonne of pods & 2t of haulms about 63 N, 11 P_2O_5, 46 K_2O, 27 cao & 14 Mgo kg/ha are removed by the groundnut crop. A balanced fertilizer programme with particular emphasis on p, k, ca & mg is essential for opt. yield.

Apply 10t well decomposed FYM and incorporate it into soil just before the onset of monsoon.

Nitrogen:-

The necessity for fertilizer nitrogen to groundnut is reduced because of being a leguminous crop, it fixes atmospheric 'N' into the soil with root nodules. Around 200 kg N/ha can be fixed under ideal conditions. Number of cowpea cross inoculation group strains are available as **NC-92 & TAL 1000,THA 205**.

In general, 20 kg N /ha – entire dose as basal is recommended for rainfed G.nut

30 Kg N/ha – in 2 equal splits at seeding & 30 DAS – irrigated crop.

However the nitrogen fixation process of plant starts working at about 20-30 days after sowing, when the nodule apparatus is fully formed. Till that time to meet the requirement for plant growth, an initial boost as starter dose of 10 kg/ha is necessary for rainfed groundnut. Depending on the number of nodules, another 10 kg/ha at 30 DAS can be top dressed depending on the rainfall.

Nitrogen should be preferably applied in the form of Ammonium Sulphate as it also supplies the sulphur.

Phosphorus:-

The total amount of 'P' uptake by groundnut plant is relatively small compared to N & K. It promotes root growth and multiplication of Rhizobium. phosphurus is applied when the available phosphorus is < 35 kg/ha

Opt. doses are

Rainfed – 40 kg P_2O_5 /ha irrigated – 50 kg P_2O_5/ha

Entire dose should be applied at sowing along with N by placement preferably using ferti seed drill.

Single super phosphate is the best source as it contains 16% P2O5, 19.5% Ca & 12.5% Sulphur along with some traces of Zn & other micronutrients traces. Therefore response to SSP is higher than with DAP at equal nutrient basis.

Phosphobacteria as *Pseudomonas striata* and *Bacillus polymixa* solubilises the native phosphorus and recorded 13-20% increase in groundnut yield.

Mychorhizal fungi inoculations have been beneficial in field tests in India and quantification of yield benefits are yet to be made in terms of phosphorus fertilizer economy and production.

Potassium:-

As most of the Indian soils are rich in K, groundnut in general will not show any significant response to applied potassium.

→ There is no necessity for potassium application to rainfed gr oundnut yielding around 1 t/ ha.

Response is observed only when the available potassium in soil is < 150 kg/ha.

For rainfed groundnut - 40 kg/ha

For irrigated crop - 50 kg K_2O/ha provided N is applied at recommended rate.

Calcium & sulphur: -

These two nutrients are absorbed by pegs & developing pods and the common source of supply is gypsum.

- Adequate calcium is essential in root and pod zones for yield and quality of kernels. Calcium deficiency leads to unfilled pods called pops and darkening of plumules of embryo.
- Sulphur is highly essential as it is directly involved in the biosynthesis of oil. It improves nodulation of Rhizobium and prevents the premature leaf fall & increase the pod & oil yield.

Ca & S are supplied to crop through cao or gypsum & it has been observed to increase the yield by more than twice depending on its availability in the soil.

About 1 meq / 100 g soil in the root zone depth and 3.0 meq/100g soil in pod zone are threshold values for calcium sufficiency.About 100 ppm of heat soluble sulphur is the critical limit of available sulphur for groundnut.

- Gypsum application @ 500 kg/ha near pegging zone as top dressing at flowering (30 DAS) appears to be ideal .
- If heavy rains occur within 2weeks after application then a second lighter application of gypsum is necessary around 3weeks after first application.

K: Ca: Mg ratio :-

G. nut is sensitive to imbalanced nutrient supply. The K:CMg ratio is more important than the total amount.

- Increase in conc. of Mg in nutrient solution decrease K uptake by G. nut & also decreases Ca uptake.
- There is a mutual antagonistic effect on the uptake of K, Ca & Mg.
- The ideal ratio is **4 : 4 : 2**.

Zinc, Boron & Iron:-

ZINC: Zn def. is common on sandy & sandy loam soils. The critical limit of available Zn in soil is <0.6 ppm.

Application of Znso4 @ 2 kg /ha once in 2 years corrects the deficiency. If it is observed in standing crop, foliar application of 0.2% $ZnSO_4$ along with 0.2% lime can correct the deficiency.

BORON: 'B' def. leads to HOLLOW HEART. Deficiency has been reported in light soils of Punjab & T.N.

The threshold level of boron is 0.25 ppm.

Deficiency can be corrected by soil application of 5–10 kg/ha of boron. In standing crop, corrected by 0.1% borax spray.

IRON: Iron chlorosis is largely due to its reduced availability in the soil. Immobilization of iron in the soil may be due to high levels of lime, high PH (>7.6) or high levels of bicarbonates in soil or irrigation.

spraying of ferrous sulphate mixed with 1% of ammonium citrate around 50 DAS corrects iron deficiency.

In Andhra Pradesh

Kharif 20 -40 – 50 kg N, P_2O_5, K_2O/ha

Rabi & summer Irrigated -- 30 – 40 – 50 Kg N, P_2O_5, K_2O /ha

Lectur No.5 **WEED MANAGEMENT**

- Weed competition is critical upto 35 DAS.
- Yield losses may be to the extent of 70%. , especially under rainfed conditions.
- When once pegging begins (40 DAS), there should not be any disturbance to pegs through manual or mechanical weeding.

Important weed flora in the groundnut crop are

Cyperus rotundus ; chloris barbata, celosia argentena, commelina benghalensis; *Boerhaavia diffusa* etc.

Cultural management:

- ✓ Hand weeding is done twice, first around 20 DAS & 2nd at about 35 DAS.
- ✓ Inter cultivation usually starts around 10 days after emergence & continues upto 35 DAS at 7 – 10 days interval till pegging begins.
- ✓ Cost effective weed management under rainfed conditions is, repeated intercultivation (harrowing) upto 35 DAS followed by hand weeding.

Use of herbicide:-

- o A mixture of oxadia zon & Dinoseb each @ 1.7 kg /ha gives excellent control of weeds besides reducing stem rot in G.nut.
- o Fluazifop (150 – 250 g) is a promising post herbicide for controlling grasses, particularly cynodon dactylon, 35 – 40 DAS
- o IWM involving the above two appears most effective & economical, provided the crop is not subjected to prolonged drought or soil moisture stress during the crop period.

Pre-plant incorporation of Fluchloralin @ 1.25 – 1.5 kg/ha

Pre-emergence application of Pendimethalnin @0.6-1.5 kg/ha or Alachlor @ 1.5-2.0 kg/ha.

Water management:-

Groundnut crop is mostly cultivated during kharif under rainfed conditions. Irrigated groundnut accounts for over 20% of the total area under the crop in the country & it yields around 4.2 t/ha.

Critical stages:-

- ❖ The period from **peak flowering to early pod development (45 – 75 DAS)** is the most sensitive to soil moisture stress. In other words, flowering, peg penetration and pod development stages are the 3 moisture sensitive stages for pod yield.
- ❖ Very early growth phase (upto 20 DAS) is least sensitive.

Scheduling of irrigation:-

- ❖ On sandy loam soils, scheduling irrigations at 25% DASM throughout the growth period results in high pod yield.
- ❖ Irrigating the crop at

  25% DASM – from pegging to early pod development

  50% DASM – at other stages appear to be ideal for high WUE without significant reduction in pod yield.
- ❖ An IW/CPE ratio of 1.0 at moisture sensitive stages and

  0.6 during other stages leads to high WUE.
- ❖ The water requirement of groundnut, on an average., ranges b/n 450 & 650 mm & WUE is 0.6 to 0.8 kg /m^3 (pod yield per unit of water evapotranspired).
- ❖ If irrigation water is not limiting , then a total of 8 irrigations are adequate for optimal yield. pre –sowing irrigation followed by an irrigation at 25 DAS, 4 irrigations at 10 days interval & final two irrigations at 15 days interval.

- ❖ At times of deficit supplies, an irrigation at 25 DAS followed by 2 at 15 days interval b/n 45 & 75 DAS appears to be minimum requirement & it can minimise yield losses due to soil moisture stress.

The first irrigation is given at 25 DAS to create moisture stress in the soil which is desirable.

→ to get the good root system.
→ to reduce excessive vegetative growth.
→ Encourage the better nodulation
→Induce heavy flowering in a single flush (synchronous flowering)

METHOD:

The crop is usually irrigated by check basin method. Border strip is more suitable than other methods

Sprinkler irrigation is ideal for g. nut crop on sandy soils.

CROPPING SYSTEMS:-

At national level, a major cropping systems have been identified. The groundnut crop is predominantly raised as intercropping or sequence cropping depending upon on the type of component crop & R.F, distribution.

SEQUENCE CROPPING:-

In general, g. nut crop is rotated with cereals commercial crops & oilseed crops. Yield of cereals following g. nut is usually increased by 25%.

Promising crop sequences for A.p., are:-

Rainfed	Stored soil moisture	Irrigated
2 years	2 crops/year	2 – 3 crops/year
G .nut – sorghum	G. nut – Chick pea	G. nut – Maize
- Pearlmillet	- Safflower	- onion
- Sesame	- Sesame	
- Tobacco		

INTERCROPPING:-

Imp. Cereal crops grown with g. nut are pearlmillet, sorghum & maize. Other long duration crops grown with g. nut as intercrops are pigeonpea, cotton and castor.short duration intercrop with g. nut are sesame, sunflower, cowpea, green gram, black gram. Suggested intercropping systems in A.P. → G. nut + pigeon pea → 7:1 to 15:1 + Cowpea → 6:1
+ Castor → 5:1, 7:1 + Pearlmillet → 3:1.

HARVESTING:-

Generally bunch and semi- spreading type comes to maturity by 100 – 105 days where as spreading type it is 125 -135 days.

The prominent symptoms of maturity:-

- ➢ Yellowing of leaves .
- ➢ Necrotic spotting on the leaves
- ➢ Dropping of older leaves / leaf fall.

- The pods become very hard & tough, they give cracking sound when split open with fingers.
- The inside of the shell turning dark, with netted venation
- Seed coat develops pink or red colour (normal colour of the varities)
- Raising of the soil to the base of the stem is observed .

Generally harvesting is done by pulling or lifting the plants from the soil with pods intact.If soil moisture is adequate, then hand pulling. If soil is dry, tractor or bullock drawn blades are used for lifting the vines with pods.

Harvesting before maturity reduces yield & oil % & seeds are highly susceptible to afflotoxins. If delayed, results in increased incidence of stem rot, weakening of gynophore/peduncle & some of the pods may remain in soil itself at the time of harvesting.

Stripping: - The process of separating pods from haulms in bunch type, if vines are still green, plants is knocked against a cross bar to dislodge the pods.

- The most common method is stripping pods with hand.

At the time of harvest, pods usually have moisture content around 40 – 50% & hence need to be dried to 10% moisture content for safe storage.

- Drying should be done rapidly to prevent fungal moulding
- Sun drying is the usual method of drying.
- Summer g. nut should be dried in shade to prevent loss of viability, if it is for seed purpose.

Storage:-

Storage at farmer level is invariably in the form of pods. Farmers usually dispose of groundnut pods within a month from drying yard itself. A few store it for 6 months (till kharif seeding) in anticipation of high price.

- Pods for seed purpose are stored for 7 – 8 months.
- Pods for seed purpose are stored in earthern pots, mud bins or bamboo baskets or Gunny bags having polythene lining.

If the seed moisture content is above the critical level of 9% then Aflatoxin production due to *Aspergillus flavus* just before the post – harvest drying & mould growth at later stage takes place.

Yield Attributes:-

Groundnut kernel yield is the product of pod number, number of kernels per pod and weight of kernels. Kernels per pod vary from 1-5, pods per plant from 5-105 and 100 kernel weight from 28 – 62 g (ICRISAT 1987). There is a high positive correlation between the number of mature pods and pod yield.

Yield:-

Rainfed: - 10 – 15 q/ha
Irrigated: - 20 – 25 q/ha.

Harvest Index : The harvest index in groundnut varies between 0.35 and 0.50 in groundnut.

QUALITY CONSIDERATIONS:-

Quality of groundnut is largely determined by volume weight of pods, shelling %, 100 kerenel weight, oil content, free fatty acid content, colour of pods & testa colour.

1) Volume weight of pods:-

- It is the wt. per unit vol. of pods, which indicates maturity & development of kernels when the pods are disposed by volume.
- Small pods have high volume weight than those of bigger pods .
- The avg. 100 pod weight varies from 73g (7 MV – 2 , Spanish bunch) to 107 g (M -13- Virginia runner)
- Volume weight is influenced by RF distribution at pod development & Ca & S in pod zone.

2) Shelling percentage:- Shelling – separation of kernels from pods.

- It is the % of kernels to pods by weight.
- It ranges from 68% in M13 to 76% in TMV-2.
- Irrigated crop has lower shelling % than that of rainfed crop.
- It depends on thickness of the shell, development of kernel & following pattern during the crop period.
- It is influenced by genotype, Rainfall distribution & Ca in pod zone.

3)100 Kernel weight:-

- It is an indication of proper kernel development.
- Average 100 kernel weight ranges from 30 g (TMV 2) to 78 g (in M13).
- It is a varietal character with marginal influence of RF distribution, nutrient management & ability of translocation of photosynthates from source to sink.

4) Oil content :-

- It generally ranges from 48 – 51 %
- It depends on temperature during first 3 weeks of pod development, maturity of kernels which is influenced by RF during development stage & 'S' content in soil root zone.
- Virgina runners have higher oil content than Spanish bunch types.

5) Oil quality :- The free fatty acid content in oil will decide the shelf life of oil. Higher the free FA content lesser is the quality & faster is the deterioration of oil quality.

- Oil etracted from runner type have best quality due to higher concentration of TOCOPHEROL.
- The ratio of saturated to unsaturated fatty acid also decide oil quality. The ratio of oleic acid to linoleic acid should be > 1.6 to have long shelf life.

Colour of pods and testa of kernel :-

Attractive colour of the pod & testa gets higher price in the markets especially for direct consumption. In general, light golden yellow colour of pods are preferred & fetch more price in market.

Kernels with pink , rose or light brown testa are preferred.

Grading :-

For easy marketing of pods & kernels the grading is done. Pods are graded into 3 categories & kernels into 4 categories based on size.

PODS	**KERNELS**
1) Large/bold	1) Extra large
2) Medium size	2) Large
3) small size	3) Jumbo(shrivelled)
	4) Splits(ill filled)

EXPORT POTENTIAL:-

- HPSK & G.nut oil cake are exported to other countries. But in recent years export of these products are drastically reduced due to increase afflatoxin load in the products & increasing demestic demand.
- China is the largest exporter of HPS kernels followed by USA & india.
- The Indian share for the export of Hps is only 2%
- G. nut cake is a good veg. protein & poultry feed. India is exporting large quantity of GN cake in western countries till 1980. Later on the export of G.nut cake was significantly reduced due to higher levels of Aflatoxins.

Lecture No. 6 CROP PRODUCTION– II Course No.Agro 301

SESAME

ORIGIN: Ethiopia Sesamum indicum

DISTRIBUTION:- Major sesame producing countries are India, China, Myanmar, Sudan, Pakisthan, Mexico, Ethiopia, Srilanka and Burma.

→ In India, major sesame cultivating states are Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Tamilnadu and Maharashtra

→ Major exporting countries are Sudan, Nigeria.

→ India stands first in both area and production.

AREA PRODUCTION & PRODUCTIVITY:-

	World	India	Andhra Pradesh
Area (M.ha)	8.80	1.74	0.132
Production(M.t)	2.80	0.60	0.018
Productivity(Kg ha $^{-1}$)	3.82	3.40	140

VARIETIES:- Popular varieties in Andhra Pradesh → Gauri, Madhavi,YLM-11, YLM-17, .
Latest Variety in Andhra Pradesh → Chandana (ICS-94)
Brown seeded varieties → Grown in Coastal areas.

Gauri, Madhavi, YLM-11, YLM-17, Varada, Usha, TMV-6 etc.

White seeded varieties → Grown in Telangana area
Rajeswari, Swetha, Pratap, RT-125, Mrug-1, TG-22, T-12, T-78 etc.,

Black seeded varieties → Krishna, Soma, etc.,
Reddish brown variety → Rama.

CROP ROTATION:-

Andhra Pradesh → Rice / Groundnut – Sesame

Sesame – Horse gram – Chickpea.

Rice / Potato – Sesame.

Cotton – Sesame – Wheat.

Sesame – Groundnut / Cotton / Maize

CROPPING SYSTEMS:- INTER CROPPING:-

Sesame + Greengram (1:1)

Sesame + Pigeonpea (2:1)

Sesame + Soybean (2:1)

Sesame + Cowpea (8:1)

Sesame + Groundnut (1:1)

SOILS:-

Sesame comes up well on soils with slightly acidic (or) neutral reaction. It can be grown on well drained soils and performs well in light loamy soils.

→ It is highly sensitive to water logging.

→ Very sandy, saline and alkaline soils are not suitable.

CLIMATE:-

Sesame is essentially a tropical crop grown in arid and semi-arid areas.

⇒ It is generally cultivated in tropical and sub-tropical countries.

⇒ It's main distribution is between 25^0 s and 25^0 N Latitudes

⇒ Its altitude range is normally below 1250 m although some varieties locally adopted up to 1500 m.

⇒ Generally, it requires fairly hot conditions during growth for optimum yield.

⇒ Ideal optimum temperature for growth is 25-27^0 C

.Extremely low temperatures of 10^0 C, there is a complete ceasing of growth.

⇒ Temperatures >40 C seriously affect the pollination when there is less number of capsules.

⇒ Sesame is a short day plant.

⇒ High light intensity increase number of Capsules / plant.

INFLUENCE OF RAINFALL:-

⇒ Sesame is capable of with standing a higher degree of water stress.

⇒ The crop can be grown entirely on stored soil moisture.

⇒ A rainfall of 600-1000mm results in optimum yield.

SEEDS AND SEEDING:-

SEED RATE:-

	Rainfed	**Irrigated**
Under broadcasting (Kg/Ha)	6	5
Row seeding (Kg/Ha)	5	4

Mixed (or) Intercropping → 1 Kg/Ha

SPACING:-

30 X 10 Cm in Andhra Pradesh (all seasons)

45 X 15 Cm is also recommended.

SEED TREATMENT:-

Seed treatment with Thiram (3g/kg) is effective against seed borne diseases. Seeds may be soaked in 0.025% solution of Agrimycin-100 for 30min. prior to seeding will minimize bacterial leaf spot.

SEASON – TIME OF SOWING:-

	Season		**Time**
Coastal A.P.	Kharif	→	First fortnight of May.
	Summer	→	Second fortnight of January.
Telangana	Kharif	→	Second fortnight of July.
Rayalaseema Kharif		→	May to June
	Rabi	→	Middle of January.

METHODS OF SOWING:-

1. Broad casting is usually most widely used in all situations. Seed is mixed with sand in equal quantities (or) 3 times to facilitate uniform distribution of yield.
   ⇒ After sowing, seed is covered by shallow ploughing and planting by cultivators and harrowers
2. Line sowing (or) Row seeding is done with seed drills to promote higher yields.
   ⇒ Optimum depth of sowing is 2-3 cm.

MANURES $ FERTILIZERS:-

N-P-K REQUIREMENT:-

	Rainfed	Irrigated	
N	40	60	½ basal
P	60	60	½ (30-35 DAS)
K	40	40	

⇒ Application of sulphur @ 50 Kg/ha increases the yield if soils are deficient in sulphur.

METHOD OF APPLICATION:-

Placement of fertilizer at seeding using seed drills is more effective than broadcast application.

INTEGRATED NUTRIENT MANAGEMENT:-

Integrated nutrient management consisting of 5 t ha^{-1} of FYM, 40 Kg nitrogen, 20 Kg Phosphorous and seed treatment with Azospirillum has given encouraging results at several situations.

INTERCULTIVATION:-

Sesame is sensitive to weed competition during the first 15-25 DAS. A minimum of two weedings, one after 15 DAS and another 35 DAS are required to keep the field relatively weed free. Row seeded crop facilitates use of blade harrows for intercultivation. Two intercultivations, 15 DAS and 35 DAS followed by one hand weeding keeps the field free of weeds.

WEED MANAGEMENT:-

Use of Herbicides:-

Herbicides use, especially under rainfed conditions, is very limited due to low yield, which may not compensate for the cost of herbicides. If necessary, Alachlor (1.0kg/ha) or Thiobencarb(2.0kg/ha) can be used as pre emergence spray for effective control of weeds. Use of pre emergence herbicides followed by one hand weeding around 30 DAS is the most appropriate way of weed management in sesame.

IRRIGATION:-

Water requirement is 300-350mm. For rabi crop 5-6 irrigations are required.

1^{st} irrigation → at sowing

2^{nd} irrigation → 3 WAS

3^{rd} irrigation → 6 WAS

4^{th} irrigation → 8 WAS

5^{th} irrigation → 9 WAS

CRITICAL STAGES FOR IRRIGATION:-

For rabi / summer sesame, a presowing irrigation is necessary for optimum seed germination and adequate stand establishment. Flower initiation and capsule filling stages are most sensitive to water deficits.

SCHEDULING IRRIGATION:-

Scheduling irrigations at 50% DASM is adequate. If irrigations are scheduled based on IW/CPE ratio, a ratio of 0.6 is optimum under most situations. Depending on soil type, weather conditions and crop duration, irrigations may be given once in 12 to 15 days. If irrigation water is not a limiting factor, flower initiation, maximum flowering and capsule filling results in optimum seed yield. Depending on the duration, sesame water requirement ranges between 350 and 450mm. The crop is usually irrigated by check basin method of irrigation.

HARVESTING:-

Depending on the variety, sesame crop takes 80-150 days for maturity. The crop is harvested when the leaves, stems and capsules begin to turn yellow and the lower leaves start shedding. To prevent shedding of seed, the crop should not become dead ripe in the field. The ripe plants are cut at the ground level carried to threshing yard, stacked for a week in the sun with the cut ends upwards.

QUALITY CHARACTERS:-

Sesame is the oldest oil seed crop of the world. The seed has high food value because of the higher contents of good quality edible oil and nutritious protein

SEED COMPOSITION:-

Sesame seed protein content varies from 20-28% with an oil content ranging between 48-55%. Its mineral content is around 6%..

Among oilseed proteins, sesame seed proteins are more nutritious It is rich in methionine and tryptophane. Like other oil seeds, it is also deficient in lysine. The other limiting amino acids are thionine, isoleucin and valine. Sesame seed contains 21-25% carbohydrates, 1% calcium and 0.7% Phosphorous

Sesame oil has two constituents namely sesamin and sesamol. They are responsible for very high stability of oil at room temperature, and frying temperatures. The sesamin content ranges from 0.07 to 0.6%.

Lecture No. 7 **SUNFLOWER**

Scientific Name : *Helianthus annus* Family: Asteraceae

It is an important oilseed crop contributes 14% of the total oilseed production from nine major oil seed crops. The genus Helianthus (Helio=Sun, anthus= flower). Sunflower is known as a "suryajmuki" as it is grown for ornamental purpose. It is the third most important oilseed crop of world after soybean, Rape seed& Mustard in India. The helio tropic movement is of great importance.

The area and production of sunflower crop significantly increased due to following merits of the crops.

1. Short duration (90-100 days) as it is fit well in multiple and intercropping systems.
2. Photo insensitivity of crop enables its cultivation in all seasons i.e *kharif, rabi* and *summer*
3. Wide adaptability: it comes well up in any type of soils.
4. Drought and saline tolerant: suitable for the best component crop in dry land farming.
5. High productivity per unit area per unit time with respect to yield of oil.
6. High seed multiplication ratio (1:80) with low seed rate requirement.
7. It is the best substitute for groundnut crop in contingency crop planning.
8. Due to cross pollination nature, there is a great scope for evolution of high yielding composites and hybrids.
9. Good quality oil with high level of poly unsaturated fatty acids (PUFA) content i.e linoleic and oleic acids. Llinolenic acid is absent.
10. Availability of good quality of hybrid seeds and varieties.
11. It is the best catch crop when the land is left otherwise fallow between two seasons.

USES/ECONOMIC IMPORTANCE

1. The oil content varies from 48-53% and it is premium oil with pale yellow in colour used for cooking and margarine.
2. Sunflower is a rich source of linoliec acid (64%) which helps in reducing the cholesterol deposition in the coronary arteries of the heart. All most of 90% fat is good for human.
3. Sunflower oil has high oxidative stability and it is more useful as frying oil.
4. Sunflower oil is used as industrial feed stock for manufacturing cosmetics, soaps and pharmaceuticals.
5. Oil contains high level of alpha tocopherol, a form of vit. E.
6. Oil cake contains 40-50% high quality protein and it is ideally suited for poultry and livestock.
7. The roasted kernels are used as food for human beings.
8. Sunflower is grown as green manure, fodder crop.
9. The bast fibre of the stem is source for making rough quality paper.
10. Recently sunflower oil is recognised as an alternative source for diesel engines with octane rating of 37 and it is rated as number 2 diesel oil.

ORIGIN: Southern USA (Peru) & Mexico

In 1972, commercial cultivation of sunflower was started in our country with the introduction of Russian cultivars namely; EC 68413, EC 68414, EC 68415 and Sunrise.

AREA AND DISTRIBUTION:

It is mainly grown in USSR, USA, Argentina, France, Italy and China. V. S. Pustovit of USSR is responsible for increasing oil content of sunflower from 30% to 50% by breeding methods.

	Area	Production	Productivity (kg/ha)
India	1.80 M.ha	1.04 M.t	580
AP	3.51 lakh.ha	2.69 lakh tonnes	771

Karnataka ranks first with respect to area (1015 th.ha) and production (549 th.t) followed by AP. The highest productivity was recorded by UP (1650 kg/ha) followed by T.N during 2008-09.

In AP, Kurnool, Ananthapur, Mahaboobnagar, Medak, Nalgonda and Karimnagar are the major sunflower growing districts.

- AICRP on sunflower - Bangalore.
- ARS on sunflower – Rajendranagar
- RARS on sunflower - Nandyal.

CLIMATE :-

- Basically sunflower is a temperate oil seed crop but it is adapted to tropical and subtropical climate.
- The crop requires a cool climate during germination seedling growth and warm weather from seedling to flowering. Warm and sunny days during flowering to maturity are most favourable.
- Minimum temperature for germination is 8-10^{o} c but it can germinate even up to 40^{0}c.
- Night temperature of 18-20^{0} and day temp. of 24-26^{0}c are ideal for growth, yield and higher oil content.
- The growing degree days for sunflower have ranged from 1042 to 1300 with base temperature of 10^{0}c. Lenoleic levels decreases at higher temperature.
- The crop is photo insensitive as it flowers at wide range of photoperiods. Optimum day length for better yield should be >12 to 14 hours.
- High humidity accompanied with cloudy weather and rainfall at the time of flowering results in poor seed set.
- Fairly drought tolerant with deep root system and comes up in areas receiving minimum rainfall of 500-700mm upto an altitude of 2500 MSL.
- Latitudinal effect was more significant. Generally it is grown between 40^{0} S to 55^{0} N latitudes but most of the production is concentrated between 20^{0}S to 50^{0}N latitude.
- Sunflower grown in Northern USA/Canada has higher linoleic acid (poly unsaturated) due low temperature. On contrary, sunflower grown in southern USA had high percentage of oleic acid due to higher temperature.

SOILS:-

Sunflower can be grown on wide range of soils but it does best in medium black to black soils with high moisture retention capacity. Sunflower does not with stand waterlogging. Good drainage is preferable for cultivation of crop. Yield and quality is drastically reduced when soil salinity reaches 10 to 12 ds/m. Optimum soil pH for sunflower in 6.5 to 8.5.

Varieties: Maruti, KBSH 44, Pro Sun 09, NDSH – 1, DRSH – 1, MSFH – 8, APSH – 11, Jwalamukhi, Sungene 85

Hybrids : TNAUSUF 7, DRSF 108, EC 69874, EC 68413, EC 68414 (Russian)

Sunrise selection (Canadian)

Cropping systems:

Development of early and medium duration varieties with thermo and photo sensitive cultivars is useful in multiple cropping systems.

Intercropping systems :

- Sunflower + groundnut (2:6) or (2:4)
- Sunflower + fingermillet (3:6)
- Sunflower + soybean (3:3)
- Sunflower + green gram/Bengal gram (1:1)

Sequence cropping under rainfed conditions is possible when *rabi* crop can be grown on stored soil moisture. Under irrigated conditions, it can be grown in *kharif* and *rabi.*

Rainfed

- Sunflower - mustard (2 Y)
- Sunflower – groundnut (2 Y)
- Sunflower – Maize (2 Y)
- Sunflower – wheat (1 Y)
- Sunflower – Sorghum (1 Y)

Irrigated conditions :

- Rice-groundnut-sunflower
- Rice – Rice - Sunflower
- Rice – Sunflower – pulses
- Rice – fingermillet – sunflower
- Rice – sunflower
- Cotton – sunflower
- Mustard - sunflower

Sunflower residues in soil have inhibitory effect because of certain allelochemicals which cause inhibition of growth of succeeding crops.

Field preparation:

Sunflower requires a well pulverised seed bed for better germination and growth. One/two ploughings with soil turning plough (or) M B plough followed by 2-3 harrowings and planking are sufficient to bring desired soil tilth.

Seeds and sowing:

For quick germination, under rainfed condition the seed should be soaked in fresh water for about 14 hours followed by shade drying as sunflower seeds have thick hulls and imbibes water at slow rate. This process is called seed hardening.

Sunflower seeds cannot be used as seed, immediately after harvest of crop since seeds will have dormancy period ranging from 40-50 days. To overcome the dormancy, treat the seed with ethereal solution for 6 hours.

Time of sowing:

Sunflower being a **photo insensitive** can be grown irrespective of the season.

- Kharif: Telangana and Rayalaseema: First week of August.
  Coastal: last week of August.
- Rabi (rainfed): First F N of step. - First F N of Oct.
- (Irrigated): November – December.
- Summer: second FN of January - First week of February

The sowing date of Sunflower can be adjusted in such a way that flowering period does not coincide with heavy rains because it affects pollination and seed set.

Seed rate:

	Rain fed (kgha $^{-1}$)	Irrigated (kgha $^{-1}$)
Varieties:	8-10	6-7
Hybrids:	5-6	4-5

Spacing: varieties: 45 × 30 cm
Hybrids: 60 × 30 cm

METHOD OF SOWING:

Line sowing by seed drill is recommended (or) behind the plough. Direction of rows preferably North – South as the sunflower head in phototropic from emergence to flowering. The head and leaves face east in morning and west in evening. Phototropic nature ceases one day before the ray florets open.

Depth of sowing: optimum depth of sowing is 4-5 cm.

Seed treatment: Captan/ Dithane M- 45 @ 3g/kg seed.

Thinning: Done at 15 DAS to avoid competition and to maintain single plant/ hill.

Manures and fertilizers:

Sunflower crop producing 2.0 t/ha seed and 3.2 t/ha stover removes 82 kg N, 30 kg P_2O_5 and 72 kg K_2O, 9.4 kg Sulphur and 37 kg Ca. It deprives soil fertility besides producing allelochemicals.

Nitrogen is essential for vegetative growth and Phosphorus to improve seed size with proper filling.

Sunflower crop is supposed to deplete the soil fertility besides producing allelochemicals. Nitrogen is most limiting element in sunflower production. The response to N, P and K is higher than other crops.

FYM @ 5-10 t ha^{-1} 2-3 weeks before sowing.

Rainfed crop: 60: 40: 30 kg N, P_2O_5 and K_2O / ha

½ N as basal and ½ N at 30 DAS

Irrigated crop: 80: 60: 40 kg N, P_2O_5 and K_2O / ha

Hybrids responds upto 120 kg N ha^{-1}

1/3rd N, 1 P_2O_5 &1 K_2O as basal

1/3rd N at 30 DAS (Button stage)

1/3rd N at 55 DAS (flowering stage)

- Sulphur is essential for increasing oil yield; addition of elemental sulphur at 25 @ kg ha^{-1} is recommended to soil at last ploughing. The response of sulphur is 13 kg seed/ kg sulphur applied. Synergistic interaction was observed between sulphur and nitrogen. SSP is the best source for phosphorus as also supplies required sulphur.

- In Zinc deficit soils, foliar spraying of $ZnSO_4$ @ 1% is beneficial.

- Borax @ 0.2 % to Capitulum at ray floweret opening improves the seed filling and oil content.

Irrigation:

1. Sunflower is highly responsive to irrigation. The total water requirement of sunflower is 500-600 mm.

2. It has the ability to withstand short periods of drought as the crop root system extending up to 2 m depth. One of the reason for preferring sunflower than other crops like groundnut, sorghum and cotton by the farmers was mainly due to stable yields even under low rainfall situations and its physiological plasticity i.e. it completes life cycling tailoring the growth and development to available moisture.
3. Under moisture stress conditions, centre portion of head is not filled properly and reduce the yield significantly.
4. The critical stages for moisture in Bud initiation (30 DAS), **flower opening (45-50DAS) (most sensitive to moisture stress)** and seed filling (60-75 DAS)
5. The total number irrigations depend up on seasons i.e. 3-6 for *kharif* and 4-8 for *Rabi*.
6. Irrigation should be stopped at 20 days before harvesting.
7. Sunflower is an excellent indicator plant for identifying the moisture stress.
8. Irrigation should be given at 50% DASM at all growth stages except at critical stage where irrigation is given at 30 DASM.
9. Irrigation at IW/ CPE of .5-1.0 is ideal.
10. On an average **WUE is 50-60** kg seed $ha^{-1}cm^{-1}$.
11. The crop is irrigated by ridge and furrow method.

Weed control:

- Sunflower has slow growth rate during 4-6 WAS hence weed free condition during the period results in better yields. The crop weed competition in sunflower is 30-45 DAS i.e. **4-6 WAS**.
- Two inter cultivations or hand weedings at 15 & 30 DAS is recommended.
- **PPI:** Fluchloralin @ 1 kg a.i ha^{-1}
- **PE:** Pendimethalin @ 1 kg a.i. ha^{-1}
- Alachlor @1-1.5 kg a.i ha^{-1}
- **Post Emergence:** not recommended since the crop is sensitive to most of the herbicides and pollinating agents are also damaged, however Nitrofen @ 0.5 kg ha^{-1} is recommended.
- Earthing up at knee high stage is recommended to avoid lodging the crop before flower opening.

Harvesting:

1. The sunflower crop is ready for harvesting when the moisture content of seed is 20%. The sunflower head is mature physiologically at 35-40 Days after flowering. It ranges from 90-100 DAS.
2. The heads are ripe when back of the head turns yellowish brown and lower leaves become brown to dark brown.
3. The harvesting should be done with the help of sickle by removing the head. The harvested head should be thoroughly sun dried and threshed by beating the centre of the head with small stick or threshers are also useful. Then winnowing, drying and storage of seeds.
4. Delay in harvesting leads to losses due to birds and shattering in the field itself.

Yield:

- Rainfed: 10-15 q/ha
- Irrigated: 20-25 q/ha
- Stalk yield: 10-12 q/ha

Quality : Oil content in kernel is 48-53% and oil content in seed is 28-35%. Protein is 14-19%, crude fibre – 16-27% .

Sunflower oil is of premium quality because of its colour,flavour and good nutritional quality. It contains high levels of linoleic acid whereas saturated fatty acids as palmitic and steiric acids are of only 15%. Being free of any toxic constituents, it is an excellent edible oil.

Amino acid composition : Sunflower protein contains higher proportion of essential amino acids. It contains higher methionine. Sunflower protein is highly digestable and has high biological value.

SEED PRODUCTION IN SUNFLOWER

Production of quality breeder, foundation and certified seed of hybrids and their parental lines calls for careful planning and management on the part of seed manager. Well drained neutral soils with good internal drainage are ideal for seed production. The selected field should not have been under crop in the proceeding 2 to 3 seasons.

Isolation requirements:

Sunflower is a highly cross pollinated crop. Hence, maintenance of prescribed isolation from other sunflower cultivates is a must for avoiding any possible contamination.

The isolation distance suggested for breeder, foundation and certified seed production under seed certificates is 600 m. an isolation distance of 1.5 km for breeder and foundation seed and 1.2 km for certified seed has been suggested by DOR, Hyderabad (AP) as most appropriate for quality seed production.

TIME OF SOWING, SPACING AND SEED RATE:

The best time for quality seed production is *rabi* and summer in conventional sunflower belt and *zaid* and spring in northern parts of the country. Recommended management practices are indicated below:

Sowing time

Conventional area: Kharif : June-July
Rabi/summer: Dec-Jan
Northern India : Spring : Second FN of January to end of Feb.

Spacing:

Row to row : 60 cm
Within the row: 30 cm

Seed rate:

Parental lines:

A line (female) production: Female: 4 kg ha^{-1}
Male: 1.25 kg ha^{-1}
R line (male) production: 5 kg ha^{-1}
Open pollinated varieties: 5 kg ha^{-1}

Hybrid seed production:

Female (A line): 4 kg ha^{-1}

Male (R line): 1.25 kg ha^{-1}

For both A line and hybrid seed plots, there should be one row of male to ensure adequate supply of pollen to female lines. Plant the first and last two rows of seed production plots with male lines. Alternately, planting female and male lines in separate blocks in 3:1 proportion in the same seed production plots will help in avoiding mixtures in hybrid seed.

Optimum stand establishment: Seed should be treated with Thiram or Captan at 2.5 g kg^{-1} when ever downy mildew is endemic.

Seed is dibbled at stipulated intra and inter row spacing. It is desirable to plant 2-3 seeds per hill and thin out excess seedlings to maintain one healthy plant per hill positively within 15 DAS. Seed should be sown around 5 cm depth in the soil.

The nutrient and irrigation management is similar to normal crop.

Weeding, rouging and hand pollination:

Seed production plots should be kept weed free up to 45 DAS. Two intercultivations with blade harrows at 15 days interval commencing from 20 DAS with a hand weeding in between can keep the field weed free. If necessary, Alachlor (1.5-2.0) or prometryn (1.5-2.0) may be applied as PRE spray after sowing the seed.

All offtypes which do not confirm to the specific population/ parental line should be removed before flowering. Pollen shedders are male fertile plants in the A line which are easily identifiable and sterile plants in the B line should be removed. The plots should be rouged 2-3 times, preferably before anthesis.

For obtaining optimum seed set hand pollination is a must. During the flowering period (2 weeks) pollinate the female heads with pollen from B in the case of A lines production R lines in the case of hybrid seed production plots on every day between 8 and 11 AM. The male line in both A line and hybrid seed production plots should be removed as soon as pollination is over.

Maturity, harvesting, threshing etc. are same as normal sunflower crop.

Lectur No. 8 ; **Rapeseed and Mustard (*Brassica* sp)**

Rapeseed and Mustard are the major *rabi* oilseed crops of India. It is next to Groundnut in area and production, meeting the fat requirement of about 50 per cent population in all the northern states. It is one of the most edible oilseed crop of Indo-Gangetic plains.

In India rapeseed and mustard account for about 27% of total oilseeds and 31% of total vegetable oil production. In common Indian language, 'Raya' refers to mustard while sarson, toria and taamira are rapeseed.

It is grown as oilseed crop as well as condiment and for their medicinal use. The young plants are used as vegetable as they supply enough sulphur and minerals in the diet. In the tanning industry, mustard oil is used for softening leather. It is used in the preparation of hair oils, medicines, soap making, greases etc...

The oil cake is used as a cattle feed and manure. It is a rich source of protein(40%).But its use is limited due to the anti-nutritional factor **Glucosinolate**.

Refined oil is called **colza** is used in Europe.

Origin and distribution

The growing of rapeseed and mustard were known from time immemorial in India and these were mentioned in all Ayurvedic Samhitas. It seems that Rai (Indian mustard) (*Brassica juncea*) was introduced into India from China. Its probable origin is Africa. It is extensively grown in Europe,Africa and Asia.From India it spread to Afghanistan and other countries. China is the largest producer of these crops. Afghanisthan together with adjoining areas of N-W India is one of the independent centres of origin of brown sarson.

India accounts second position in area and third position in production. China, India and Pakistan accounts for 90% of world production. Other major producing countries are Canada, Germany and France.

	Area	Production	Productivity
India	58.00 L. ha	63.5 L.t	1142 kg/ha
A.P.	4 thousand. ha	2 tthousand .t	333 kg/ha

Classification

There is lot of confusion and misunderstanding about the names and kinds of rape and mustard that are grown in India. The same local vernacular name may be used for forms and different local names are used for the same form in different areas. Singh (1958) tried to remove this confusion by giving the following description of Indian rape and mustard.

Rape and mustard belonging to the family Cruciferae and genus Brassica. Brassica includes the following important oilseed species.

Rapeseed: (*Brassica compestris* var. Sarson and toria): It is a herbaceous annual plant. The plant is shorter than mustard (rai). The height of the plant ranges between 45 and 150 cm. The stems are generally covered with waxy deposit. Plants of rape are easily distinguished from mustard (rai) by the character of leaves. In rape leaves are born sessile and are glabrous and hairy. The lower part of blade (lamina) grasps the stalk partially or completely. Fruits are thicker than those of mustard (rai) and are laterally compressed, with a beak of one – third to half their length. Seeds are either yellow or brown with a smooth seed coat.

Mustard (*Brassica juncea*): It is known as rai . The plants are tall (90-200 cm), erect, and branched. The leaves are not dilated at the base and not clasping as in the case of rape but are stalked, broad and pinnatified. The fruits (pods) are slender and only 2 to 6.5 cm long, strongly ascending or erect with short and stount beaks. The colour of the seed is brown or dark brown. Seed coat is rough.

Table: Classification of kinds of rapeseed and mustard grown in India

Indian group	International commercial name	Species	Common name	Local name	Chromosome number
1.Sarson	Indiancolza, colza, rape	a) *Brassica compestris* var.Yellow sarson	Turnip rape	Yellow sarson	20
		b)*Brassica compestris* var.Brown sarson	Turnip rape	Brown sarson	20
2. Toria	Rape	a) *Brassica compestris* var.Yellow toria	Indian rape	Yellow toria	20
		a) *Brassica compestris* var.Black toria	Indian rape	Black toria or Lahi	20
3. Rai	Mustard	a)*Brassica juncea*	Indian mustard	Rai or Raya or Laha	36
		a)*Brassica juncea* var. Rugosa	Rugosa	Pahari rai	36
		a)*Brassica nigra*	Black mustard	Banarsi rai	16

Crop Rotation and Cropping Systems :

Mixed cropping: It is grown as a mixed crop with wheat, barley during winter season.

Intercropping: Brassicas are generally intercropped with rabi crops. Some Profitable systems are

Wheat + Mustard 4:1
Gram + Mustard 4:2
Barley + Mustard 6:1
Intercropping in autumn planted (adsali) sugarcane has increased the net returns without affecting the yield of sugarcane.

Rotations: Brown sarson and mustard (rai) are usually cultivated as pure crops in rainfed areas. During rainy season no other crops should be sown, rather moisture should be conserved as much as possible by ploughing. In regions where irrigation facilities are available, following crop rotations may be followed.
Toria being a catch crop, maturing 90-100 days can easily adjusted in the following crop rotations.

Irrigated conditions :

Rice – Toria

Rice – Toria – mung

Maize - Toria - Wheat

Maize - Toria - Sugarcane

Maize - Toria - Cotton

Maize - Toria - Sugarcane - Ratoon

Moong – Brown or Yellow sarson or Rai

Soybean - Mustard

Guar (green manure) – Sarson or Rai

Maize – Sarson or Rai

Early paddy – Sarson or Rai

Rainfed : Pearlmillet - Mustard
Sesame - Mustard
Jute – Toria

Climate requirements:

Rapeseed and mustard are of the tropical as well as the temperate zone crops. Grown as *rabi* crop. It requires relatively cool temperature and a dry harvest period. Cool temperature, clear dry weather with a plentiful of bright sunshine accompanied with adequate soil moisture increases the yield. These favourable conditions are existing in northern India. It is grown in *rabi* season from September-October to February –March.

They prefer moderate temperature of 24-28ºC with an optimum of 20 ºC. Brassicas grow well in areas receiving 350-550 mm of rainfall.Sarson and Taramira are preferred in low rainfall areas where as raya and toria are grown in medium to high rainfall areas respectively.

Toria is more liable to suffer from frost and cold is, therefore, usually sown earlier and harvested before the onset of frost.

Rape seed and mustard are long day plants. These crops neither tolerant to drought nor water logging.

Varieties:

a) Toria : Agrani, Bhawani, Parbati, Anuradha and T-22(Punjab selection)

b) Mustard : Pusa Agrani, Pusa Jaikisan. Geeta, Kranti, Jagannadh, Jawahar Mustard 2, Vasundhara,Varuna, Vardhan, M-27

Soil:

Brassicas can be grown on wide range of soils as Alluvial,medium loam, sandy loam or heavy loam soils.. Heavy clay soils, subjected to water logging are not desirable.

Land preparation:

A fine seed bed requires to ensure good germination. In rainfed areas where toria, brown sarson or raya are taken as a pure crop after *kharif* fallow seed bed preparation should be started during mansoon rains. For getting good yields the field should be well prepared first by ploughing deep with soil turning plough followed by two cross cultivations. Every ploughing should be followed by a light rolling or planking so that soil is finely pulverised and levelled. Care should be taken to see that weeds and stubbles etc. are removed from the field and that the soil contains adequate moisture to ensure good germination.

Seeds and sowing:

Planting time is the single most important variable affecting the seed yie ld of rape and mustard to a great extent. Since the rate of development of oil in seed is greatly influenced by variation in atmospheric temperature, humidity and other biotic factors, sowing either too early or too late have been reported to be not desirable.

In case of mixed cropping they are generally sown in rows 1.8 to 2.4 meters apart in the main crop. 5 to 6 kg seed should be sown in rows at a depth of 2.5 to 3.0 cm in case of a pure crop. When sown mixed with some other crop, 1.5 to 2.0 kg seed per hectare is sufficient. Sowing could be done either behind the local plough or through seed drill. Before sowing seed should be treated with thiram or captan @ of 2.5 g per kg of seed.

To ensure good seed germination and early seedling vigour, seed must be soaked in water before sowing. This is best done by covering the seed with moist gunny bag. The seed can be mixed with equal quantity of sand for uniform seed distribution at sowing.

Depth of sowing : 3 – 4 cm

Spacing ; 30 x 10 cm or 45 x 15 cm

Time of sowing:

Toria: 1st fortnight of September

If wheat is to follow sow the crop by the end of August

Sarson: 3rd week of September to 2nd week of October

Raya: 2nd week of October to 2nd week of November.

Thinning of the plants at 20-25 days after sowing to maintain a plant to plant distance 10 to 15 centimetres.

Lectur No. 9

Manures and fertilizers

12 - 15 tons of FYM ha^{-1}

Under irrigated conditions, if the preceding crop is heavily manured, brassicas can be grown on residual soil fertility.

The nitrogen requirement varies from 20 – 160 kg/ha depending on the soil type, rainfed or irrigated and yield potential of that variety.

The recommendation is 30-60 kg/ha under dryland condition and 100-120 kg/ha under irrigated conditions.

Based on the recommendations of ICAR – 40, 60, 80 kg N /ha for toria, sarson and raya respectively.

One tonne of rape/mustard removes 9 to 11.3 kg phosphorus. It seems 20 kg/ha P_2O_5 is sufficient for rainfed and 50 kg/ha for irrigated crop.

Response to potassium is uncertain. In highly K deficit soils, 20 kg/ha K_2O

Half of N at sowing and the remaining half at first irrigation. Whole P & K to be applied at the time of sowing.

Rape seed and mustard have higher requirements for sulphur; therefore, nitrogen should preferably be applied through ammonium sulphate and phosphorus from single super phosphate.In coarse textured soils, application of 20-20 kg S/ha is suggested. But higher rates of sulphur application may increase the antinutritional factor glucosinolates.

Among micro nutrients, Zn and Boran have positive role in increasing the yield of raya. In rice fallows, 25 kg $ZnSO_4$ applied to rice is sufficient for the succeeding brassica crop. Application of 2 kg boran/ha is sufficient to meet the requirement especially on saline soils.

Irrigation:

Due to scanty winter rainfall, brassicas show favourable response to irrigation. About 60% of the total area under brassicas is under irrigation. Among the brassicas, raya is most responsive to irrigation.

Rape and mustard have low water requirements.It ranges from 450 – 600 mm. Generally they are grown utilising the residual moisture of the monsoon in medium to heavy soils. In toria, yellow sarson and raya, two irrigations have been found to be beneficial.

With regard to the time of irrigation, it is recommended to dealy the first irrigation as much as possible. This helps the plants to branch well, which in turn results in profuse flowering and fruiting. The best time for first irrigation is when the flowering has sufficiently advanced. The second irrigation should be given at fruiting stage.

Ridge and furrow system results in yield advantage with 20% saving in irrigation water.

Weed control: Brassicas are fast growing crops and rarely infested with second flush of weeds.

In early stages the crop should be kept free of weeds since the weed competition results in serious yield losses. 2-3 weedings are necessary. First weeding along with thinning, and remaining weeding at fortnight interval. One Intercultivation at 3 weeks after sowing is beneficial.

PPI of Fluchloralin @ 0.5-0.75 kg/ha is also effective.

Pre emergence application of Isoproturan 0.75 – 1 kg/ha or Oxadiazon 0.5 – 075 kg/ha. Post emergence application of herbicides is limited because of smothering effect of brassicas.

Harvesting and threshing:

Toria is the earliest brassica oil seed crop to be harvested. It takes about 80-100 days for maturity and thus this crop is ready for for harvest from middle of December to middle of January depending upon the time of sowing and variety used. Rai can be harvested in 110-180 days. Yallow sarson 130-160 days. Brown sarson 105-145 days.

When the crop is ripe, the leaves become yellow, the plants are uprooted or harvested with the help of sickles. Sarson is less liable to shattering. But in case of mustard care should be taken to see that it is harvested just before the pods open in order to avoid heavy losses from shattering of seeds. Threshing can easily be done by beating with sticks. The pods easily shatter and give away seeds. The seeds should be dried for a couple of days before they are stored.

Yield Attributes: No. of plants/unit area, No. of pods/plant, No. of seeds/pod and test weight

Yield: Average yield of rapeseed and mustard is about 500 kg ha^{-1}. Toria gives an yield of 800-1000 kg ha^{-1}. Rai is the highest yielder of all. Average 12-15 q ha^{-1} have been reported.

Oil Quality Considerat ion : Seed colour could be yellow, black or white or brown depending upon the cultivars. Yellow coloured seeds have lesser seed coats, hence higher oil content. The light coloured oil from yellow seeds of brassicas are the premium oils to enter trade.

The brassica oilseeds have the oil content of 30-48% in air dried seeds. Colour of the oil is yellow to brown. Rapeseed and mustard oils have anti nutritional factors like erucic acid. However, varieties are now being developed with reduced erucic acid (<2%). The cultivars with <2% of erucic acid in oil and < 30 micromoles/gram of glucosinolates in oil meal are called as Conola varieties suitable for edible purpose. It is also desirable to have less linolenic acid (<3%) and higher linoleic acid(>30%) for prolonged cooking and higher shelf life. But brassicas destined for industrial purpose should contain higher erucic acid (>60%) as it has high heat stability and used as lubricating oil, fossil fuel and additive to diesel.

Lecture No: 10 **SAFFLOWER**

Botanical name - *Carthamus tinctorius*
Family - Compositae

Safflower is an ancient oilseed crop grown in India for the orange red dye (Carthamin) extracted from it bright coloured florets as well as seed oil. Due to the availability of synthetic dyes at present, it is used for extraction of oil only.

The cultivated *Carthamus tinctorius* in supposed to originated either from

Carthamus lanatus - Saffron thirstle

Carthamus oxycantha- Wild Safflower

Safflower was known to ancient India and the poet laurate kalidas compared safflower to the "sakhis of shakuntala" as kusum (or) kusumba in Sanskrit literature. Carthamus is derived from Arabic word "Quartum".

USES :-

1. Safflower oil is rich in poly unsaturated fatty acids as **linoleic acid up to 78%** which playan important role in reducing cholesterol content and it is a drying oil. It contains **24-35% oil**. So, it is also recommended for heart patients.
2. The hot oil poured in cooled water, it become a plastic of thickness and used for adhesive in glass industry.
3. The oil is used in the preparation of "**ROGHAN**" which is used for preservation of leather and production of water proof cloth. It is also used in manufacturing soaps and varnishes.
4. Safflower oil is the healthiest oil of all vegetable oil and its value is increased when it is blended with rice bran oil.
5. The Safflower cake is used as cattle feed which contain 20% protein.
6. Safflower was recognized as it remedies Rheumatism.
7. Dry petal is used in the preparation of herbal medicine and drugs. The Safflower also used to provide resistance to inflammation.
8. In Ethiopia, decorticated seeds are pounded finely and mixed with water to prepare a beverage "FIT-FIT".
9. The yield of floret ranged between 70-100 kg/ha and it contains two colouring materials. Water soluble yellow pigment "**carthamidin**" and orange red dye (2%) which is insoluble in water but readily soluble in alkaline solution is known as **"CARTHAMIN"**.
   Carthamin is of commercial importance and is used as additive in food, beverage, cosmetics

& paints. Also for dyeing of cotton and fabrics.

Carthamus +H_2SO_4+Phosphoric acid - Carthamidin & Isocarthamidin

10. Safflower is grown as border crop to protect the main crop of wheat in North India and is also green manure crop at young stage.
11. Hull is used is manufacture of cellulose insolations.
12. The safflower cake is used as cattle feed which contains 20% protein but low in lysine. It is consumed domestically and hardly enters international market.

ORIGIN:

Decondolle – Arabia. Vavilov – India

Spiny type of Safflower is having higher oil content than non spiny type. Yellow coloured flowers yielded higher oil content. It is a xerophytic in nature.

AREA AND DISTRIBUTION:

India, China Mexico, USA, Ethiopia, Argentina and Australia are the major growing countries. China mostly grown Safflower for medical purpose.

Safflower occupies seventh place in the area among nine oilseed crops.

In India 98% of the area comes from three states viz- Maharashtra, Karnataka and A.P. it is cultivated with an area of 3.00 L.ha and production of 1.89 L.tons with a productivity of 630 kg/ha. India is the largest producer of Safflower with 54% area and 40% production.

	Area	Production	Productivity
India	3.00 L. ha	1.89 L.t	630 kg/ha
A.P.	0.16 L. ha	0.12 L.t	750 kg/ha

Maharashtra and Karnataka are the first and second with reference to area and production where as productivity is highest in Gujarat(1000 kg/ha) followed by Karnataka (2008-09).

In A.P., it is cultivated in Ranga Reddy, Medak, Mahaboobnagar, Adilabad, Kurnool, and Naziabad.

AICRP on safflower – Sholapur (Maharashtra).ARS in Andhra Pradesh – Thandur.

CLIMATE:

Safflower is well adapted to wide range of climatic condition. However, the maximum production is confined up to 1000 MSL in semi arid tropics and arid areas with latitude of 14 to 22°N. Important production factors are soil temperature and soil moisture. Temperature is the most important climatic parameter as it is thermo sensitive and it is mainly grown as *rabi* oil seed crop.

Optimum temperature of soil for seed germination 15-16°C. It may tolerate to temperature of 49°C, if sufficient soil moisture is available.

Temperature more than 40°C reduced the plant height, dry matter production and seed set and test weight. Day temperatures in the range of 24-32°C at flowering is the optimum. Higher temperature at flowering is harmful to crop resulting in sterile heads.

Crop is tolerant to frost at seedling stage but sensitive at later stages. It is a day neutral plant, but a day length of 12-14 hour is essential for flowering and seed set. When compared to day length, temperature is more important.

It is a drought resistant and susceptible to water logging. It comes up well with a rainfall of 500-600 mm. It cannot withstand excessive soil moist/ humidity at any stage due to damage from fungal diseases.

SOIL:

Being a drought resistant, it is cultivated in all type of soils, but well drained, fertile and deep soil with high water holding capacity are the best. Safflower is mostly grown on residual soil moisture.

South India – Deep black soil (A.P, Karnataka, Maharashtra).

North India – latosols (Laterite and sandy loam soil).

Commercial cultivation is extended on medium to deep black soils in peninsular India

Higher yield are obtained at neutral soil pH ranged of 5-8.0. It is salt tolerant crop i.e. up to 7ds/m. However, seedling stage sensitive to salinity.

Varieties – Manjira, Sgaramuthyalu (APRR – 3), Parbhani Kusum, Phule Kusum, A-1 (National Check)

Hybrids - DSH – 129, NH – 1 (Firdt non-spiny hybrid in the world), NARI – 15, NARI – 38, Bhima, Girna, Sharda and Sweta.

LAND PREPARATION:

Safflower requires fairly pulverized seed bed free from clods. Being a deep rooted crop it requires deep ploughing. Crop raised for dye purpose require more and fine tilth than oil crop.
One deep ploughing with M.B. plough is sufficient followed by 2-3 harrowings with planking.

SEED AND SOWING:

Season – *rabi*
Time of Sowing –
Telangana: II. FN September to I. FN of October.
Coastal and Rayalseema – October. If the crop is delayed, Aphid damage is more common.
Seed Rate – 8-10 kg/ha pure crop.
4-6 kg/ha - Mixed crop/ Border crop.
Spacing - 45×20 cm.
Method of sowing – Broadcasting, behind the plough (pora method) and seed drill.
Depth of sowing – 4-5 cm (Normal). 7.5-10 cm (dry Land).
Thinning – 10-15 DAS.
Very high density of plant population significantly reduces the branching ability.

MANURES AND FERTILIZERS:

On an average safflower crop remove 60 - 65 kg N, 30 kg P_2O_5 and 40 – 45 kg K_2O ha [?1.]
One tonne of seed removes about 45 kg N.
FYM @ 5-10 t/ha
Depending on rainfall, 30-40 kg N.
Band placement at 3-5 cm deeper in moist zone and 2-3 cm away from seeds.
Under irrigated conditions, response is found even upto 120 kg/ha.
Nitrogen is applied in two splits -- ½ as basal and ½ at flowering.
30-40 kg P_2O_5 /ha, 1/2 as Basal application. Response is 7-7.5 kg seed per kg P_2O_5 applied.
20-30 kg K_2O /ha basal recommended in K deficient soil.
Under rainfed conditions, entire fertilizers is applied by drilling at sowing.
Under irrigated conditions, ½ N and whole P & K fertilizers are applied at sowing and another ½ N is topdressed 5 weeks after sowing.

WATER MANAGEMENT:

Water requirement 250-300 mm. Safflower is generally grown as rainfed in residual soil moisture and it is highly drought tolerant as it is a deep rooted crop. The crops have the ability to extract moisture from deeper layer of the soil. In light soil, 2-3 irrigations are given where as in vertisol residual soil moisture is sufficient. One life saving irrigation should be given when drought condition occur.

Rosette stage (Early vegetative stage) is the most critical stage of safflower i.e. **21DAS or 4-6 leaf stage** and yield can be increased by 40-60%.

Poorly drained soil and water logged condition enhanced the problem of wilt and root rot. The WUE is 5.64 kg/seed/ha/mm. safflower is cultivated on saline soils by sowing on the slope of the ridge. Under high salinity, the oil content is reduced by increasing hull percent. Broad bed & furrow at 1.5 – 2 m is suitable to minimise contact of water with above ground part & minimize root & stem rot in heavy soils.

WEED MANAGEMENT:

The growth habits of safflower make it extremely susceptible to weed competition. The critical period of crop growth competition is **Rosette stage to flowering stage**.

The rosette stage - 25-30 DAS in Rabi and may be prolonged up to 60 DAS in winter situation.

The field should be free from weeds infestation during early growth stage depending on the length of the rosette stage.

PPI of Fluchoralin @ 1 kg ai /ha.

PE of Oxadiazon @ 1 kg ai /ha.

PE of Alachlor @ 1.5kg ai /ha.

PE of Atrazine @ 1 kg ai /ha.

Pendimethalin @ 0.75 kh/ha + one hand weeding provides weed free environment and cost effective.

Safflower is sown in wide rows. So, intercultivation implements can be used for weed control.

Two harrowings at 25-30 DAS & 45-50 DAS in combination with one hand weeding in between them can effectively check weed growth.

CROPPING SYSTEMS :

In low rainfall areas receiving 400-500 mm, safflower is superior to other winter crops as it extracts moisture from subsoil.

Intercropping : Although sole crop of safflower is more profitable under conditions of adequate moisture availability, it is grown as intercrop with traditional crops to overcome the risk of crop failure under adverse conditions.

In Andhra Pradesh – Chickpea + safflower - 3 : 1 or 2 : 1

Coriander + safflower - 3 : 1 or 2 : 1

Karnataka - Linseed + Safflower - 6 : 2

Maharashtra - Wheat + safflower - 3 : 1 or 2 : 1

Sequence Cropping : It is profitable in Andhra Pradesh where rainfall is 700 – 800 mm.

In Northern Telangana Zone - Maize – Safflower

Sorghum – Safflower

Sesame – Safflower

Mungbean – Safflower

Scarce rainfall Zone – Greengram – Safflower

Sesame – Safflower

Soybean– Safflower

HARVESTING:

The crop comes to maturity within 110-120 days. As soon as the leaves and most of the bracteoles except a few of last formed become brown and seeds are dried and easily separated from the head. The crop is harvested either by uprooting the plant or cutting at the bottom.

Plants are thorny and harvesting is taken up at the early hours of the day and to be completed before 10.00 am when the spines will be soft. As the day advanced, spine becomes stiff causing inconvenience to harvesting. The harvested plants are heaped for a day or two in the field and threshed by beating with stick, cleaned, dried and stored at 8% moisture content.Combined harvesters used in wheat could also be used for harvesting and threshing.

Oil Quality :

Traditional safflower seed contain 50% hull & 28-32% oil. It is pale yellow. Good drying oil. Fatty acid composition is - Linoleic acid 70-80%, Oleic acid – 6-8%, Stearic acid – 2-3% and Palmitic acid – 5-8%. Due to 90% of poly unsaturated fatty acids, safflower oil is considered to be the best edible oil.

Lecture No.11 **Soybean (*Glycine max*)**

Introduction

- The **soybean** (U.S.) or **soya bean** (UK) (***Glycine max***) is a species of **legume** native to **East Asia**
- Grown for its edible **bean** which has numerous uses. The plant is classed as an **oilseed** rather than a **pulse**
- The English word **"soy"** was derived from the Japanese pronunciation of **shoyu** the Japanese word for **soya sauce ;** "soya" comes from the Dutch adaptation
- The word **glycine** is derived from the Greek - **glykys** (**sweet)** and likely refers to the sweetness of the **pear-shaped** (*apios* in Greek) **edible tubers** produced by the native North American twining or climbing herbaceous **legume .**
- Glycine max from soy-a or soya to soy plus bean or soybean or soyabean
  Chinese pea, Japan pea and Japanese fodder plant, known as Bhat Bhatmer rumkut
- Soybean accounts for "50%" total production of oilseed crops in world.
- A very small proportion of the crop is consumed directly by humans. Soybean products do, however, appear in a large variety of processed foods.
- It was during **World War II** that the soybean was discovered as **fertilizer** by the United States Department of Agriculture
- Soybeans, like most legumes, perform nitrogen fixation by establishing a symbiotic relationship with the bacterium *Rhizobium japonicum*
- U.S., Brazil, Argentina, China and India are the world's largest soybean producers and represent more than 90% of global soybean production
- Prior to fermented products such as **Soy sauce, tempeh, natto**, and **miso**, soy was considered sacred for its use in crop rotation as a method of fixing nitrogen
- Wild ancestor of soybean is **Glycine soja** a legume native to **central China**
- Soybeans are one of the **"biotech food"** crops that have been **genetically modified,** and genetically modified soybeans are used in number of products

Uses :

- Soybeans are an important global crop, providing **oil** and **protein**
- It contains about **20 per cent oil** and **40 per cent** high **quality protein**
- It contains a good amount of **minerals, salts** and **vitamins** (thiamine and riboflavin) and its sprouting grains contain a considerable amount of **Vitamin C**
- A large number of Indian and western dishes such as **bread, `chapati', milk, sweets, pastries** etc., can be prepared with soybean
- It can be used as **fodder, forage** can be made into **hay, silage** etc. Its forage and cake are excellent nutritive foods for **livestock** and **poultry.** Soybean being the richest, cheapest and easiest source of best quality proteins and fats and having a vast **multiplicity of uses** as **food** and **industrial products** is sometimes called a "**wonder crop".**

Origin and distribution:-

- Soybean is one of the important crops of the world.
- Soybean is native of China
- Spread to India and Nepal in 16^{th} century
- Soybean cultivation in India started during 1970's
- **Area & Production :** Globally, area is 65 m ha, production :130 mt, productivity :2 t ha^{-1}
- USA, Brazil, China, Argintina, are the important soybean producing countries.

- USA has highest productivity of 2.2 t ha^{-1} followed Argentina
- India : Area : 5 m ha, Annual production : 5 mt, productivity : 1000 kg ha^{-1}.
- Largely grown in Madhya Pradesh, Rajasthan, Uttar Pradesh Maharashtra and Gujarat.
- It is also grown on a small acreage in Himachal Pradesh, Punjab and Delhi .
- Madhya Pradesh, ranks first both in area and production
- Andhra Pradesh : Area : 1.7 lakh ha, production : 32.3 l tons, productivity 2000 kg/ha.

Climate :-

- Basically it is a tropical crop but extends to subtropics and temperate climates.
- Commercial production is between 25° and 45° N latitude at 1000 m altitude .
- Soybean is short day plant, but response to day length varies with variety and temperature.
- A temperature of 26.5 to 30°C appears to be optimum for most of the varieties.
- Optimum temperature for germination is 30-35°C.
- Maximum flowering occurs at 30°C.
- Temperature of 18°C or less ,there is no pod setting.
- Temperature below 24°C – delays flowering by 2-3 days.
- Temperature of 40-46°C results in pod abscission .
- A lower temperature tends to delay the flowering.
- Day length is the key factor in most of the soybean varieties as they are short day plant and are sensitive to photo-periods.
- Most of the varieties will flower and mature quickly if grown under condition where the day length is less than 14 hours provided that temperatures are also favourable
- Critical photoperiod for bud initiation is 14 hrs.
- Maximum floret blossoming occurs at 10-13 hrs
- Moderately salt tolerant (sal. Threshold 5 dsm^{-1}).
- Sensitive to water logging especially during early stages
- Optimum soil P^H range is 6-6.5
- **Growth and Development :** Have two growth habits – determinate, indeterminate.
- Flowering starts from 20 DAS, or even delays upto 50 DAS and continues for 4-6 weeks.
- Pods are visible at 10-15 days after flowering
- 2-20 pods per inflorescence and upto 400 in single plant is observed.
- 2-3 seeds per pod at maturity.

Seasons :-

- In Andhra Pradesh :

" Kharif" : A rainfed crop is sown from June 15 to July 15th in light soils
"Rabi" : Irrigated crop is sown from November – December
"Summer" : Sown in January, and extends upto February

- **Seed rate of soybean** : It depends upon germination percentage, seed size and sowing time. If seed is of 80 per cent germination, 70-80 kg seed per hectare is required. For late planting and for spring crop, seed rate should be 100-120 kg per hectare
- Since soybean loose its viability in 2-3 months, hence higher seed rate: 75 kg/ha or 25-30 kg/acre is to be given
- **Spacing :** Heavy soils : 45 x 5 cm
  : Light soils : 30 x 7.5 - 8 cm.
- Depth of sowing should not be more than 3-4 cm under optimum moisture conditions
- If seed is placed deeper there is crust formation just after sowing, the seed germination may be delayed and may result in a poor crop stand.

- Seed drills are used in large areas , and sowing in ridges are to be followed under irrigated condition.
- **Plant population :** 40 plants / sq mt or 1,60,000 plants/acre
- Thinning should be completed within – 3 weeks after germination.
- **Seed treatment :** seed is to be treated with Thiram (2g) + Carbendazim (1 g) or Thiram (3 g) + Imidachloprid (5 g) or Carbosulfan (30 g / 8-10 kg of seed)

Varieties

S.No.	Vareity	**Duration** (days)	**Yield** (q/acre)
1.	JS – 335	90-95	8-10
2.	PK - 1029	100-110	7-8
3.	MACS - 450	100-110	8-10
4.	LSB – 1	65	6
5.	LSB – 3	110-115	6-7
6.	JS- 93 - 05	90	7-8

Fertilizer and Nutrient Management :-

For obtaining good yields, should apply 15-20 tones of FYM or Compost per ha.
But soybean being a legume crop has ability to supply their own "N" needs provided they have been inoculated .
Application of 20-30 kg N per ha as a starter dose will be sufficient to meet the "N" requirement of crop in initial stage in low fertile soils having poor organic matter.
Soybean requires relatively large amounts of phosphorus than other crops.
Phosphorus is taken by soybean plant throughout growing season. Period of demand starts just before pod formation and continues until about 10 days before seeds are fully developed.
With the application of phosphorus, the number and density of nodules are stimulated and the bacteria becomes more mobile.
Soybean also requires a relatively large amount of potassium than other crops.
The rate of potassium uptake reaches to a peak during the period of rapid vegetative growth then slows down about the time the bean begins to form.

FERTILISER SCHEDULE :

- Light soils :- 20 + 40-60 + 20-40 + 20 kg N P K S /ha
- Rhizobium culture @ 500 g / 7-5 kg seed/acre
- Andhra Pradesh : Rhizobium + 30 + 60 + 40 + 8 kg N P K S/ha (Irrigated)
  The fertilizers should preferably be placed, at sowing time, about 5-7 cm away from the seed at a depth of 5-7 cm from seed
- In Light soils : 50% N and full dose of P & K is applied basally , and remaining 50% N is top dressed at 30 DAS
- For Rabi crop : Entire fertilizer is applied basally at seeding.

Water Management

- The soybean crop generally does not require any irrigation during *Kharif* season.
- However, if there were a long spell of drought at the time of pod filling, one irrigation would be desirable.
- During excessive rains, proper drainage is also equally important.
- Basically it is a rainfed crop, in deep black soils for Kharif and rabi, the crop responds to irrigation in intensive cropping system
- Due to deep tap root system with 1.8 m deep withstands moisture stress for short periods
- Under soil moist stress, Flower drops, but due to "extended period of flowering," late formed flowers will compensates early flower drop.
- **Critical stages :** flowering and pod development stages are sensitive stages for moisture stress.
- Scheduling irrigation : at 50 DASM or at IW/CPE 0.6
- Irrigation in Light soils can be given once in 10-12 days, in heavy soil at an interval of 18-20 days
- Irrigated by check basin or border method, but furrow method is ideal.
- Under Water scarcity conditions, sprinkler irrigation and alternate furrow can be followed.
- WUE is 0.4 – 0.7 kg m^{-3}. and water requirement is **450 -750 mm.**

Weed management

- First 6-7 weeks after seeding is critical period, hence clean cultivation is essential.
- Since crop is sown in lines/rows, intercultivation can be done 2 times ,first at 20-30, followed by second at 45 DAS along with manual weeding .
- For wide range of weeds in soybean, foliage herbicides provide excellent weed control
- **Pre plant herbicides (PPI) :** Fluchloralin 1.0-1.5 kg ai/ha.
- **Pre emergence herbicides :** Alachlor (1.5-2.0), Acetachlor (1-1.5) Metachlor (1-1.5) oxyflourfen (0.5-1.0)
- **Post emergence herbicides :** Quizol fop ethyl (Turgasuper) @400 ml/acre Imzythpyr (250 mg / ac) (pursuit) for broad leaved weeds.

Harvesting :-

- When plants mature, leaves turn yellow, start dropping , pods dry out quickly.
- There is a rapid loss of moisture from the seed. At harvest, the moisture content of the seeds should be 15 per cent
- Harvesting can be done by hand, Plants are uprooted, or cut with sickle above ground level
- After cutting , plants are heaped and sun dried for a day or two
- Threshing is usually done by beating with sticks or using mechanical threshers.
- Threshed produce is winnowed to separate seeds from chaff
- cleaned seed is dried for 1- 2 days
- Seed is stored in moisture proof bags / seed bins
- For seed purpose – seed is stored after treating with thiram / captan (3 g/kg).

Quality consideration:-

- It is protein rich oilseed and presently number one edible oil source globally.
- **Seed composition :** Seed consists of Hull (8%) cotytyledons (10%) hypocotyls (2%), oil content 14-23%, protein (32-50%).
  Oil content and quality : Oil content influenced by temperature. High temperature increases oil content.
- Oil contains neutral lipids (88%) phospholipids (10%) Glyco lipids (2%) saturated fatty acids (11-26%)
- Commerical oil contains – Linolenic (5-9%) linoleic (43-56%)

Utilization:-

- Soybean is used as processed products, soyflour, protein products, fermented food products.
- **Other products** : are Beverage, whole milk, milk extender, Coagulated products like panneer
- **Fermented products :** soy-sauce, yogurt, cheese etc
- **Sprouted cooked beans** – fried and roasted nuts
- **Fortified foods like** – bread, biscuits, cake etc.
- **Substitute products** like bison, frozen desert
- **Textured products** like nuggets, chunks etc
- High protein biscuits + granules

Cropping systems

Mixed cropping of soybean with maize and sesamum has been found feasible and more remunerative

Intercropping :	Soybean	+	maize	(2:1, 2:2)
	Soybean	+	pigeon pea	(2:2, 4:2)
	Soybean	+	finger millet	(2:2)
	Soybean	+	cotton	(1:3, 2:1),
	Soybean	+	groundnut	(1:4, 1:6)
	Soybean	+	sorghum	(1:2, 2:2)
	Soybean	+	pearl millet	(2:4, 2:6)

Some of the common rotations followed in north India are as given below:

1. Soybean – wheat
2. Soybean – potato
3. Soybean – gram
4. Soybean – tobacco
5. Soybean – potato – wheat

Crop growth stages

Seedling stage

Crop under field conditions

Flowering Stage :

Pod Development stage


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Lecture No.12

Linseed (*Linum usitatissimum*)

Introduction

- Flax, is One of the oldest cultivated crops grown for seed from which oil is extracted
- It is world wide cultivated commercially for flax, while in India it is cultivated for oil
- **Flax** also known as **common flax** or **linseed**, (binomial name: ***Linum usitatissimum***) is a member of the genus ***Linum*** in the family ***Linaceae*.**
- It is known **Tisi** in Hindi, and Avishallu in Telugu.
- Before the spread of the mechanical cotton gin in the early 1800s, most Americans had a choice of two clothing fibers – wool or linen
- In addition to being a fiber source, flax was also an important oilseed.
- Linseed oil, squeezed out of flax seed, used as a preservative finish on wood.
- Linseed oil is a **"drying oil",** as it can polymerize into a solid form.
- It is an edible oil but, because of its strong flavor and odor, is only a minor constituent of human nutrition.
- In parts of Europe, traditionally eaten with potatoes and quark (cheese).
- It is regarded as a delicacy due to its hearty taste, which spices the bland quark
- Flax fiber is obtained from the stem of plants, from a blue flowered plant and woven into a fabric generally known as **linen Flax** .
- Common names of flax are alsi, tisi, kshuma, lin, llion, liner, linum, line, linen, lein
- Flax is grown in modern times for two entirely different purposes (i) for fibre and (ii) for seed .The seed of the flax plant is known as linseed
- In India, flax is grown primarily for linseed oil which is not only used for human consumption but also for commercial use as paint, varnish, finished leather and printing ink.
- Flax oil is high in omega-3 fatty acid, which lowers cholesterol, in the diet
- Flax seed is fed to chickens, eggs from those chickens, marketed as omega eggs.
- India import the flax fibres from European countries and does not utilize the flax produces in India. The reasons for this are, Indian flax does not match with the quality standards of imported flax.
- But now a number of dual purpose varieties including Gaurav, Shikha, Jeevan and Parwati released from Chandra Shekhar Azad University of Agriculture & Technology **(CSAUAT),** Kanpur are suitable for both **oil** and **fibre** purposes.
- Among the four varieties, the white flowered variety (*Linum usitatisimum album)* produces stronger plants and are resistant to diseases than the blue flowered vrieties (*Linum usitatissimum vulgare)* which yields fine fibres of high quality

Origin and Distribution

- Linen's history dates back to 7000 BC when Mesopotamians used flax
- Romans and ancient greeks cultivated flax for fibre and seed and established Linen industry
- As per Vavilov cultivated annual linseed originated from India and Ethiopia
- It is native of eastern Mediterranean to India and was probably first domesticated in the Fertile Crescent.
- Later on Egyptians, Babylonians, Greeks, Romans and other civilized people cultivated flax for fibre .
- Major producers are Canada, Argentia, USA, Poland, Uruguay, Romania, USSR, China and India
- Reported to have spun in countries like Belgium, Russia, Switzerland, Brazil, England, France and Argentina etc. and is used in making fine quality fabrics called linen

Area and Production

- Flax is currently grown on about 12 million acres worldwide, with the majority of the production in northern Europe and Russia.
- India occupies 25 per cent of world acreage and ranks first in area (4.368 Lakh ha), fourth in production (1.725 Lakh tonnes) and eighth in productivity (395.0 Kg/ha) of the flax crop.

Morphology

- Flax is a broadleaf with small, narrow leaves that are less than an inch long.
- **Stems** are slender,flexible, branched, near base of plant, with height 30 -36 inches., dividing at their tips into inflorescences bearing attractive blue flowers.
- **Flowers** are mostly self-pollinated, with some cross pollination by insects.
- New flowers will emerge for a few weeks, each developing into a round seed capsule or boll about one-third inch in diameter.
- Each **capsule** contains 4 -10 seeds, Glossy in appearance, traditionally brown color.
- However, a new variety of flax, Omega, is golden-colored to make it more acceptable in the food market.
- If exposed to water, flax seeds will become sticky due to mucilage in the seed coat

Climate

- Crop, grown for seed ,performs well in moderately cold climate, but the crops for fibre purpose , requires cool and moist climate.
- Linseed requires moderate or cool temperature during vegetative stage and dry weather during the maturity of the crop.
- Requires temperature of 25-30^{0}C during germination,15-20^{0}C during seed formation.
- It requires high humidity.
- Temperature above 32^{0}C along with the drought during flowering reduces yield, oil content and oil quality of linseed.
- Plants are susceptible to frost and causes injury to blossom
- It is resistant to drought and grows well in areas receiving an annual rainfall of 450-750 mm.

Soils

- Crops grows on well drained, moderately deep silt loam, clayloam & silty clays
- Light sils area not suitable especially in low rainfall areas
- Crop can tolerate soil acidity but ideal pH is 6.0.

Land Preparation

- More sensitive to salinity, but fibre and oil content decreases at EC of 6.1dsm-1
- Majority of linseed area is rainfed and grown in marginal and submarginal lands,
- Hence adoption of soil & moisture conservation practices is important for good yie lds
- Ploughing 2-3 times with cultivator, followed by 2-3 harrowings to obtain fine tilth,
- Hoeing after each shower conserves the soil moisture

Varieties

State	Utera	Rainfed	Irrigated
Himachal Pradesh	Surabhi, Janki, Himalini	Surabhi , Janki	Janki, Himalini, Nagarkol
Maharastra	R-552	Kiran,Sheetal	Jawahar-23
Madhya Pradesh	R-552	Kiran,Sheetal	Jawahar-23
Punjab		LC-54,Himalini	LC-54, Himalini
Uttar Pradesh		Swetha,Shubra	Garima, Shubra, Neelam

Sowing Time

- **S**owing time varies from October - Nov 15th in different states depending on availability of soil moisture, irrigation and cropping systems
- Early sowing helps to escape attack of powdery mildew, rust, and linseed bud fly
- Pure "Rabi" crop should complete the sowings by **Nov 15th** .

Seed rate

The following seed rates are optimum under moist conditions

- Under rainfed **:** Broad casting @ 40 kg/ha - 5 lakhs plants/ha
  : Drilling @ 30kg /ha - 5 lakhs plants/ha

- Under irrigated **:** Broadcasting @ 35 kg / ha - 5 lakhs plants/ha
  : Drilling @ 25 kg/ha - 5 lakhs plants/ha

- Under all situations **:** Dual methods @ 25 kg/ha - 4 lakhs plants/ha
- Thinning should be done 15 days after emergence.

Seed Treatment

- Seed treatment with thiram @ 3g/kg of seed or bavistin @ 1.5g or topsin M @ 2.5g/kg seed to protect the linseed from seed borne diseases.

Sowing depth

- Shallow sowing @ 2-3 cm with adequate soil moisture helps in early establishment.
- Drilling facilitates even distribution, uniform depth of seeding result in better stand and good yields
- In drier situations, where surface moisture is not adequate, sowing in deeper layers of 5-8 cm ensures germination

Spacing

- Spacing between the rows : 25 - 30 cm
- Spacing between the plants in a row : 7 - 10 cm

Nutrient Management

- Application of FYM or compost @ 5-8 t/ha, final land preparation, improves water holding capacity of soil , improves soil structure, increases nutrient uptake there by leading to good yields.

Nitrogen deficiency : is very common in linseed crop.

- Which shows small erect, pale green to yellowish green leaves
- Early defoliation, crop matures earlier, producing lesser flowers and fruits leading to poor yields

"P" deficiency :

- Shows dwarfness of plants, dark green color, small leaves and dies prematurely.
- Phosphorus increases oil in the seed and yield of flax
- Hastens root development, promotes deeper penetration, helping in preventing lodging and better utilization of soil moisture.

K deficiency

- Shows stunting of shoots with shorter internodes.
- Brown scorches at the tips and withering.
- Use of potassium causes complementary effects to the use of N and P increasing the yield of linseed.

Sulphur deficiency

- Sulphur requirement of oil seeds is high
- Sulphur deficiency Shows stunted plants, leaves turn yellow and become chloratic.
- 40 kg S /ha should be applied to linseed crop to improve the oil yield

Zinc deficiency

- Shows stunted plants
- Grey brown spots appear on the younger leaves on the upper surface and dark green blotches on lower surface.
- Internodes are shortened and forms rosette
- Defeciency can be corrected by soil application of zinc sulphate @ 22.5 kg/ha once in 2-3 yrs or spraying of zinc sulphate @ 0.25% after 2 weeks of emergence is recommended.

Fertilizer Schedule :

Under rainfed conditions : 40 + 20 + 20 kg N P K / ha
Under irrigated conditions : 90 + 40 + 30 kg N P K /ha

Weed Management

- Weed free conditions upto 30-45 days is critical
- Adequate tillage, prior to seeding, minimizes the weed growth.
- Two intercultivations at 20 and 30 DAS with the manual weeding is ideal
- Fluchloralin @ 1 kg ai /ha as PPI or Pre emergence application of alachlor @ 1kg ai/ha or Post emergence of dichlofop methyl @ 0.7 kg ai/ha at 30 DAS is effective.
- Pronamide @ 1.5 kg ai/ha is effective in controlling Cuscuta infestation in linseed.

Irrigation

- More than 90% of area under linseed is rainfed, where bold seeded and deep rooted varieties are preferred.
- Small seed with the shallow rooted varieties are to be preferred under irrigated conditions
- Frequent light irrigations are ideal and economical than heavy irrigations at longer intervals
- Linseed responds well to irrigations.
- Irrigations at critical stages like flowering and seed development is essential under moisture stress conditions.
- Providing irrigations at 35 and 75 DAS has doubled the yields of linseed.
- Moisture stress at stem elongation stage benefited the seed yields and adversely effected the straw yields
- Sheduling irrigation at 50% DASM and IW/CPE is 0.6.

Harvesting

- The crop should be harvested when the leaves are dry. A rule of thumb is to harvest when 90% of the seed capsules are brown and shiny.
- For fibre purpose, harvesting should be done at physiological maturity when the crop is still green.
- Crop is harvested in March to April, cutting the plants close to the ground or pulling the plants.
- Harvested crop is left in the field for few days for sundrying.
- Threshing is done by beating the dried plants with the sticks or trampling under the cattle feet.
- The seed is separated from chaff by winnowing.
- Care should be taken in cutting the stalk and facilitate undamaged stalk in retting.

Quality considerations

- Linseed contains 20-24 % protein, 37-42% oil, 15-29% CHO's ,5- 9% crude fibre, 2-4% ash.
- Linseed oil cake contains 30% protein, 7% fat, carbohydrate -42% which is a valuable protein source to poultry and ruminants.

Uses

- All parts of linseed plant are utilized for various purposes either directly or used for processing
- Flax is roughly 40% oil by weight, about 55% of which is alpha linolenic acid (also called omega-3 fatty acid).
- On a small scale seed is directly used for edible purpose and 80% of oil goes to industries. Oil is rich in Linolenic acid (66% and above) and is a perfect drying oil and used in paint and varnishes
- Its use is limited to animal feed because of undesirable compounds like phytic acid, cyanogenic glucoside and goitorogen.
- It is used in the manufacture of lithographic inks and soaps
- Oil cake is good feed for milch cattle and also as a manure having microbial activity
- Linseed stem yields fibre of good quality having strength and durability. The fibres are lustrous and blend with the wool and silk
- The fibre is used in gloves, foot wear, netting sports, paper and textile industry, cigarette wrapping paper, strong canvas, suitings and shirtings
- Woody matter and short fibres used as raw pulp in paper industries.
- One hundred kg retted flax yields the following co product.

Sno.	Products	Quantity (kg)	Utility
1.	Sketched flax	16	Spinning
2.	Tow broken fibre	8	High grade paper
3.	Woody parts	54	Chip board panels
4.	Seed	10	Oil and meal
5.	Straw	7	For fodder
6.	Dust	5	compost

Utera / Pyra cultivation

- Pyra or utera cultivation is broadcasting linseed in standing kharif rice, when the crop is at is at flowering and dough stage or 10-12 days before harvest of the crop.
- This practice is followed for utilizing the conserved soil moisture in post rainy season, there by utilizing the available irrigation sources judiciously in season.
- In sufficient water available areas, a new method of utilizing available soil moisture ,Crack system of sowing linseed is practiced.
- This method involves development of deep 5 cms cracks, in the standing rice crop at the end of dough stage, followed by watering/ irrigating the field.
- Then sowing are done in October preferably with short duration varieties .
- Varieties like R-7 (Jawar -7) & (R-552) resistant to rust, powdery mildew and wilt are preferred for utera cultivation.

- **Fertilizers :** Linseed utilizes residual fertility of manures and fertilizers applied to the rice crop.
- 10 kg of Nitrogen is applied to rice crop itself at flowering or one week before sowing of linseed , which is beneficial for establishment and growth.
- **Weeding :** Once manual weeding is done in linseed crop after rice is harvested.
- Utera method gives 50% higher linseed yield, without any adeverse effect on rice yields.

Double purpose linseed

- Linseed when grown for fibre is known as fibre flax, when cultivated for seed known as seed flax/oil flax/linseed.
- **Linseed or seed flax :** varieties are dwarf profusely branched & high seed potential.
- **Fibre flax** : varieties are tall, scarcely branched, having low seed yielding, ability with high fibre yields. Commonly cultivated in temperate regions.
- Identification & development of the crop having both the characters of high seed & fibre yield is the concept of double purpose linseed.
- Total monetary returns per unit area or per unit time is an important consideration
- Extraction of fibre from well grown linseed crop requires cooler temperature during retting process.
- In India after the harvest of crop, temperature rises and alters quality of fibre and thus Indian flax does not command good price in international market.
- Dry scotching machine was developed for oil and fibre extraction.
- DPL 21, LCK 152 & RL 993 (Meera) are the promising double purpose linseed varieties.
- Giza 5 and Giza 6 are high yielding double purpose varieties.

Yield : of fibre flax is about 10-15 quintal/ha

Retting flax

There are several methods of retting flax.

It can be retted in a pond, stream, field or a tank.

When the retting is complete, the bundles of flax feel soft and slimy, and quite a few fibers are standing out from the stalks.

When wrapped around a finger the inner woody part springs away from the fibers.

Pond retting is the fastest. It consists of placing the flax in a pool of water which will not evaporate. It generally takes place in a shallow pool which will warm up dramatically in the sun; the process may take from only a couple of days to a couple weeks. Pond retted flax is traditionally considered lower quality, possibly because the product can become dirty, and easily over-retts, damaging the fiber. This form of retting also produces quite an odor.

Stream retting is similar to pool retting, but the flax is submerged in bundles in a stream or river. This generally takes longer than pond retting, normally by two or three weeks, but the end product is less likely to be dirty, does not smell as bad and, because the water is cooler, it is less likely to be over-retted.

Both Pond and Stream rettings were traditionally used less because they pollute the waters used for the process.

Field retting is laying the flax out in a large field, and allowing dew to collect on it. This process normally takes a month or more, but is generally considered to provide the highest quality flax fiber and produces the least pollution.

Retting can also be done in a **plastic trash** can or any type of water tight container of wood, concrete, earthenware or plastic. Metal containers will not work, as an acid is produced when retting, and it would corrode the metal.

If the water temperature is kept at 80°F, the retting process under these conditions takes 4 or 5 days.

If the water is any colder, then it takes longer time.

Scum will collect at the top and an odor is given off the same as in pond retting. **Currently 'enzymatic' retting** of flax is being researched as a retting technique to engineer fibers with specific properties **"Pectinolytic enzymes** and retting," "Processing techniques for improving enzyme-retting of flax," .

The young linseed crop

Flowering stage

Linseed flower (White, Voilet flowers)

Maturity stage

Niger (*Guizotia abyssinica*)

- Niger crop is grown for seed used for extracting oil which is about 37 to 43 percent of the seed weight
- The crop sheds a large quantity of dry leaves in the field and thereby adds lot of organic matter to the soil
- Named after French historian "*Guizot*"
- Known as "Kalatil" "Ramtil" and "surguja" in Hindi.
- Seed resemble to sunflower seed in shape, but dark and small in size.
- Tolerant to drought and less susceptible to attack by animals, birds, insects and diseases.
- Niger is a minor oilseed crop in world and meets economy of India; still it is of considerable importance for rainfed conditions on poor soils of coarse textured especially on hill slopes and shallow soils of marginal lands.
- Gives good yield even with poor management.
- Niger oil is similar to safflower oil in edible quality.

Description :

- Herbaceous annual, 0.5–1.5 m tall; stems pubescent leaves opposite, sessile, subcordate to ovate-lanceolate, serrate, subscabrous, to 22 cm long; involucre with ovate, biseriate scales;
- Flowers yellow, conspicuous, in solitary or clustered heads to 2 cm across, arranged in corymbs; heads with 40–60 tubular hermaphroditic florets, surrounded by a marginal row of ligulate florets, flowering in each head lasting 7–8 days, cross-pollinated, probably by bees.

Origin and Distribution

- Niger is native of *Abyssinia (Ethiopia)*
- It is originated from *G scabre* and sub-species G. *Schimperi*.
- Migrated to East Africa and India through Persian Gulf traders along with other crops popularly known as **Savanna complex.**
- Grown in East Africa, India, Germany, Switzerland, France, USSR, Sudan, Uganda, Tanzania and Malawi.
- India, chief niger producing country in world.
- In India : Madhya Pradesh, Orissa, Maharashtra, Karnataka, Tamil Nadu are imporatnt states cultivating niger crop

Area and Production

- World statistics for Niger are scarce and unreliable.
- World : Area : 2 lakh/ha
  : Production : 1 lakh ton
  : Productivity : 500 kg/ha
  India : Area - 0.6 m ha
  : Production - 0.2 mt
  : Productivity - 300 kg/ha
- Ethiopia is the the major niger produc ing country in the world
- Maharastra ranks first both in area (0.21 m ha) and production (0.035 mt) in the country.

- Productivity is highest (500 kg/ha) in Orissa.

Climate

- It is a temperate region crop and also adapted to semi-tropical environment.
- Niger is a short day plant
- Requires moderate temperature of 18-23°C for its growth.
- Temperature above 30°C growth rate and flowering are adversely affected and hastens maturity.
- Frost will kill the young seedlings.
- Rainfall of 1000-1300 mm is optimum although 800 mm will produce reasonable yield.
- The peak flowering period of crop should not coincide with rainy periods as the honey bees, which are main pollinators, are disturbed ,resulting in poor seed setting.
- High wind or rain at seed maturity will cause severe maturity.
- Temperature below 10°C, emergence is restricted – leading to in adequate stand establishment.

Soil

- Niger is grown on all soils from sandy deep clay loam.
- Crop prefers light textured soil, but well drained heavy soils can be used for cultivation.
- Niger tolerates water logged soils, it is resistant to poor oxygen supply in soil by developing *Arenchyma* cells
- Can tolerate salinity to some extent, increased salinity delays flowerings.
- Grows well in the soils having pH 5.2 to 7.3.

Tillage / land

- Since a small seed, leveled seed bed is essential to ensure uniform planting and subsequent emergence.
- Good tilth is obtained by 1 or 2 ploughings followed by 2 harrowings.
- In hilly areas furrows run across the slope to avoid soil erosion.

Season

- 2 seasons : ***Kharif*** **:** June – July
  Rabi **:** September (under stored soil moisture)

State	Sowing time
Andhra Pradesh	2nd week of August – Mid of September
Madhya Pradesh	2nd and 3rd week of July
Maharashtra	June end to early August
Karnataka	June – August
Orissa	3rd week of July – first week of August

Varieties

- Recommended improved varieties are Ootacamand, GA 10, Phulbani, GAZ, GA 10, CHH4, RCR 317, TN 5 and Gujarat Niger, Mature in 75-100 days.

Seed rate and spacing

- Seed rate depends on method of sowing
  (a) Broadcasting : 8 kg/ha
  (b) Line sowing : 5 kg/ha
- Spacing : 30 x 10 cm
- Optimum plant population varies from 2,50,000 to 3,00,000 plants/ha.
- Thinning should be completed within 20 DAS to maintain required plant density.

Nutrient management

- Crop is mostly grown on marginal and submarginal lands without manure or fertilizers.
- Niger – Responds to fertilizers
- N recommendation varies from 10-40 kg/ha in different states
- In Andhra Pradesh : 20 kg N/ha
- Soil 'P' levels are low in many areas where niger is grown.
- Application of 40 kg P_2O_5 / ha is recommended for niger.
- Since niger is continuously grown in same land every year in mixed cropping there is possibly of mycorrihzae root relationship in the soils.
- 10 kg P_2O_5 / ha is used when the niger is rotated with well fertilized crops in rotation.
- However recommended fertilizer schedule is 20 + 20 kg NP /ha
- Recommended fertilizer should be applied by placement using seed drill.
- Half of N + entire dose of 'P' should be applied as basal at sowing.
- Remaining half dose of N should be top dressed at 30 DAS preferably coinciding with rainfall.

Water management

- Niger is invariably grown in rainy season and it is not irrigated mostly.
- It is reported that niger yields can be doubled under irrigation.
- Irrigation is to be scheduled according to soil and climate conditions (as there is no much information available on irrigation .)
- Irrigation must be given at seedling stage for proper growth followed by based on the needs of the crop.
- Check basin or border strip system of irrigation is ideal for niger.

Weed management

- Niger grows rapidly once the seedlings are established and dense growth competes with weeds
- Two weedings first at 15 DAS and second at 30-35 DAS before top dressing.

- Dodder (*Cuscuta chinensis*) is a parasitic weed in Orissa, on niger, which can effectively controlled by pre-emergence herbicide – "Pronamide" @ 2 kg per ha and as Po-emergence as soil treatment @ 20 DAS.

Harvesting and threshing

- Normally matures in about 80 -145 days after emergence.
- **Stage of harvest :-** when leaves dry up, head turns brown or blackish or 45-50% of moisture content in buds.
- After drying in the sun for about a week by stacking ,then the crop is taken to threshing floor and crop is manually threshed.
- Crop is also threshed by trampling under the feet of bullock.
- Threshed produce is winnowed in the wind and clean seeds are obtained.
- Yield : Pure crop : 400 – 500 kg ha^{-1}.
  Inter crop : 150 – 300 kg ha^{-1}

Storage

- Seeds are sun dried for 2-3 days.
- Stored in gunny bags in houses *with* good ventilation.
- High humid coupled with moisture conditions prevailing inside store houses should be avoided.
- For small farm seed storage – 200 litres oil drums fitted *i.e.,* lids – have proved effective for storage

Quality considerations

- Niger seed contains 35-40% oil, ash 4 - 5.8%, 20% - protein, crude fibre content is 10%
- Niger oil is pale yellow, nutty in taste and sweet odour, and low acidity in raw oil hence used in cooking.
- Linoleic acid is major fatty acid, followed Oleic acid also.
- Niger cake contains 24-34% protein, 4-14% oil, 8-24% crude fibre, 20-28% sugar and 8-12% ash.

Economic importance

- 75% of niger seed produced is used for extraction of oil in India, and rest is used for food in confectioneries making, also Exported to western countries as cage bird feed
- Consumed by sheep
- Niger also used as green manure
- Niger seed cake is a valuable cattle feed
- Niger seed is used as human food
- Oil is subjected to oxidative and rancidation , reducing its keeping quality poor, due to high Oleic acid (38%) and linoleic acid (51.6%).
- Oil is used for culinary purposes
- Used for manufacturing paints and soft-soaps and cosmetics
- Niger oil is used as a base oil in perfume industry
- Niger oil is use for pharmaceutical purpose
- Niger based agar medium which is required for brain ailment.

Crop in field

Lecture No - 13

Castor (Ricinus Communis)

- Castor belongs genus : Ricinus, Family : Euphorbiaceae
- Known as **Erand** in Hindi **"Amudam"** in Telugu plays an important role in country's Vegetable oil economy.
- Castor is one of the ancient important non-edible oil seed crop which has industrial and medicinal value.
- Ricinus is derived from latin term " Dog's Tick" because of the resemblance of mottling on the seed to the common pests of dog.
- Cultivated chiefly for trading, since it has no food value
- Castor is coined by English Traders, who confused the oil with Vataxagnus castus.
- Though generally known as castor bean plant, its seed is the castor bean which, despite its name, is not a true bean .
- To many people the castor plant is just an overgrown, undesirable weed, and yet it produces one of nature's finest natural oils
- It is used as a lubricant in high-speed engines and aeroplanes.

Origin & Distribution

- Castor is a native of east Africa especially Ethiopia
- India, Brazil, China, Argentina, USA, Thailand, Queensland, Egypt and Sudan are the important countries producing countries.
- In India, important states producing castor are Andhra Pradesh, Gujarat and to some extent T.N, Karnataka, Orissa Madhya Pradesh and Bihar.

Area, Production and Productivity

	World	India	Andhra Pradesh
Area	1.5m/ha	0.72 ha	157 l/ha
Production	13 mt	0.9 mt	087 l/tons
Productivity	900 kg/ha	1221 kg/ha	511 kg/ha

- Globally, India ranks first both in area and production.
- Productivity of castor is highest in Gujarat (1650 kg/ha).

Morphology

- Castor plants is of 2 types **:** Tall / Giant types with perennial habit,tap root system
  : Short / Dwarf types with shorter duration
- **Stem :** is Round, glabrous, bluish ,waxy gives resistance to jassids, hoppers.
- Stem is solid in gaint types and become hallow with age in dwarf types.
- **Leaves** are large, green in color, glossy and sometimes red due to anthocyanin pigmentation. Usually leaves consist of 5 to 11 lobes.
- **Inflorescence:** Forms a pyramidal " **raceme, spike / candle** " born terminally on main lateral branches
- Lower portion of raceme consists of male flowers and upper portion bears female flowers and the ratio between them is varietal character and influenced by climate.
- High temperature leads to maleness, spraying gibberellins tends to increase the female flowers

- Plant produces the flowers over an extended period through out the year.
- **Fruit :** It is globular capsule, spiny becomes hard and brittle when ripened
- **Seed :** Capsule contains 2-3 seeds, oval shape, shiny, brittle, white/brown /black/red with a mottling on testa. Seed size varies with variety in diff. racemes on same plants
- Seed has dormancy for many months. But dwarf type are non dormant and germinates with in 10-12 days

Climate

- Basically a warm season crop grows in temperate and tropical regions throughout the world.
- Can be successfully grown from **300-1800 m** above sea level
- Castor production lies between 40° N and 40° S
- In India successfully grown upto 1500 m
- **Temperature:-** Requires moderately high temp of 20^0-26^0 C with low humidity through out growing season to give high yields.
- Low temperature extends emergence, making more liable to attack by fungal diseases & insects. High temperature 41^0 C results in blasting of flowers & poor seed set.
- A **frost** free growing period between 130-190 days depending on cultivar is necessary for satisfactory yields.
- **Day length :** Basically a long day plant, fairly adaptable to day length from 13-18 hrs.
- **Rainfall :-** 600-760 mm rainfall is required.
- For optimum growth and development - 100 mm evenly distributed rainfall in first few months period is desirable.

Soils

- Grows on any type of soil, well drained, sandy loams will produce optimum yields.
- Crop is sensitive to excessive moisture.
- In Andhra Pradesh grown in sandy loams and shallow black soils.
- Prefers slightly acidic pH of 5- 6.5, but can also grow upto pH 8.

Tillage / and land preparation

- As castor crop is deep rooted plant with the trap root system extending beyond 2-3 meters for extraction of soil moisture from deep layers, deep plouging (<45cm) and chiseling in shallow soils with sub surface hard pan is adopted to support deep root system, reducing weeds.
- Castor is a hardy crop for better crop insitu moisture conservation, summer tillage or offseason tillage with pre-monsoon rains helps in removal of weeds for better infiltration and rain water retention.

Varieties

S. No.	Variety	Season	Duration (in days)	Yield q/acre	Characters
1.	Kranti (P.C.S 4)	Kharif / Rabi	90-150	5.6-6.4	Drought tolerant bold seed. Suitable for late sown conditions.
2.	Haritha (P.C.S 124)	Kharif / Rabi	90-150	5.6-6.4	Wilt tolerant

3.	Kiran (P.C.S 136)	Kharif / Rabi	90-150	5.2-6.0	Drought tolerant escapes Botrytis to some extent
4.	Jyoti (D.C.S 9)	Kharif / summer	90-150	4.8-6.0	Wilt tolerant
5.	Jwala (48-1)	Kharif	150-180	4-4.8	Tolerant to wilt and Botrytis disease
6.	P.C.H. 1	Kharif/ Rabi	90-180	5.6-7.2	Suitable for rainfed conditions. Tolerant to drought. 1st bunch will come to maturity early. 15days earlier than GCH-4
7.	G.C.H. 4	Kharif	150-210	5.6-7.2	Tolerant to wilt and root rot. Tolerant to drought.
8.	D.C.H 32	Kharif for rainfed conditions	90-180	5.6-7.2	Comes to harvest early
9.	D.C.H 177	Kharif / Rabi for rainfed conditions	90-180	6.0-7.6	Drought tolerant

Aruna(220-280 days), and short duration varieties like Bhagya and Sowbhagya are the oldest varieties of cator.

Seasons and sowing time:

- **Kharif** : with the onset on the monsoon, June 15th is a ideal time of sowing
- **Rabi** : September to October
- **Summer** : January

Seed Rate

- Rainfed crop : 12 - 15 kg/ha : with plant population of 55,000 plants / ha
- Irrigated crop : 5 - 6 kg/ha : with the plant population of 18,500 plants/ha

Varieties

- Kranthi, Haritha, Kiran etc released by ANGRAU
- Jyothi, Jwala, DCH-177, DCH-519 relased by DOR Hyderabad.

Spacing

Regions	Cultivar	Spacing (cm)
• All castor areas (Rainfed)	Improved var's / Hybrids	90 x 20 or 60 x 30
• Andhra Pradesh & Gujarat	Hybrids	90 x 60
• Delayed planting (in want of rains)	60 x 15	60 x 30 (Ideal to curtail veg. growth.)

- Seed is sown in furrow behind plough furrow at 10-12 cm below soil surface.
- Fertilized drill is preferred in rainfed areas and widely spacing of 90 cm in larger areas.
- Dibbing the seed either in flat bed or at the base of ridge is common under irrigated conditions.

Nutrient Management

- Crop yielding 2000 kg seed removes around 80 kg N, 18 P_2 05, 32 kg K_2O, 12 kg Ca, 10 kg Mg ha^{-1}
- Nitrogen application is related to available soil moisture through rain/ irrigation.
- For improved varieties under rainfed conditions, 90-140 kg N/ha is recommended
- For hybrids under irrigated conditions, 200 kg N/ha is recommended

Phosphorus :- Under rainfed condition, 30 kg P_2O_5 / ha is adequate

- Improved cultivars responds upto 75 kg P_2O_5 / ha

- **Potassium :** Tropical soils are well supplied with available K

- But application of N & P may result in increased potassium uptake

Recommended fertilizer schedule:-

- Rainfed conditions in Andhra Pradesh **:** 40-60 + 40 +30 kg N P K/ha.
- Irrigated conditions in Andhra Pradesh **:** 80-100 + 40 + 30 kg/NPK/ha.
- Under rainfed conditions nitrogen should be applied in three splits
- 50% of the dose at sowing time, 25% at 35 – 40 DAS, 25% at 65- 75 DAS.
- Under irrigated conditions nitrogen should be applied in four splits.
- 30 kg N at sowing , 60 kg N splitted three times with 20 kg each time at 30-35 days, 60-65 days, and 90-95 DAS

- Entire dose of P & K should be applied basally at sowing time.
- Use of Single Super phosphate as a source of P can meet the requirements of "S" Calcium, Magnesium.

- Integrated nutrient management involving crop rotations with legumes, green manures, phosphate solubilising bacteria etc will reduce the cost on fertilizers besides improving the soil fertility.
- Alley cropping or Green leaf manuring with subabul, contributed to " N" pool in soil

Water management

- Castor is drought tolerant rainfed crop but responds well to irrigation.
- Water requirement of castor crop is 500-700 mm.
- Flowering and seed development stages are more sensitive for moisture stress.
- **Scheduling Irrigation: -** Information on scheduling of irrigation is limited but it is desirable to give heavy irrigations at longer intervals than the frequent irrigations.
- In a crop duration of 180 days, require around 6 irrigations to obtain optimum yield
- As the crop is sensitive to water logging, furrow method of irrigation is ideal as it drains out the excess water from the field.
- In **Rabi,** first irrigation should be given at 50 DAS after sowing, followed by irrigations at an interval of 20 days.

Weed Management

- Castor crop is highly susceptible to weed competition in intital stages, has the growth of castor is slow initially and larger area is exploited by weeds.
- Hence, weed control is of paramount importance.
- Critical period for weed free competition is 45-50 days.
- Clean cultivation in terms of summer ploughing and thorough seed be d preparation eliminates weeds to a larger extent before sowing of castor.
- For rainfed castor **:** 2-3 intercultivation with blade harrow ,starting from 20 DAS along with manual weeding is ideal.
- For irrigation castor **:** 2-3 hand weedings at an interval of 15 days starting from 15 DAS is ideal.
- Herbicides are economical in irrigated castor.
- **PPI herbicides :** Fluchloralin (0.75-1.0), Trifluralin (0.75-1.0), EPTC (2.0 – 2.5), Nepatalam (3.5-4.0)

Pre -emergence herbicides : Alachlor (1.0 -1.5), Metalachlor (1.0-1.5), Pendimethalin (1.5- 2.0), Nitrofen (1.5-2.0)

Harvesting

- Harvesting castor spikes should be done at right time
- 15-20% of yield is lost in the field due to dehiscence of capsules under rainfed conditions of A.P waiting for all the spikes to come to maturity for single harvesting.
- On an average, castor plant produces 4-5 sequential order spikes over a span of 180 – 240 days.
- Main spike is ready for harvest within 100 days after seeding, subsequent harvest can be done at 30 days interval in improved cultivars.
- Optimum stage for harvest is capsules turning yellow and starts drying.

- Pre-mature harvest should be avoided.
- Dried capsules on the spike are plucked, /collected and threshed instead of cutting the entire spike from the plant.
- Harvested spikes are usally placed in heaps around one week and than sun dried for a couple of days.
- Threshing is done by beating with the sticks or trampling under the cattle feet or tractor or power operated threshers.
- Castor seed can be stored in gunny bags without loss for three years.

Storage Of Seed

- Castor-seed is very hard and does not require much care during storage.
- No insect or fungus attacks the seeds.
- Under ordinary conditions of storage in jute (gunny)bags, the oil and the free fatty acid content of the seeds are not affected even after three years of storage.
- Usually, castor - seeds are not required to be stored in warehouses over long periods.
- Being an important industrial and export commodity, it is immediately crushed locally or exported.
- In warehouses, castor seed is stored in gunny bags.
- Sometimes, if the bags get wet due to high humidity or leakage of rain-water, the seeds become slightly mouldy but this does not affect either the oil or the free fatty acid contents.
- With sun drying, the source of damage can be eliminated.
- It is recommended that castor seeds be dried to 7-8% moisture content before storing.
- At domestic or farm level, storage of large quantities of castor seed is not recommended as it occupies a considerable space
- Castor seed is also not recommended to be stored in open as both heat and sunlight damage the germination and reduce the oil content.
- Artificial low temperature storage also affects the viability.
- Castor seed stored at 5 to 7^0C temperature for 6 months reduced the germination percentage.
- During bagging the seeds, handling should be minimized.
- On large scale handling, wooden scoops, shovels and rubber conveyor belts are recommended.
- Seeds should be stored at dry place and cooler part of the house.

Quality considerations:-

- Oil content ranges from 40-45%, 12-16% proteins 27% of carbohydrates 23-27% fibre.
- Dehulled types contains 60-70% of oil and 18-26% protein.
- Castor oil is unique that it contents 85-90% ricinolic acid which imparts high degree of viscocity and oxidative stability, four times stable than olive oil.
- Castor cake contains 6% nitrogen, 2.5% P_2O_5, 1.5% K_20, as it contains toxic constituents, unfit for edible puropose, except to poultry, cannot be fed to any animals.
- Castor seed contains an alkaloid called “recinine” which is extremely poisonous.

Economic importance:-

- Seed consist of oil ranging from 50-55%, the various uses of castor oil is ascribed because of presence of fatty acid called as “ricinolic” acid.
- Oil is used as lubricant, because of its quality, can remain as liquid at low temperature 32^0C and viscouys at high temperature.
- Used in textile soaps, cosmetics, nylon, pharmaceuticals, paints, varnishes, dying, carbon and papermaking
- Used for production of wetting agents, detergents, sebacic acid, secondary octyl alchol, undecylinic, acid, resins, fibres etc.

- Associated with medicinal and veterinary use of obstetrics, dermatology etc.
- Used as purgative, laxative and a soothing medium for eye diseases.
- Used in production of artificial leather, printing inks.
- In cytogenetic studies, soaking root tips in oil for 2 hr help in excellent chromosomes spreading
- It is a good source for synthetic flower scents and fruit flavours.
- Castor cakes is used as a manure and anti termite products
- Protein from a castor seed is used to produce distemper; oil bound water paints, adhesives, casein plastics.
- Pulp from the stem mixed with the bamboo pulp produce papers.
- Green leaves are used in raising eri silkworms.
- Grown as shade crop in turmeric, windbreak in sugarcane, as an attractant to catch pests in tobacco.
- Few castor seeds are mixed in safe storage of sesame seeds.

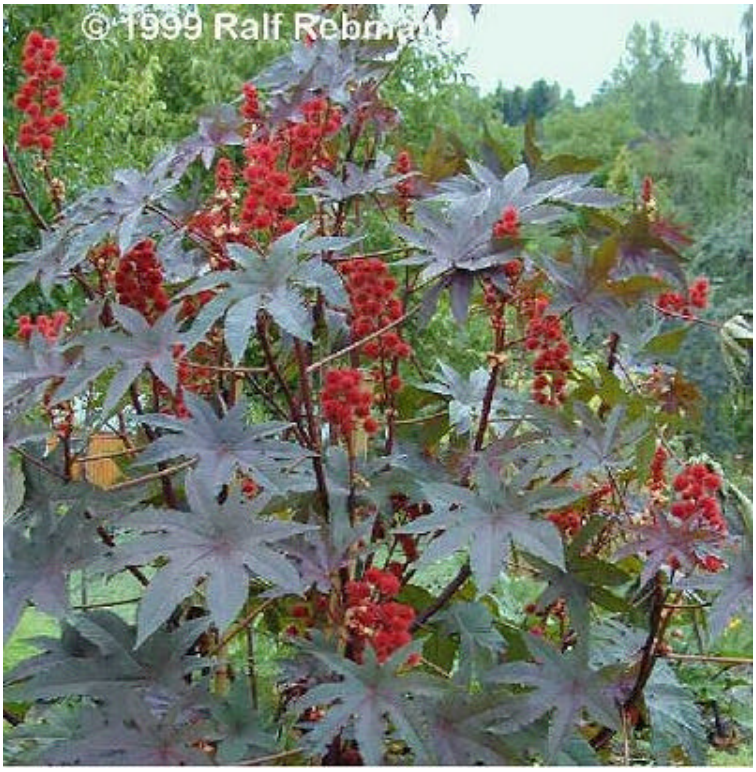
Intercropping combinations recommended/practised	**Proportion**	**States**
Castor + Red gram	**1:1**	**Gujarat, Andhra Pradesh**
Castor + Cowpea	1:2	Gujarat, Andhra Pradesh
Castor + Blackgram	1:2	Andhra Pradesh
Castor + Greengram	1:2	Andhra Pradesh
Castor + Cluster bean	1:1	Andhra Pradesh
Castor + Groundnut	1:5 or 1:7	Andhra Pradesh
Castor + Groundnut(Bunch)	1:3	Gujarat
Castor + Soybean	1:1	Bihar
Castor + Sunflower(Hybrid)	1:1	Gujarat(Irrigated)
Castor + Lathyrus	1:5	Bihar
Castor(Local)+turmeric	1:5	Bihar

CASTOR PLANT

Male & Female flowers

Castor with spikes

Flowering stage



Capsule formation

Castor with dried capsule

Castor seeds

Lec No: 14: **AGRONOMY** **Course No: AGRO-301 (Crop Production-II)**

Cotton- Importance-Origin-Distribution-Cotton growing Zones- Classification-Soil, Climatic requirements-Seasons- Seeds & sowing.

Cotton

Cotton is one of the oldest and the most important commercial crop of the world and forms the most important fibre crop. Cotton textile industry is the oldest Agricultural industry of India. The fibre obtained from seed is used for variety of purpose. But major use of fibre is manufacturing of textiles which provide clothing to the mankind. Ever since the dawn of civilization, cotton served the purpose of providing this need and even today it dominates despite of the production and marketing of many synthetic fibres Cotton is referred to as " King of Fibres "and also known as "White Gold"

Cotton is also used for several other purposes like making threads, for mixing in other fibres and extraction of oil from the cotton seed. Oil content ranges from 15-25 percent.

Cotton seed cake after extraction of oil is good organic manure contains 6.4% N, 2.9% P_2O_5 and 2.2% K_2O.

Cotton seed and pulp obtained during oil extraction and cotton meal are good concentrated feed for cattle.

Origin and History:

Cotton has been used as a fabric in India from time immemorial. It has been cultivated in the Indus Valley for more than 5000 years before. The excavations of Mohen – jo- daro indicates a high degree of art in spinning and weaving with cotton at that time. It finds mention in the Rigveda, the oldest scripture of the Hindus. Manu also refers to it in his Dharma Shastra. India appears to have been the centre of an important cotton industry as early as 1500 B.C. The cultivation of Cotton spread from India to Egypt and then to Spain and Italy. Every available evidence proves that India is the original habitat of Cotton.

The cultivated Species are divided into two groups.

They are Old world cotton:

India is the major cotton growing country, growing all four species of cotton commercially. India is considered as centre of origin of old World cotton and believed that two Species (arboreum and herbaceum) belonging to old world cotton have spread along the commercial routes to several countries in the East and also to the Northern countries like Africa to Egypt and other Mediterranean regions through trade and business.

New World cotton:

Cotton belonging to species barbadense are derived from a perennial cotton, a native of Peru called Tangins. This variety was introduced into USA and by selection a new type of annual cotton was developed known as Sea Island Cotton which was the longest and finest fibre of all the cultivated cotton. Hirsutum species is the native of Central Mexico and spread to other parts of USA, Asia, Africa etc from native place.

Area and distribution:

Cotton is the most important fibre crop of the world cultivated over an area of 34.5 ha with a total production of 54.5 mt.

The important cotton growing countries are India, USA, Russia, China, Brazil, Egypt, Pakistan, Turkey, Mexico and Sudan. These ten countries account for nearly 85% of the total production.

Climate:

It is a tropical crop and thrives well in hot and humid climate. It is heat loving and sun loving(heliophyte) plant. A daily minimum temperature of 16°C is required for germination and 21 to 27°C for proper vegetative growth. It can tolerate temperature as high as 43°C, but does not do well if the temperature falls below 21°C. During fruiting phase, the day temperature ranging from 27 to 30°Cand cool nights are needed.

Abundant sunshine during the crop growth period particularly the period of boll maturation and harvesting is essential to obtain a good quality produce. Successfully grown in areas receiving an average annual rainfall ranging from 500mm, of which 175-200mm should be received during crop growth period. If, during the fruiting period heavy showers of rain occur or heavy irrigation is applied, shedding of the flowers and young bolls results. At harvesting also high rainfall is not desirable since it not only affects the quality of lint but also delays harvesting and makes the harvesting difficult.

Cotton is highly sensitive to frost occurrence. Even for short period, frost will result in killing of plant cells and severe frost situation, death of entire plant occurs. Hence, its cultivation is confined to plains and extends from MSL occurs to an altitude of 1000 m only. For successful crop, it requires a frost free period of a minimum of 180-200 days, starting from the emergence of the plant.

Soils:

Cotton is a deep rooted crop. As the tap root extends even up to a depth of 200-250cm deep soils are ideal for better root penetration and development. Soils should have good water retention capacity as most of the cotton is confined to rainfed conditions.

Soils must be well drained and well aerated since the crop is sensitive to water logging. Crop can tolerate P^H of 5.5 to 8.5. The Principle soil types for cotton cultivation in the country are

a) Alluvial Soils: Punjab, Rajasthan , Haryana, U.P, Bihar, West Bengal, Orissa, Assam, Godavari, Krishna region (A.P)

b) Black Cotton Soils: Central and Western M.P, parts of M.S, South Orissa, South and Coastal A.P, North Karnataka

c) Red Soils: Tamilnadu, Karnataka, N-E parts of AP, Parts of MP, Orissa, Assam, UP, West Bengal, Rajasthan

d) Laterite Soils: Madhya Pradesh, Orissa, Karnataka, E Parts of A.P, Tamil Nadu, Assam, and Kerala.

Land Preparation:

he field, after the harvest of the preceding crop, should be ploughed 15-20cm deep with mould board plough. There after two to four harrowings depending upon the soil type are done. After each ploughing, planting is essential to make soil pulverized, leveled. No stubbles of the previous crop should be left in the field. For irrigated crop, particularly in North, the field should be prepared by applying heavy pre-sowing irrigation.

Seeds and Sowing:

Time of Sowing:

Time of sowing season of cotton varies considerably from tract to tract and is generally early April – May in N-India and is delayed as one goes down to south.

Cotton is essentially grown as Kharif crop in the major parts of the country - Punjab, Haryana, Rajasthan, U.P, M.P, Gujarat, MS and parts of A.P and Karnataka. In these areas Irrigated crop – March to May, Rainfed Crop – June/July

In parts of Gujarat and M.P, pre-monsoon dry sowings are practiced in the end of May or early June to give early stand to the crop.

T.N. – Irrigated and rain fed – Sept/Oct, Summer sowings – Feb/March

A.P. Northern region – June/July, Central region – Aug/Sept, July/Aug(Hybrids)
Eastern region – July/Aug, Rice fallows – Dec/Jan

Seed rate is influenced by the variety and method of sowing.

High yielding variety – 10 to 15kg/ha, Hybrids – 2.5 to 3.0kg/ha

Spacing: Straight varieties – 45 to 60X15cm (R)
-90 to 120X45 to 60 cm (I)
Hybrids -90 to 150X45 to 60 cm

Method of Sowing: Seed drill /behind the plough, dibbling (hybrids)

Depth of Sowing: 4 to 6cm

No. of seedlings/hill: Varieties 2, Hybrids 1

Seed treatment :

The seed of the most of the cotton varieties particularly of American types is covered by short fibre called Fuzz. The fuzz makes the seeds cling together, thus hampering their free passage through the seed hopper and tubes of the seed drill or they are not easily separated for sowing by dibbling. The fuzz also interferes with the absorption of the water by the seed and delays germination. The H_2SO_4 poured on seed and simultaneously. Wash the seed with fresh water followed by lime water again with fresh water to neutralize the acid residues. The fuzz gets burnt and immediately washed 3-4 times in water and dried under shade. This is called delinting. Delinting can be done mechanically in the cotton gin or chemically or the seed is rubbed with mud or a mixture of earth and fresh cow dung. By this treatment, the fuzz on each individual seed becomes pasted on the seed itself and the seeds no longer cling to each other.

In order to control the seed borne diseases the seed is treated with 0.01% Streptomycin Oxytetracyclin (Paushamycin or Agrimycin) and with 0.1% Systemic fungicide like carboxin (vitavax) solutions for 6-8 hours. The treated seed should be dried in shade before sowing.

Gap filling and thinning:

To maintain optimum population, gap filling is done with the same stock of seed which was used at the time of sowing. This is done on the 10th day. Wherever seed has not germinated to fill the gaps, the water soaked seeds are dibbled so as to have quick emergence or seedlings are raised in polythene bags at the time of sowing and these are used for gap filling. So that crop growth is uniform.

Thinning should be done within 3 WAS, by removing the excess seedlings that are weak, diseased or damaged and retaining robust and strong plants. The main objective is to maintain optimum plant population per unit area.

Lec No: 15: **Cotton- Zones of India, Classification of Cottons**

Cotton growing regions of India:

Cotton is cultivated in Inida from Sub–Himalayan region of Punjab in the North to Kerala in south and from dry regions of Kutch to high rainfall areas of Manipur in East. Based on soil, climate and types of cotton grown, the country is divided into six cotton growing tracts.

1. Northern hirsutum: – arboreum region: Comprises of Punjab, Western UP, Delhi, Haryana and N.W.Rajasthan. This is most important cotton growing and potential region. More than 90% of the area in this zone is irrigated. Two species of cotton i.e hirsutum and arboreum are grown in this region. At present 60% of the total cotton acreage consists of hirsutum varieties and growing of arboreum has assumed secondary importance. The soils are of alluvial origin.

2. Central arboreum region: This region comprises of many districts of M.P, Maharastra, Gohilwad, Amreli dts of Gujarat and Adilabad dt of A.P. Entire region is characterized by black cotton soils locally called REGAR soils which are highly suitable for cotton cultivation.

3. Southern hirsutum – arboreum region: Comprise the states of Tamilnadu and Kerala. Major soil groups are red soils but also grown on sandy and heavy black soils.

4. Central herbaceum – arboreum – hirsutum: Comprises A.P and Karnataka. The principal soils on which cotton is gr own are coastal alluvium, deltoic alluvium, red, black cotton soils, lat erite and loamy soils. The major area of cotton is confined to black cotton soils (80%)

5. Western – herbaceum region: Comprises of Gujarat and parts of Bombay and Karnataka. Improved varieties of cotton are grown in this region. Major soil group is black cotton soil followed by loamy soil.

6. Eastern region: Comprises the states of Orissa, West Bengal, Bihar, Assam, Manipur and Tripura. Longest zone with respect to area but the production is negligible from this region.

Cotton growing zones of A.P:

Cotton cultivation is spread over three distinguished areas i.e. Coastal, Rayalaseema and Telangana regions which vary widely in climate and soil types and also production levels. In A.P Cotton growing regions are divided into three regions.

I) Northern region:

It comprises of Adilabad, Warangal and Nizamabad districts. Two distinct cotton grown zones are there in this zone.

1) High plains locally ca lled as "Ghat areas of Adilabad : Soils are black cotton soils which are fairly deep and highly water retentive .Fairly assumed rainfall of 750mm from June to October. Most of the area cultivated during Kharif with American cotton.

2) Low altitude plains or Gaorani tract comprising parts of Adilabad, Nizamabad and Medak. Soils are black cotton soils and are less deeper, rain fall is 550mm and is often ill distributed under rainfed

condition desi cotton is grown and under irrigated condition of Sri Ram Sagar command area American cottons are grown.

II) Central region:

Traditional cotton growing area of Rayalseema. Desi cottons (G.arboreum and G. herbaceum) and American cotton (G.hirsutum) are grown purely under rainfed conditions distributed over three districts of Kurnool, Kadapa and Anantapur. Based on the agro climatic conditions and varieties grown, this region is sub divided into four tracts.

1.Mungari tract (early kharif planting): G.arboreum cottons are grown in light red and black loam soils of KNL, KDP and ATP Dts during early Kharif season.

2.White Northern tract: Desi cotton G.arboreum are grown as late Kharif (Hingari) season. The soils are very deep and highly moisture retentive. However, the mean annual rainfall of 650 mm which is most unpredictable both in intensity and distribution.

3.Rainfed American Cotton tract: American cottons are grown during late Kharif season as Hingari cotton. Dominant soils are black cotton soils. Mean annual RF 650mm with normal distribution. Confined to rainfed conditions but in Tungabhadra command area grown as irrigated crop.

4.Western tract: Desi cottons(G.herbaceum) are grown during late Kharif (Hingari) season under rainfed conditions. Low rainfall region i.e 450-500mm annually.

III) Western region:

Based on climate and soil it is divided into two cotton growing areas.

1.Kharif cotton areas: It comprises of the Nagarjuna Sagar Project ayacut areas of Guntur, Prakasam, Krishna, Nalgonda and Khammam Dts. Two types of soils viz black and light red soils are available in 2:1 proportion. The annual rainfall in the region is 900-1100mm. The American cottons are grown under irrigated and rainfed conditions.

2.Rabi/Rice follows area: It comprises parts of Krishna and Nellore dt. And confined to rice fallows with supplemental irrigation. Both desi and American cottons are cultivated in this zone.

India ranks first in the world in respect of acarage with about 9.0 m ha under cotton and fourth in total seed cotton production (10-14 m bales).

In India, cotton is cultivated on a large scale in Maharashtra, Gujarat, Andhra Pradesh Karnataka, Madhya Pradesh, Punjab, Rajasthan, Haryana, Tamilnadu and Uttar Pradesh. Gujarat is the largest producer of cotton in India followed by Maharashtra. Maharashtra is first in area with nearly 3.0 m ha.

Classification:

The predominant species cultivated

Gossypium hirsutum	- >90% of the area
" arboretum	- 5%
Gossypium herbaceum	– 2%
Gossypium barbadense	– negligible

Gossypium hirsutum:

(American Cotton) Species contain haploid number of chromosomes (26) plants are either annual shrubs or large perennial shrubs (1-1.5mt tall), Flowers are creamy white in colour when first open and turn pink or red later. The capsules are 3-5 locular with 5-11 seeds in each locule. Seed contain a thick coat of lint hair besides a thick coat of fuzz hair. Fibre is medium coarse and length varies from ¾ " to $1^{1}/_{4}$" (27-30mm)

Gossypium barbadense:

(Sea island / Egyptian Cotton): Species contain haploid number of chromosomes (26). Plants are either anuual shrubs or perennial shrubs. Petals are yellow with purple spot at the base. Capsules are 3.5 locular with 5-8 seeds, in each locule. Seeds bear a thick coat of lint and thick coat of fuzz and fuzz may be absent in some varieties. Fibre is fine and extra long ranging from $^{1}/_{2}$" to 2'' length. Lint is readily detachable from the seed.

Gossypium arboreum:

Species contain haploid number of chromosomes (13). Plant may be annual sub shrub or perennial. Capsules are tapering with prominent oil glands in the pits and are 3 or 4 locular with 6-17 seed in each locule . Seeds are usually covered with two coats of hair (lint +fuzz). Fibre is coarse and short and length varies from ½" to $^{7}/_{8}$"

Gossypium herbaceum:

Haploid number of chromosomes (13). Plants are sub shrubs. Capsules are brown provided with beak, smooth surface or with shallow pits with oil glands. The capsules are 3-4 locular with 8-10 seeds in each locule. Seeds are covered with two coats of hair (lint+fuzz). Fibre is coarse and short with lint length varying from $^{1}/_{2}$" to $^{7}/_{8}$''

Branching in Cotton: There are two types of branches observed in cotton.

Monopodial branches:

They arise from basal region upto 1/3rd height of the plant, few in number, they does not bear flowers, also termed as vegetative branches. They appear as growing straight. They bare sympodial branches.

Sympodial branches:

They arise from main stem as well as on monopodial branches. They are many in number, they bear flowers on it, hence also termed as reproductive branches. The growth pattern of sympodial branches is stop-grow-stop pattern.

Lec No: 16:

Cotton- Manures and Fertilizers- Water Management- Weed Managenment- Topping- Bud and Boll Shedding- Harvesting.

Manures and Fertilizers:

15 to 20 t Fym/ha should be incorporated into the soil at last ploughing. Recommended dose of fertilizers depends on the variety grow n, whether rainfed or irrigated and the nutrient supplying capacity of the soil recommended dose is not uniform in all the cotton growing regions.

	N/ha	P_2O_5/ha	K_2O/ha
Desi Cotton	: 20 – 40 kg	20Kg	20 Kg
American Cotton Varieties	: 90 Kg	45 Kg	45 Kg
Hybrids	: 120 Kg	60 Kg	60 Kg

Entire P_20_5 should be applied as a basal dose at last ploughing and duly incorporated in the soil. Nitrogen and Potassium is applied in three equal splits each at 30, 60 and 90 DAS.

While top dressing, fertilizer should be applied in pockets 7 -10 cm away form the plant and at a depth of 7 – 10 cm for a rainfed crop. Fertilizer application should be done only in presence of adequate moisture. For the irrigated crop, provide irrigation soon after application of fertilizers.

	N	P_2O_5	K_2O
Rain Fed :			
Desi	40	20	20
American	60	30	30
Hybrid	90	45	45
Irrigated:			
American	120	60	60
Hybrid	150	75	75
Rain fallsVariety	135	45	45
Hybrid	150	60	60

Water Management :

Cotton is a drought tolerant crop due to its deep root system. Water requirement of the crop is 600 to 800 mm. Cotton cannot tolerate excess moisture in the soil and so frequent irrigation is not necessary. Interval between two irrigations depends on the soil type, rainfall and others related climatic factors. The crop must not be allowed to suffer from water stress during flowering and fruiting period, otherwise excessive shedding of flower buds and young bolls may occur resulting in loss of yield. The crop cannot tolerate water logging conditions at any stage of growth.
Critical Stages : Square formation stage

: Flowering stage
: Boll developing stage

Weed Management :

First 50 -60 days after sowing is the critical period of Crop Weed Competition, Initially the crop growth is very slow, thus more vulnerable to weed compertiaton. During this period, the field should be free form weeds for better growth and higher yields. 5 – 6 intercultural operations should be done depending on the intensity of weeds. Weeds near the plant should be removed by manual labour. Chemical method of managing weeds helps in maintaining the filed weed free. Following herbicides can be used in cotton.

Pre–eme Pendimethaline @ 1.5 – 2.0Kg a .i/ha
PPI fluchloralin @ 1.5 Kg a.i /ha
Pre –eme: Alachlor @ 1.5 kg/a.i/ha
Diuron @ 0.8 - 1.0 kg ai /ha
Pronamide @1.5 – 2.5kga.i/ha
Cinmethiline @ 0.5 -1.5 Kg /ha
Post – eme: Paraquat @ 0.5 Kg a.i/ha or Glyphosate – 3.5 – 4.5 as directed spray on the foliage of weeds

Topping:

Cotton is indeterminate plant, to check excessive vegetative growth topping is practiced , Toping refers to the removal of the terminal bud. Level of topping or at what node topping is to be done will differs with cotton plant type.
MCV –5: Topping at 15th node level (70 – 80) DAS resulted in better yields
MCV 7: 10 – 12th node (90DAS)

Topping is done manually. In USA machines are used . Excessive vegetation growth can also be controlled by using chemicals which are growth retardant like cycocel (ccc). It restricts excessive vegetative growth retards senescence, keeping the leaves green for longer time thus prolonging their effective period.

American Cotton – 40 to 60 PPm
Desi cotton - 60 to 80 PPm 50 to 80DAS

Bud and Boll shedding:

It is a natural phenomena in cotton . Heavy shedding of flower buds and young bolls occur which is aggrevated under adverse conditions of soil, climate and management under such situation it may be as high as 60% . under natural conditions 10 to 15% loss occurs.
Various reasons for bud and boll shedding in Cotton is

1)Unfavaurable Weather conditions:

- Reduced light conditions
- Excess or lack of moistures in the soils
- Cloudiness
- High relative humidity

2) Imbalanced nutrient supply

3)Incidence of pest and disease

4) Weeds alter the microclimate

5) Physical injury - due to use of farm machinery

This problem can be minimized by using certain hormones like NAA, since it increases the supply of auxin to bolls and buds, thus the senescence of them is reduced. Spraying of NAA – planofix @10 ppm at flower initiation (1 ml in 100 liter) 50 – 60 DAS & 15 days after 1st applicaton resulted in retention of more bolls.

Harvesting :

Harvesting usually commences in the month of Nov. and extends to March depending upon sowing time and duration. Harvesting is done usually by manual labour ie hand picking the cotton from the open matured bolls. Since cotton is indeterminate type, flowering occurs in no. of flushes hence all the bolls do not mature at a time and bolls come to maturing stage at intervals of 2-4 weeks period. Harvesting is done in 4 -5 pickings as and when bolls are fully matured. Precautions must be taken to maintain the quality of fibre at the time of picking.

1) Picking needs good experience, care is taken that all the cotton from all segments should be removed in one stroke. without leaving any fibre in the boll.

2) Produce from each picking should be dried separately and stored separately . Cotton from all pickings should not be mixed since they vary in their quality. Cotton should be dried on clean floor in shade.

3) Kapas should not be contaminated with foreign materials like leaf bits, trash, soil particles etc, at the time of picking and shading.

While picking weather conditions must be taken into account. Usually pickings are done in the early hours of the day, As the day advances the fruit wall becomes brittle due to sun and while picking they easily collapse and contaminate. Picking must commence after cessation of dew fall
Cotton of early picking are of superior quality and later pickings produce inferior quality fibre due to inadequate nutrient supply at later stapes, high incidence of pest and inadequate moisture at later stages.

Boll affected with insect is common feature which not only reduce yield but produce yellow stained cotton which is considered inferior fibre.

Yields :

Dryland crop - 10to 15 q/ha
Irrigated Crops - 25 to 30q/ha
Hybrids - 35 to 40 q/ ha.
1 Bale = 170 kg.

Lec No: 17: **Cotton- Quality parameters - Yield attributes**

1.Colour of fibre:

Colour of the fibre of cotton is white with few exceptions like desi cotton which have reddish or yellowish tinge. White coloured cotton which are shiny are considerd as superior cotton. Cotton obtained from first picking will be bright white in colour and the later produced will be dull or yellowish tinge in colour. The fibres may also be discoloured or stained by insect damage, fungal diseases mechanical harvesting and the sap of green plant parts.
Colour of the cotton is decided by visual observation cotton marketed in India are classified on the basis of visual observation into white , grey, brownish , greenish and light reddish. In lab colour grading is done by using NICKERSON – HUNTER calorimeter,. Where a light is reflected from sample of cotton and the extent of yellowish tinge is calculated.

2.Length of fibre:

The length of fibre is mainly predetermined by heredity and is only slightly influenced by growing conditions. fibre length is the mean length of lint hair expressed in mm. longer the length superior will be the quality.. Presence of excess moisture and poor nutrition will result in long fibre with poor strength. length is determined by varies methods (at 65%RH &21^{o}C temp.)

1. Seed is combed making halo and length is measured by a disc, which gives mean length

2. By measuring each fibre with scale and getting average length which is teadious, laborious and not practicable on large scale.

3. By using digital fibrograph where in sum amount of light is transmitted through the fibre beared after combing along the fibre length and calculated. On the basis of fibre length , cotton is classified into six groups.

Groups	Length (mm)	Varieties
Short staple	< 19.5	Lohit , G - 27
Medium staple	20.0 – 21.5	Raichur 51 ,DB-3-12
Medium long Staple	22.0 – 24.0	MCV-7,G cot 12
Long staple	24.5- 26.5	Krishan, JKHY – 1
Superior long staple	27.0 – 29.5	MCU -5 , H4, Amaravathi
Extra long staple	32 & above	Suvin and sujatha

Holo length : it is overall length of the lint without the fibre taken out of the seed

3.Fibre fineness:

It denotes the diameter of the fibre hair or thickness . Lesser the diameter superior is the quality . Thickness of the fibre ranges from 15-20 microns. Fineness is measured by taking the weight per unit length of fibre which gives indirectly the finesses because measuring diameter of the fibre is very difficult as they are thin and minute. Fibre fineness is generally expressed as microgram/ inch of the fibre which is also called micronaire value. It is measured by the

1) Weight /unit length – specified number of fibre are taken with known length and weight is recorded using a sensitive balance.Lesser the weigth, superior is the quality and finer the lint hair.

2) By using instrument MICRONAIRE . In this cotton plugs are prepared by using known weigth of cotton lint, i.e. 3-4 gm by pressing in a specially designed cylinder. Air is passed at high pressure through cotton plugs and fineness is determined indirectly by the flow of air through the plug. Finer cotton will allow more air to pass than coarse fibre ,. This is calculated on a scale and expressed as micronaire value. On basis of fineness, cotton are classified into five groups.

Groups	Fineness	variety
Very fine	< 3.0	-
Fine	3.0 – 3.9	MCU -5 , Varalaxmi ,H6
Average	4.0 – 4.9	H4
Coarse	5.0 -5.9	AKH -4 ,maljari
Very coarse	>6.0	

4.Fibre strength:

Fibre strength doesnot refer to a individual fibre but to a tuft of fibres of a given thickness. It is expressed as maximum load in terms of Kg that a fibre bundle can take when stretched in one direction before it breaks. Strength is determined by using STELOMETER . Generally the tuft of finer fibre will have greater strength . Fibre strength is measured in thousands of pounds /sq inch or kg/sq cm and grade is allotted, based on strength cotton is classified into

Group	Grade
Very strong	>95
Strong	86 – 95
Average	76 – 85
Fair	66 -75
Weak	66- below

5.Spinng count:

Spinnabilty of the fibre depends on length and thic kness of the fibre . It is expressed in counts or hanks. A count is the number of hanks that a pound of cotton gives. One count is equal to 840 yards . Thus finer the thread the greater will be the count. Ordinarily Indian cottons have 22 counts . While the best quality cotton may have count ranging between 80 to 400 . On the basis of spinnability cottons are divided into five groups.

Group	Counts	Vareties
Course Cotton	1 - 17	Maljari
Medium coarse	17-26	AKH4, Sanjay
Superior medium coarse	26 – 35	Nerma
Fine	35 -48	Bur 1007
Superior fine	40- 80	MCU5, H4, H6

> 80 Varalaxmi, Suvin, DCH 12

6.Fibre maturity :

Fibre is matured when the cavity of the lint is completely filled with the cellulose . Extent of the filling indicate its maturity . According to cellulose content fibres are classifed into

Mature fibres - Yellowish white fibre
Half mature fibres - Bluish or bluish green
Imature fibre - Deep blue or purple
Trash content or Foreign Matters:

Foreign matter mainly consists of debris of leaves and broken stems of cotton and weeds that mix very easily with the lint during harvesting the amount of foreign matter remaining in the lint after ginning depends mainly on the efficiency of the drying and cleaning process in the ginning plant.

Presence of foreign material will reduce the quality and yarn manufactured from such cotton will have poor strength and gives bad appearance presence of foreign material can be detected and measured quantitatively by instrument called SHERLY ANALYSER

7.Hygroscopicity:

The dry cotton absorbs moisture from the atmosphere. Presence of moisture in the lint affects the colour,elasticity, luster etc, and the fibres having moisture break very frequently. Thus the fibres which absorbs less moisture are considered to be of superior quality and vice-versa.

Ginning percentage:

Recovey of lint from seed cotton is called Ginning percentage. A variety of cotton with high percentage of ginning is prefered as more lint per unit weight of seed cotton can be obtained form such varieties. This value ranges form 24 -43 % in different cottons
Barbadense – 28-30%, Hirsutum -34-38% , desi cottons -36-42%

$$GP = \frac{\text{Weigth of lint}}{\text{Weigth of seed cotton}} \times 100$$

8.Neppiness:

It refers to formation of small knots or specks in the yarn manufactured form cotton. Knots generally occur if fiber is not cleaned and ginning not done properly, lesser the nippiness, superior is the quality of fibre. Neps are tangled knots of fibre, caused by mechanical processing.

9.Lint Index :

It is the weight of lint form 100seeds

$$\text{Lint Index} = \frac{\text{Weight of 100 seeds}}{100 - G.P} \times GP$$

10.Seed Index:

It is the test weight , which is weight of 100 seeds (g). Seed index of cotton varies from 4.8 to 11g.

11.Oil content:

It varies from 14.5 to 22.5% is desi cotton and ranges between 17.5 to 22.5 % in American cottons.

Yield attributes:

1. Number of plants per unit area.
2. Number bolls for plant
3. Seeds per boll
4. Boll weight
5. Lint percentage

Coloured cottons:

Natural coloured cottons are in existence in all shades form white to black. As per historical documents, blue, purple , pink, green, brown cottons were in cultivation and usage in coastal Peru. In Mexico wild trees of brown cotton are grown as perennial crops. The brown cotton are called coyoqui and yellow cotton is coyuchi. These are still spun by tribals in Mexico. In Indian brown cottons of G.arborium and G.herbaceum are grown in some remote areas of Kakinada in AP and Tripura. The natural colored cotton are environmental friendly and economically viable as they are sold at premium price. They do not fade on washing. The disadvantage of coloured cotton is as they yield less, fibres are shorter, low strength , low micronaire value and low maturity coefficient.

Lecture No. 18

JUTE – FIBRE CROP

Introduction

- Jute is a natural fibre with golden and silky shine and hence known as Golden Fibre.
- Jute is cheapest vegetable fibre and second most important vegetable fibre after cotton.

Origin

- Jute has two cultivable species
    1. Corchorus capsularis – originated from Indo-Burma region.
    2. Corchorus olitorius – Originated from Africa
- Wild species of Jute include Corchorus oestuans, Corchorus tridens, Corchorus trilocularis, Corchorus urticifolices, Corchorus japanicum.

DIFFERENCES BETWEEN THE TWO CULTITVABLE SPECIES OF JUTE

Corchorus capsularis	Corchorus olitorius
❖ Common names – White Jute, Tita Jute, Bitter Jute	❖ Common names – Tossa Jute, Mitha Jute
❖ Originated from Indo Burma region	❖ Originated from African region
❖ Colour of the Fibre is White	❖ Colour of the fibre is Yellowish or Reddish brown
❖ It is herbaceous annual with slender and straight stem and grows to a height of 1.5 to 4m with tapering stem	❖ It has cylindrical stem and grows up to a height of 5m
❖ Leaves are glabrous, ovate & oblong	❖ Leaves are glabrous, coarsely toothed
❖ Stem is green to red in colour, may/may not branched	❖ Stem is green and are usually branched
❖ Pods are round in shape	❖ Pods are elongated
❖ Leaves and flowers are smaller but seeds are larger in size (1g = 300Nos.)	❖ Leaves and flowers are larger but seeds are smaller in size (1g = 500Nos.)
❖ Fibre Quality is poor	❖ Fibre quality is Finer, Softer, Stronger and more lustrous than C..capsularis
❖ Tolerates water logging, can be grown on both uplands and lowlands occupying more area of cultivation	❖ Cannot tolerate water logging grown only on uplands hence occupying low area of cultivation
❖ Seed rate 10 to 11 Kg/hac	❖ Seed rate – 6 to 7 Kg/ha
❖ Spacing 30 X 5 cm	❖ Spacing – 20 X 5 cm
❖ Plant population – 2.5 lak/ha	❖ Plant population – 4.5 lakh/ha
❖ Seed yield is more but fibre yield is less	❖ Seed yield is less but fibre yield is more.
❖ Longer duration 180 – 200 days	❖ Shorter duration – 120 to 150 days
❖ Grown in loamy soils	❖ Grown in sandy loams
❖ Sowing time is February to March	❖ Sowing time is April to May
❖ Fertilizer requirement is high	❖ Fertilizer requirement is low
❖ It withstands water logging	❖ It withstands drought

Distribution:

- Jute is extensively grown in India, Bangladesh, China, Pakistan, Mayanmar, Nepal
- In India, it is extensively cultivated in eastern regions like West Bengal, Bihar, Orissa, Assam, Tripura, Meghalaya, Uttar Pradesh.

Area, Production and Productivity of Jute in India and Andhra Pradesh

State	Area in 000' hectares	Production in '000 bales of 180 Kg	Productivity in qt/hectare
Assam	69.00	680.00	17.74
Meghalaya	9.6	61.5	12.03
West Bengal	504.5	7032.4	25.09
Bihar	137.1	1100.0	14.44
Orissa	33.8	164.5	8.76
Andhra Pradesh	54.0	425.0	14.17
Tripura	2.2	18.6	15.22
Others	35.7	73.0	6.78
Total	845.5	9555.0	20.34

India is the largest producer and consumer of raw jute

- Bangladesh is largest exporter of Raw Jute
- India stands 1st in area and production of Raw Jute
- In India West Bengal stands 1st in area, Production and Productivity
- 50% of total raw jute production in India is alone from West Bengal
- In Andhra Pradesh, negligible amount of area is under cultivation of Jute and is mostly confined to North Coastal Zone.
- 1st Jute mill was started production in Bengal in 1856
- Jute is an important crop providing livelihood to 2,50,000 mill workers and 4 million farmer families.
- Jute plays an important role in improving Indian economy by adding Rs.6089 millions annually by export..

Properties of Jute:

- It has high tensile strength, low extensibility and ensures better breath ability of Fabrics
- Jute Fibre is 100% biodegradable, recyclable and this environmentally friendly
- Jute has good insulating and antielastic properties
- Jute has low thermal conductivity and moderate moisture gain
- Jute has properties like more heat and fire resistance
- These fibres are grouped under bast fibres and they are lignified
- A bitter glucoside called "Corchorin" present in white Jute

Uses of Jute:

- Jute fibre is used in manufacturing rugs, carpets, coarse fibres, twines and coarse blankets
- Broken fibres of Jute is called ' Tow ' which is used in making low grade paper
- Jute waste is used as fuel in making activated charcoal
- In market Jute and Mesta fibres are together known as " Raw Jute "
- Leaves of Jute have medicinal Properties

Types of Jute:

- Based on general utility purposes, Jute is of 4 types

A] Hessian or Burlap:

- Made of good quality Jute Yarn
- It has wide range of applications as in cloth form or in the form of bags

B] Sacking:

- Also known as "heavy goods"
- It is made from lower grades of fibre and used for bags of all types

C] Canvas:

- Finest Jute product, closely woven of the best grades of fibre widely used in India for protection from weather

D] Jute Yarn and Twine:

- Most of the single strand Jute Yarn produced in consumed by the mills themselves in fabric and twine manufacture.

Varieities:

- Varieities of Corchorus capsularis – JRC 212, JRC 321, JRC 7447
- Varieities of Corchorus olitorious– JRO 524, JRO 878, JRO 835

Jute based cropping systems:

- Under rainfed conditions
  1. Jute – Wheat
  2. Jute – Mustard

  } 2 crops per year
- Under irrigated conditions
  1. Jute – Rice – Wheat
  2. Jute – Rice – Potato → followed in West Bengal
  3. Jute – Rice – Cauliflower / Cabbage
  4. Jute – Potato – Rice

     (Kharif)-(Rabi)-(Summer)

Soils:

- Alluvial sandy loams and clay loamy soils are the best suited for Jute cultivation.
- Capsularis Jute can grow even in standing water especially towards the latter part of growth

- Olitorius Jute cannot thrive in standing water and is more drought resistant and hence grown in light soils.
- New grey alluvial soils of good depth, receiving salts from annual floods is best suited for Jute cultivation

Climate:

- Jute is a rainfed crop
- Grows well in warm and humid climate with temperature in the range of 24^0 C – 37^0 C with 65-90% relative humidity.
- Jute is mainly grown in Kharif or monsoon season as vegetative growth is more in kharif that results in higher yields of fibre.
- Alternate sunshine hours and rainy days are congenial for better growth.
- Temperatures less than 20^0C and more than 40^0C are harmful because it restricts the plant growth especially the plant height.
- Annual rainfall is 80 to 100cm.
- Low plant population is not preferred because of branching and reduces quality of fibre.
- Early sowing of *Corchorus Olitorius* is not preferred because it comes to early flowering, quality is reduced.
- Constant rain or water logging is harmful.

Tillage :

- Deep ploughing is necessary because root system is extensively developed.
- Seed bed should have fine tilth since seeds are very small.

Cultivated species of Jute	Seed rate (Kg/ha		Spacing (cm)	No. of Plants Per Sq.mt
	Line Sowing	Broad Casting		
Corchor us olitorius	5	7	25 X 5	80
Corchorus capsularis	7	10	30 X 5	67

Time and methods of sowing:

- In midlands and high lands sowing starts with summer showers in March and April and continues till early June in Western part of Jute belt.
- Method of sowing is generally broadcasting or line sowing.

Lecture No: 19

Manures and Fertilizers :

- 5 tons of well decomposed farm yard manure should applied in last ploughing.
- Nitrogen should be applied in 2 splits –
  1st split as basal and 2nd split at 4-6 weeks after sowing.
- Application of Phosphorous reduces the lodging and improves fibre quality .
- Potassium application prevents disease incidence.

Cultivated Species	Nitrogen	Phosphorus	Potassium
Corchorus capsularis	60 Kg/ha	40 Kg/ha	60 Kg/ha
Corchorus olitorius	40 Kg /ha	40 Kg /ha	60 Kg /ha

Weed Management

- Critical period of crop weed competition is upto 60days after sowing.
- Hand weeding is done thrice at 20-25DAS and 35-40DAS.
- Basal application of herbicide – Fluchloralin @ 1.5 Kg/ha at 3 DAS followed by irrigation.

Irrigation:

- Water requirement is 500mm.
- 1st irrigation is given after sowing.
- Life sowing irrigation is given on 4 DAS.
- Afterwards, irrigation is given once in 15 days.
- Critical stages of irrigation are Germination and Knee high stage.

Crop Rotation:

- In crop rotation system, one legume crop must be included so as to improve soil health.
- In light sowing soils green manure crop is grown prior to sowing of Jute.

Harvesting:

- Duration of Corchorus olitorius – 120 to 150 days
  Corchorus capsularis – 180 to 200 days
- Early harvesting gives lower fibre yield but fibre is of finer quality, whereas, late harvesting gives higher fibre yield but the fibre is coarse in texture

- Ideal stage of harvest in Jute is 50% of tender pod formation.
- Late harvesting leads to poor quality fibre due to lignifications of bast fibres
- Harvesting is done by cutting the plants close to ground with sickles.
- Harvested plants left standing in the field for 2-3 days for shedding of leaves.
- Afterwards plants are ready for retting.
- Fibre yield is 6-8 years on wet weight basis of stalks.

Process of Fibre extraction:

Bundle stalks → Retting → Stripping → Washing → ↓

Storage / Transport ← Kutcha packing ← Boiling ← Sundry Squeezing excess water

A] Retting

- Retting is a microbial process in which bast fibre gets loosened for an easy separation from woody stalks
- During retting, gums, pectins and other mucilaginous substances are removed from the plants by combined action of water and microbiological action.
- Retting is of 2 types – Dry retting and Wet retting
- When water is not available for retting immediately after harvest, plants are allowed to dry, whenever monsoon occurs, dried plants are retted. This process is called Dry retting..
- Harvested plants are immediately retted directly in water without drying and this process is called Wet retting.
- Wet retting is preferable than dry retting because of good quality of fibre.
- After 2-4days of harvesting, plants are shaken for complete leaf shedding then they are tied into bundles of 25cm diameter.
- Then bundles are steeped in standing water vertically, bundles are submerged in water in a horizontal position laid side by side and tied together to form a sort of platform called “Jak”.
- Jaks are covered with plants like water hyacinth or any other material which do not release tannins as well as iron.
- Float is then kept with weight to make the float completely immersed in water.
- Wood logs and concrete slabs may be used for this purpose
- Freshly cut mango logs or banana stems should not be used weighing material of Jak because tannins coming out from stems reacts with iron of retting water and gives black color to fibre called “Shyamala”.
- This colour can be removed or reduced by adding 2% tamarind solution.

- For ideal retting, JAKS should be kept submerged of at least 20cm deep .
- Most of the defects in fibre quality are due to improper or incomplete or faulty retting.
- Incomplete submergence results in under retting produces a fibre called “crappy fibre” which is of extremely of low value where as over retting results into “dazed fibre” which is very weak fibre.
- So gently flowing fairly deep clean and soft water are congenial for ideal retting.
- Optimum temperature of water should be around 34^0C .
- Retting period is 8-30 days.
- Incase of stagnating water, addition of Ammonium sulphate will hasten up retting process.
- For finding out exact end point of retting, JAKS must be examined every 10-12days.
- Fibre should be slip from the wood easily when the plants are pressed between thumb and finger.
- Soon after the end point, JAKS or platforms should be taken out of the water and fibre should be extracted.

B] Stripping:

- Process of removal of fibres from the stalk after completion of retting is called Stripping.
- Fibre may be extracted in two ways – Single Reed method and Break – Break – Jerk Method
- Fibre is extracted by hands either from individual plants or from bundle of 10-12 plants.

C] Washing:

- After extraction, fibre is washed thoroughly in the running water

D] Fibre is Squeezed for Excess Water

E] Sun Drying:

- After squeezing the fibre for excess water, fibre is dried on bamboo frames in the mild Sun.

F] Boiling and Packing:

- Extracted fibre is weighed in amounts of bales
- 1 Bale of Jute =180Kg
- Jute fibres are pressed based on different grades
- Jute fibre is graded into

1. Tops – Very Strong Fibre, Good Luster and Colour
2. Middles – Strong Fibre, Average Luster and Colour
3. Bottom – Sound Fibre, Medium Strength
4. B – Bottom – Sound Fibre, Medium Strength, not suitable for high grades
5. C – Bottom – Medium Strength Fibre, Any Colour
6. X – Bottom – Weak Jute

Yield:

- Green Plant yield is 45 – 50 t / ha
- Fibre yield is – 2.0 – 2.5 t / ha

Factors hastening up Retting Process:

1. Warm water
2. Retting in already used water
3. Harvesting time
4. Climate Conditions like high temperatures
5. Deep water (Too deep water will delay retting)
6. Addition of Chemicals

Quality Parameters:

1. **Length of Fibre:**
   - If the length of the entire fibre is more, more is the quality
2. **Strength of Fibre:**
   - Fibre should offer less resistance while using for packing material and other low grade yarn.
3. **Colour of the Fibre:**

   Bright Colour is superior
4. **Luster of the Fibre:**
   - Bright fibre of smooth surface will have superior luster
5. **Stiffness and Hardness:**
   - Properly retted fibre will be soft and fine

6 Fitness of Fibre:

- Coarse fibre always fetches low price than fine fibre

7 Percentage of Cuttings of Stem or Percentage of Cutting of Fibre:

- Less the number of cuttings, More the Superiority of fibre

8 Proportion of faulty materials:

- Roots, Specks, Knots, Runners should be avoided for good Quality.

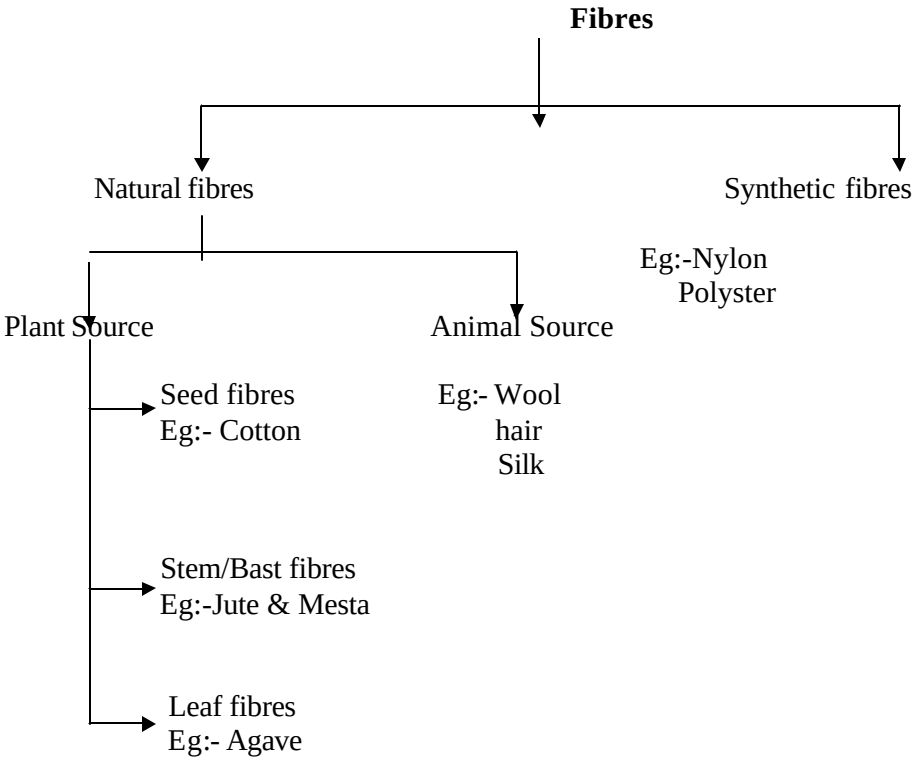
Factors influencing Quality of Fibre:

1. Retting Water – Gentle flowing, clean and soft water give good quality
2. Materials used as weights on JAKS
3. Seed rate should be more
4. Stage of harvesting
5. Method of Retting – Complete submergence of jak is prefered
6. Variety of Jute – C. Olitorius gives good quality fibre than C. capsularis
7. Method of fibre extraction – Single Reed Method is preferred
8. Period of Retting – under retted or over retted fibres are of inferior quality
   - ❖ Fibres should be stripped off immediately after Retting Process.

Different Institutes working on Jute:

1. J A R I - Jute Agricultural Research Institute – West Bengal
2. C R I J A F - Central Research Institute for Jute and Allied Fibres Burrackpur, West Bengal
3. J T R L - Jute Technological Research Laboratories – Kolkota West Bengal
4. I J M A - Indian Jute Mills Association
5. J M D C - Jute Manufacturers Development Council
6. I J I R A - Indian Jute Industries Research Association
7. I J S G - International Jute Study Group
8. N C J D - National Centre for Jute Diversification

Lecture No. 20 MESTA



MESTA S.N.: Hibiscus Cannabinus
Hibiscus sabdariffa

Family: Malvaceae
Origin: Hibiscus cannabinus – Africa
H. Sabdariffa – India

Introduction:

Kenaf is a bast fibre next to jute fibre.. The main kenaf fibre producing species of economic importance are Hibiscus Cannabinus and Hibiscus sabdariffa. Kenaf is called as 'Roselle hemp' (H.Sabdariffa). in India. Other commercial (or) Common Names for Mesta, are Deccanhemp, BimiliJute, Java Jute and Golden green stick., Kenaf is more adaptive than Jute under diverse conditions of climate and soil and it is also very resistant to drought.

Distribution:

The Principle producer countries of kenaf fibre of both species are India, China, Brazil, Egypt and Australia. In India it is mainly cultivated in Andhra Pradesh, Bihar, Orissa and Maharastra. These states contribute about 75% of the area under this crop.

West Bengal, Assam,Tripura, Karnataka also cultivated this crop.

Uses:

- Both the species are used for fibre and also vegetable purpose.
- The fibre is used Principally for manufacture of textile and Cottage products, twines, gunny bags, ropes and fishing nets.
- Fibre is also used for manufacture of car interiors, and also used as a natural substitute for fibre glass.
- Fibre is also used for excellent substitute for Bamboo and wood pulp which is used as making paper.
- It has been proved at the laboratory level that Mesta is well suited for the production of news print.
- It has been estimated that about 10 tonnes of Paper pulp can be produced from one hector of Mesta.
- Mesta seed contain 17-22% oil which is used for the making soaps, culinary purposes and paints.
- Calyx of the mesta flower are used in Dyeing industries.

Area and Production:

Area Production and Yield of Jute and Mesta during 2008-09 in major producing states

State	**Area (m.ha)**	**Production (M.bales)**	**Yield kg/ ha**
Westbengal	0.59	7.97	2422
Bihar	0.15	1.22	1455
Assam	0.07	0.67	1856
Andhra Pradesh	0.04	0.30	1435
Orissa	0.02	0.11	918
Meghalaya	0.01	0.55	1170
Maharastra	0.02	0.03	260
Others	0.01	0.02	------

In India 90% area under Hibiscus Sabdariffa (Rosellehemp). Andhra Pradesh, Orissa, Bihar and Maharastra these states contribute 75% area.

- ❖ Andhra Pradesh stands First in Both area and Production followed by Madhya Pradesh and Maharastra.
- ❖ In Andhra Pradesh Mesta crop commercially grown in the Vizianagaram, Srikakulam and Visakhapatnam. These Districts contribute about 90% of area.

Note:- Only one Research Station that is working on Mesta is located at "Amadalavalasa" [Srikakulam District] that is "Agricultural Research Station" (ARS)-"Amadalavalasa".

Differences between Hibiscus Cannabinus and Hibiscus sabdariffa:-

Sl.No.	**Hibiscus Cannabinus**	**Hibiscus Sabdariffa**
1. 2	Short duration have 120-150 days Flowers are large	Long duration have 180-200 days Flowers are small
3.	Leaves are deeply lobed lobes are harrow & serrate	Leaves are Polymorphic Pinnate deeply lobed and alternate on stem.
4	It is not tolerant to drought	More tolerant to drought
5	Fibre quality is good	Fibre quality is poor
6	The Stem has a higher basal diameter and it's wood is soft	It has harder wood
7	Leaves have no bifercations in the entire plant	The basal leaves are the lack bifurcations and are not lobed but the upper leaves are lobed.
8	Fibre is used for house hold purpose	Fibre is used for industrial purposes.
9 10	Fibre yield is less Seed is irregular, sub-reniform	Fibre yield is more Sub-reniform
11	These are less resistant to Root-knot nematode and Anthracnose	These are Resistant to Root-knot Nematode and Amthracnose.
12	Less cultivated area occupied by these species in India Varieties:- Bimili 1; AMC-108 HC- 583	More cultivated area Occupied by these species in India. Varieties:- HS 4288; HS 7910 AMV 1; AMV 2; AMV 3

NOTE:- In trade market Jute and Mesta are together categorized as Raw Jute.

Varieties:- H. Sabdariffa Varieties.

1. AMV – 1
2. AMV – 2
3. AMV – 3 (Surya)
4. AMV – 4 (Kalinga)
5. AMV – 5 (Durga)

AMV- 3 and AMV- 4 varieties are more popular in Andhra Pradesh.

AMV – 108
Bimili – 1
HC --583 } Hibiscus Cannabinus Varieties

High yielding varieties of Mesta are HS 4288, HS 7910, HC 583, AMV 108 and AMV

Soils:- Mesta grown under wide range of soils which Include Marginal and Sub marginal lands. Does not withstand water lagging initially. Good growth and development of the crop. Soil should be well drained, shallow and of a light sandy loamy texture with good quantity of organic matter. P^H is 6.5-8

Climate:-Mesta is a hardy crop capable of growing under a wide range of climatic conditions. The crop requires warm and humid climate and hence it is grown in Kharif season only. The crop can withstand the temperature of 43^0C. The RH is 40-100%. It can grow a elevation of 1000 MSL. The rainfall requirement of crop varies from 500-900mm. Photoperiodically Mesta is a shortday plant

Land preparation:-

The crop comes up well in all types of soils except stiff clays, Provided good drainage facilities are require as the crop cannot with stand water logging initially.

→ Plough the land to get good tilth it helps quick establishment of crop better stand and Growth

→ Apply organic manures at 5 T/ha before sowing

Application of Phosphorus reduce lodging and improve the fibre quality

Potassium prevents the disease incidence.

Intercultivation:-

Ist hand hoeing at 3 weeks after sowing

2^{nd} hand hoeing at 5 weeks after sowing

Thinning is also practiced in the Mesta crop. It is done at 15-20cm height of the crop. Intercultivation is helpful to suppress the weed growth.

Weed management: -

Critical period of crop weed competition is 45 DAS

For broad cast crop 2 hand weedings are done at 21 DAS and 35 DAS.

In line sowing two intercultivations at 20 days intervals

Use of Herbicides Fluchloralion @ 1.5 – 2.0 Kg ai/ha

Trifluralin @ 0.5 – 1.0 Kg ai/ha

Metachlor @ 0.75 -1.0 Kg ai/ha

Irrigation:-

The Mesta crop exclusively grown as rainfed. It requires 500-900 mm water requirement. Critical stages for irrigation are germination stage and Knee-height stages.

Crop rotation and cropping systems:-

→ Mesta – Groundnut/Pulses
→ Mesta – Rice

Seeds and Sowing:-

Time of sowing is April – May. Delaying of Kharif sowing results into drastic reduction in fibre yield.

Pre Rice Mesta crop is sown in March – April in low lands with supplemental irrigation.

Optimum sowing period of crop is May – June.

Early sowing helps in quick establishment of crop and facilitates vigorous growth with pre monsoon showers.

Seed treatment:-

Seeds are treated with Thiram (or)Captan @ 3-5/Kgseed protects the crop from seed born disease like stem rot and foot rot.

Seed Rate:-

Drilling – (line sowing) → 6Kg/ha

Broad casting → 12 Kg/ha

Spacing:-

Spacing can affect the quality of fibre. The recommended spacing is 22.5 X 10cm

The crop is sown in lines at 30 X 8-10cm

Depth of sowing is 3-5cm

Method of Sowing:-

Broad casting – suited for good quality fibre

Drilling – suited for seed purpose

Lecture No. 21

Manures and Fertilisers in Mesta

Fertilizers are applied as per the soil test recommendations. In Andhra Pradesh recommended dose is 25-20-20 Kg N-P-K /ha

Nitrogen apply in 2 splits → ½ N + Entire P & K apply at basal
Nitrogen apply in 2 splits → ½ Nat 30 DAS

Hibiscus sebdariffa absorbs more N-P-K than *H. cannabinus*. A well managed crop removes 50 – 30 – 40 kg N-P-K per ha. Depending up on the soil type Nitrogen rate vary that is ranging from35-80kg/ha.

Higher dose of Nitrogen will affect the fibre quality.

Harvesting:-

For fibre purpose 50% of population attains at flowering stage. For seed purpose – Dead ripe stage

Method of Harvesting:-

Generally 2 methods are followed

1. Pulling the Whole plant → Fibre yield is more but the quality of fibre will be reduced due to roots and other inert material adherent to the fibre.
2. Cutting the plants close to the ground → Fibre yield is less but good quality fibre can obtained.

Retting:- same as to the Jute (Refer Jute crop)

Extraction of fibre:- It is of two ways

1. Single reed method – Gives good quality fibre
2. Break – Break Jerk Method – Gives good quality fibre

The extracted fibre is cleaned with water and dry for 4-5 days in mild sun over bamboo racks and grade the fibre before sending market.

Quality Parameters in Mesta: -

1. Length of the fibre → More the length and more the quality.
2. Strength of fibre → more strength, more quality
3. Colour → Bright colour is superior
4. Lustre → Bright colour fibre gives good luster it fetches more price
5. Fineness → Coarse fibre fetches low price than smooth fibre
6. % of the cuttings on the fibre → more the cuttings on the fibre, quality is less

Factors influencing quality parameters in Mesta: -

- **Quality of Retted water** → Gentle flowing, clean, and soft water with 34^0C temperature give good quality fibre
- **Weighing materials which are placed on Jacks** → Freshly cut mango trunks and banana stems should not used as a weighing material as it will affect the quality of the fibre
- **Seed Rate** → More seed rate for the good quality fibre
- **Stage of Harvest** → For Fibre purpose the crop is harvested at 50% flowering stage.
- **Method of Retting** → i) Dry Retting – Give poor quality fibre
  ii) Wet Retting - Give good quality fibre
- Variety of Mesta Crop
- **Method of Fibre extraction** → i) Single reed method – Good Quality fibre
  ii) Beat-Break Jerk Method – Poor quality fibre
- **Period of retting** → Avoid under and over retting.
- Fibre should be stripped immediately after retting process

AGAVE / SISAL

S.N. : Agave sisalina
A. Americana
Family: Amaryllidaceae / Agavaceae
Origin: Mexico

Introduction:-

Agave (or) Sisal is a semi perennial hardy plant. It yields creamy white fibre from its leaves. The leaves are arranged in a rosette, darkgreen in colour, thick and generally spinous. Flowers are yellow in colour and produced on 4 - 6 m tall panicles. It is also known as Century Plant .

Distribution:-

Sisal was introduced from Mexico to India. In the world it is grown in Brazil, East and Central Africa, and Mexico. In India, Agave sisalina is grown for the Management of Soil Conservation in Orissa state.

In India it is cultivated in Bihar, Orissa, Andhra Pradesh, Assam, West Bengal, Maharastra, Madhya Pradesh as a hedge (or) Plantation crop.

Uses:-

- The fibre is used for manufacture of Marine and Industrial ropes, twines and also used for manufacture of bags, sacks, carpets, fishing nets, Brushes, Decorative material.
- The sisal wax is prepared from "sisal pulp" which is used for shoe and car polishes and manufacture of carbon paper.
- The extract of leaves is a source of "Hecogenin" which is the base material for the production of Cortico steriods used as Anti – inflammatory drugs.
- Agave is a soil – binding crop it can be raised on slopy lands to serve the purpose of checking soil erosion.
- Agave leaves generally spinous hence these are planted around the boundaries and its serve as a protection from the trespass. Hence it is called as Hedge crop.

Climatic and Soil requirement:-

Physiologically Sisal is a hardy plant. They require annual rainfall of 625mm. Sisal does not tolerate water logging and shady situations. Frost affects the fibre yield and quality.

Soils:-

Sisal can be grown on a wide range of soils. viz., sandy loam, light calcareous and gravelly soils, with well drainage facilities. Sisal can give good fibre yield where the soils have high in Calcium" content.

Propagation:-

Agave can be propagated through 2 ways. 1. Suckers 2. Bulbils

Suckers are the best propagating material than Bulbils.
Suckers are obtained from roots after 3rd year of planting. These suckers are directly sown in the field in the pit with dimensions of 1m x 1m x 1m.
Bulbils are the small plant lets which are born from the inflorescence of 8-10 years old crop. These are removed and used as a propagating material.
The bulbils are not suitable for planting directly in the field because they cause Early Polling (Flowering). Hence the bulbils require Nursery.

Polling :- Flowering in Agave is known as Polling

Raising of Nursery for Bulbils:-

As soon as plant produces the flower shoots then those are removed and planted at the distance of 15 X 20 cm in the Nursery. They attain at a height of 20cm in the nursery it will take 8-10months. Then those are removed and planted in the main field in the pits at 1.5-2m distance .
The best time of planting of Sisal is the monsoon that is July to September
Method of planting is – Single row planting → 2.4 X1.2 m(or)
- Double row planting → 3 X 1 X 1 m
For plantation crop Spacing is – 3m
For Hedge Crop - 3 feet (90cm)

Fertilisers:-

Recommended dose is 30-10-20 Kgs of N-P-K per hectare
The Nitrogen can be applied at two splits
Ist ½ split at Kharif (June – July)
IInd ½ Split at December – January

Weeding :-

It is a slow growing crop hence weeds should be controlled for the first 2 (or) 3 weeks by mechanically (or) chemically

Reasons for Early Polling :-

- Plants are raised from Bulbils leads to Early Polling than that of suckers. Hence suckers are good for propagating material
- Cutting (or) Harvesting of more no. of leaves at younger stage of plant leads to stress that results into early polling
- Non-removal of suckers for longer time accelerate the polling
- Inadequate nutrient supply
- Abnormal weather conditions

Harvesting:-

Leaves are ready to harvest when the plant attains at 30-40 months of planting [Sometimes take 4 years] Each leaf will weight about 5kg

No. of leaves cut per plant is about 20-40 at one spell like wise average production of mature leaves will be about 180-200 during its lifespan of 10-15years.

Lecture No. : 22

SUGARCANE (*Saccharum officinarum*)

- Genus : Saccharum is derived from the Sanskrit word "sarkara - white sugar
- It is an important crop in the Indian sub-continent.
- Sugar industry is second largest agro-based industry next only to textiles
- Sugarcane crop contributes more than 62% of world sugar production.
- S-cane provides cheapest form of energy giving food [sucrose].
- In addition to sugar, 38 value added products are obtained.
- Juice is used for making of white sugar, brown sugar [khandasari] and jaggery
- Is a source as bio-fuel, fibre, fertilizer etc. by products viz, bagasse [power of sugar mills} and molasses [main raw material for alcohol].

Area & Production

- Brazil has the largest sugarcane area
- Cuba, China, Pakistan, Mexico, S. Africa, Australia, Indonesia, are cane growing countries.
- Today, India ranks second in the world, after Brazil, in terms of area (4.1 m.ha) and sugarcane production (355 million tonnes in the yea r 2007)

	A.P.	**India**	**World**
Area (m ha)	4.5 lakh acres	4	20.42 **(m ha)**
Production (m t)	136 lakh tons	167	1333 **(**m t)
Productivity(t / ha)	60-70	68	

- Among the states, Uttar Pradesh occupies half (2.25 m.ha) of the total area followed by Maharashtra (1.04 m.ha).

- Though UP dominates in production with 134 MT followed by Maharashtra with 79 MT, in terms of productivity, Tamil Nadu leads with 105 t/ha followed by Karnataka (88 t/ha) and Andhra Pradesh (82 t/ha).
- U.P has the highest area under s. cane followed by Maharashtra .
- Bihar, A.P, TN , K'taka, Gujarat and Punjab are the other cane growing states
- In A.P. crop is cultivated in 4.5 lakh acres with 136 lakh tones production.
- In Andhra Pradesh average yield per acre is 68 tones only.

Sugarcane in India is grown in two distinct agro-climatic regions-the **Tropical** (largely comprising Maharashtra, Karnataka, Gujarat and Tamil Nadu) and the **Sub-tropical** (Uttar Pradesh, Punjab, Haryana and Bihar).

Table 1. Sugarcane in the world: Area, Production And Productivity

Country	Area(m.ha)	Production(m. tons)	Productivity(Tons/ha)
Brazil	5.343	386.2	72.3
India	4.608	289.6	62.8
China	1.328	92.3	65.5
Thailand	0.970	64.4	66.4
Pakistan	1.086	52.0	47.9
Mexico	0.639	45.1	70.6
Colombia	0.435	36.6	84.1
Australia	0.423	36.0	85.1
USA	0.404	31.3	77.5
Philippines	0.385	25.8	67.1
Indonesia	0.350	25.6	73.1
Cuba	0.654	22.9	35.0
S.Africa	0.325	20.6	63.4
Argentina	0.295	19.2	65.2
Myanmar	0.165	7.5	45.4
Bangladesh	0.166	6.8	41.2
WORLD	**20.42**	**1333.2**	**65.2**

There are 3 cultivated species of sugarcane : *Saccharum officinarum*, *S.barberi*, *S.Sinense* , and two wild species : *Saccharum spontaneum* , *Saccharum robustum*

Origin : *S. officinarum* is Indo Myanmar china border and New Guinea as centre of Diversity

Climate

A growing season which is long and warm with adequate rainfall or irrigation, long hours of bright sunshine and higher relative humidity which permits rapid growth to build up adequate yield (more tonnage) and a ripening season of around 23 months duration having warm days, clear skies, cool nights and relatively a dry weather without rainfall and higher difference in day (maximum) and night (minimum) temperatures for build up of sugar are required

Temperature : Optimum cane growth is achieved in temp. between 24 & 30º C

Rainfall : In India, grown in areas ranging from 600 to 3000 mm, rains at active growth period ,encourages rapid cane growth, cane elongation whereas rains at ripening period, leads to poor juice quality.

Humidity: High humidity coupled with warm weather at vegetative growth is essential, humidity of 45 to 65% + limited water supply is must at ripening phase

Sunshine : S'cane is sun loving plant. Higher sunshine hours, favours higher cane yield, sugar recovery

Frost : In, N.India extreme cold conditions will arrests cane growth

Soils

- Crop can be grown on various types of soils varying from sandy to heavy clays.
- Moderately heavy and medium deep loams, are better suited than heavier and shallow soils
- Soil must be of good depth and drainage with no compactness.

Tillage

- Field is ploughed 2-4 times with iron plough and pulverization to break the clods.
- Surface soils are dug to a depth of 20 cm to facilitate drainage and deep root system. Tractor ploughing is a common practice

- **Good Land Preparation** **Improper Land Preparation**

Planting Season

- Optimum time for Sugarcane planting is December to end of March month ending.
- For coastal districts it is January- Middle of March, for Rayalseema it is January to February middle.
- in Telangana for Eksali crop during December to January middle,
- For Adsali crop it is August – September middle is the optimum time of planting.

Duration of Sugar cane crop varies 10-18 months

- Kamsali crop : < 10 months
- Eksali crop : 10-12 months
- Adsali crop : 12-18 months
-

Suitable Varieties for different situations

Late maturing varieties (12-13 months): Co 7219, Co7706, Co8011, CoR8001.

Mid-late maturing varieties (11-12 months) : CoA7602, CoT8201, Co7805, Co8021, 85R186, 86A146, 87A 397, 83V15, 83V288.

Early maturing varieties (9-10 months) : Co6907, Co7505, 90A 272, 81A99, 82A123, 83A145, 81V48, 85A261, 86V96, 84A125, 91V83, 93V297, 83R23, 87A298.

Under rain fed conditions for planting in February: Co6907, 81A99, 85A261, 81V48, 83R23, CoT820, CoA7602, 87A298, Co7210.

For Planting in May - June: Co6907, Co8013, 84A125, 85A261, 81A99, 87A298, 81V48, 91V83, 93V297.

For water logged (swamp) conditions: Co697, 84A125, CoR8001, 83V288, 83V15, 81V48, 91V83, 87A298, 85A261, 87A261, 87A397, 89V74.

For Moisture Stress conditions: Co6907, CoT8201, CoA7602, Co7219, 84A125, 85A261, 83V15, 81A99, 83R23, 89V74, 83V288, Co7508.

For redrot affected areas: Co7508, CoA7602, Co8014, CoR8001, 85A261, 87A298, 90A272, Co6907, 86V96, 83R23, 91V83, 88R58, 92A126, Co7219, 86V96, Co7805, Co7706, 83V15, 89V74, 87A397.

Smut diseæse tolerant varieties: Co8013, Co8014, 81A261, 84A125, 81A48, 83V15, 83V288, 83V96, 89V74, 93V297, 90A272, C07805, 86A146, 87A397.

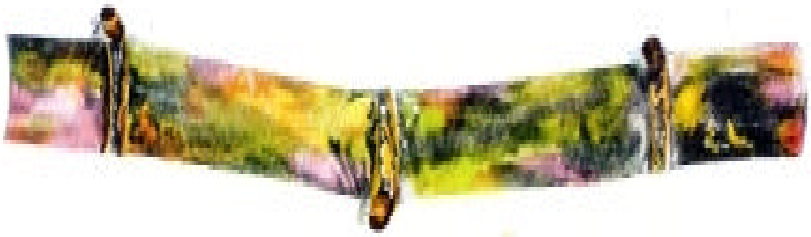
For jaggery preparation: Co7706

For Saline / Alkaline Soils : 81V48, 81A99, CoT8201, 93A145

Seed rate

- Around 30,000 setts of three budded setts or an opt. seed rate of 70-75 Q/ha
- 80,000 setts with 2 buds are also adopted

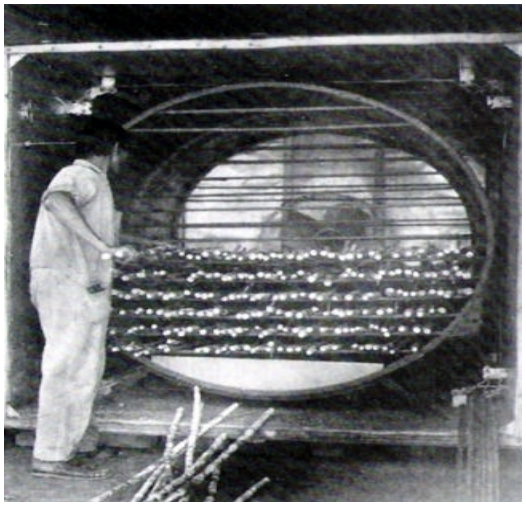
Three Bud Sett



Two Budded Setts

Seed treatment

- Dipping of setts, which are sufficient for one acre planting, for 15minutes.
- In a solution containing 150gms carbendazim and 600ml of malathion mixed in 300 litres of water before planting will control pineapple disease and scale insect.
- To avoid grassy shoot disease hot water treatment of seed material at 52^0C for 30 minutes or treatment with aerated steam at 54^0C for 4 hours to be done.



Spacing

- Mostly planted by opening a furrow with ridges .
- Row to row spacing varies from 60-90 cms
- Adsali Planting : 120 cm row spacing is followed
- Early varieties' : 80cm
- Mid late varieties : 90 cm

Lecture No.23

Planting Material

1) Sett : Propagated by vegetative methods by planting the stem of immature cane, known as setts. Buds on sett germinate to give plants. Top setts are taken from a crop ready for harvest For planting, setts should be free from pests and disease

2) Rayungans : Setts with shoots produced by cutting of the tops of standing Canes

3) **Seblang :** Tiller separation is also an ideal method. Clump with its sett intact is transplanted. Survival is better and growth quicker. If labor is not scarce this method is appropriate.

4) Space transplanting [STP] : Nursery beds of 10x5 m ,30 days old seedling for transplanting .600-800 single bud setts are planted in bed @ 2 tons /ha seed material is sufficient against 6-7 tons/ha **.**Single budded setts from top half of cane is planted, by Normal watering & other management aspects are followed .Some of the advantages are :

- Uniform crop stand
- Low incidence of pests and diseases.
- Reduce cane lodging.
- Increase in seed multiplication
- Around 25% yield increase are the advtg of this method
- High stalk pop 1-2 lak canes /ha

5. **Tissue culture technique :** This technology is mostly used in reviving degenerated varieties. Meristem tips are grown in artificial laboratory conditions Multiplication is faster. Used to develop seed material from limited number of buds

Sugarcane Planting Methods

1. Planting in flat beds

- It is very popular method on Northern India and in parts of Maharashtra.

- Shallow furrows of 8-10 cm deep are made.
- Distance between two rows should be kept 75-90 cm.
- Generally 3 budded setts are used to plant in the end to end planting system.
- The furrow is covered by 5-7 cm of soil and field is leveled by planking.

2. Ridge and Furrow Method:

- The method is adopted in areas with moderate rainfall but have drainage problem.
- Deep furrows are opened in 'v' shape,10-15 cm deep in N. India,20 cm in S.I.
- It is also practiced in Eastern UP,& in Peninsular India particular in heavy soils.

3. Trench Method or Java method

· In some coastal areas as well as in other areas where the crop grows very tall and the strong winds during rainy season cause lodging of cane, trench method is adopted to save the crop from lodging.
· Trenches at a distance of 75-90 centimeters are dug with the help of ridger or by manual labour.
· Trenches should be about 20-25 centimeters deep.
· After this already prepared mixture of fertilizers (NPK) should be spread uniformly in the trenches and mixed thoroughly in the soil.
· The setts are planted end to end in trenches.
· Gamma BHC 20 EC at the rate of 5 liters in 800-1000 liters of water per hectare is sprayed over planted setts in trenches to control termites and shoot and root borers.
· The tractor-drawn sugarcane planter is suitable device for planting cane in trenches.

4. Rayungan method

- It is Indonesian term meaning-a developed cane shoot with single sprouted bud.
- A portion of field is selected for Rayungan production is left at harvesting time.
- The top of the cane is cut off which results auxiliary buds begin to sprout.
- For quick and effective sprouting, fertilizer especially nitrogen in heavy dose is applied and field is irrigated.
- After 3-4 weeks sprouted buds are separated in single bud setts &transplanted on ridges.
- It is costly hence is not commonly adopted in India however is usually used for filling gap.

5. Distant Planting Method

- It was developed at Indian Institute of Sugarcane Research (IISR) Lucknow.
- Single budded setts are planted in nursery @ 20 q/ha or 18000 setts/ha.
- After 45-60 days single budded setts are planted in main field at 90cm×50cm.

6. Pit Planting

- Method is very popular in Tillah soil in Assam and also in Kerala hilly tracts.
- Pits are made at interspacing of 20-30cm in rows along the contours with row to row spacing of 75 cm,
- Organic manure is placed at bottom of pits.
- Cane setts are placed in the triangle in pits and covered with soil.
- System can be used in rain fed agriculture

7. Skip Furrow Planting

- It is common in Orissa.
- It is hybrid of flat and trench method.
- Trenches are dug 45 cm apart & gap of 90 cm is left after each two rows

8. Sabling or Sprouting Method:

- Plants are sown in fertile soil with wide spacing, shallow planting, frequent irrigations and adequate fertilization.
- Tillers soon after they develop their own roots are separated from the mother plant and planted separately.
- It is very successful in Java and Cuba.

9. Tjeblock Method

- Improved over Rayunga n method because it takes care of proper availability of energy and nutrient to all the buds.
- Here stalks are cut off at its half length and planted vertically with node in the soil for rooting.
- Planted ones and the mother stalks are adequately irrigated and fertilized.
- Now the upper buds of both Tjeblocks and mother cane, which sprout in due course of time, are planted by cutting them into setts, as rayungans.

10. **Bud transplanting**

- Sugarcane buds with half of its stalk can be planted in small polythene ba gs filled with organic manure and soil
- After sprouting they can be transplanted in the main field.

- The polythene is tore at the bottom for the easy rooting. There is less mortality about 5 % only.

11. **Algin method of sugarcane planting**

- In this method, Upper most nodes are collected while striping the canes for crushing.
- Then planted in wheat field in rows after every 4 rows of wheat at 90 × 50 cm
- The method was developed by Allahabad Agriculture Institute, Allahabad.

Recommended planting method

- Ridge and furrow method is easy and mostly followed
- Areas subjected to water logging immediately after planting : Partha method
- Farm with Drip irrigation Facility- Paired row planting
- Saline soils - Modified trench method
- Ridges are made at a spacing of 60-75 cam with a depth of 25 cm and irrigation and drainage channels should be opened along the field borders at regular intervals.
- Phosphates are applied in the furrows, then treated setts are placed in end to end or in overlapping fashion.
- Setts are covered with soil and irrigated
- **Dry** planting followed in light soils
- In heavy soils furrows are irrigated soil is brought to more or less puddle condition and setts are pressed in the soil ,which is called as **"wet method"**
- At the time of planting buds should face upwards, buds facing downwards do not germinate or difficult to emerge facing upwards may be exposed in washing of soil while irrigating and thus may dry out.
- System facilitates easy irrigation, provides good soil aeration, solid support to the plant when earthed up.

Sett showing facing upwards

Wet Method of Planting

Setts covered with soil

Lecture No.24

MANURES & FERTILIZERS

Nitrogen

- Influences sugar yields and quality
- Required for vegetative growth [tillering foliage formation, stalk formation and root growth]
- Deficiency of Nitrogen: shows paleness of foliage, early leaf senescence thinner and shorter stalks longer but thinner roots.
- Excess Nitrogen, prolongs vegetative growth, delays maturity and ripening, increases reducing sugars, lowers juice quality, susceptible to lodging and pests and diseases incidence.

Phosphorus

- "P" requirement is less than N and K.
- Essential for proteins ,Cell division, root growth ,plant metabolism etc
- Required for adequate tillering
- Interacts with N and thus enhance ripening.
- P deficiency leads to reduced tillering, delays in canopy development
- Affects stalk elongation
- Less production of secondary and tillering stalks
- Leaf color appear violet green.

Potassium

- Essential for carbon assimilation, photosynthesis translocation of carbohydrates
- Involved in various enzymatic activities
- Important for sugar synthesis, maintains cell turgidity, moist stress
- Develop resistance to pests and diseases and lodging
- Balances the effect of N & P.

Recommended rate of N P K fertilizers for AP

a) Srikakulum, Vizianagaram, Visakhapatnam, Medak : 112+100+100 kg/ha

b) Nellore, W. godavari, Krishna, Guntur : 168+100+120 kg/ha

c) Kurnool, Cuddapah, Anantapur, Chittoor : 224+100+120 kg/ha

d) Nizamabad : 250+100+120 kg/ha

- FYM @ 10 t / ha must be incorporated 4 - 6 weeks before planting .
- Green manuring with legumes.

- Biofertilizers like Azatobacter @5 kg/ha, PSB [Bacillus, Achromobacter, Acrobacter] and fungus [Aspergillus penicillium] or Press mud @4t/ha are also recommended.
- Secondary nutrients like Sulphur @50-100 kg/ha and micronutrients like Zn So_4 @25 kg/ha, $FeSo_4$ 25-60 kg/ha are essential for sugarcane.
- For standing crop , when deficiency symptoms of Zn and Fe are seen, foliar sprays are recommended.

Time & Method of application.

- Nitrogen requirement is maximum at tillering, early grand growth period from 1-6 months. Late application of N beyond 120 days, reduces the juice quality, increases soluble N in juice, and formation of water shoots.
- First application should be given at 30 days of crop age, next at 60 and 90 DAP.
- Phosphorous applied basally in furrow bottom and mix slightly with soil before planting.
- Potassium application normally done along with N application because of better utilization of N, in the presence of K. therefore K is applied at 45, 90 DAS.
- Late application of K, at 6 months under drought situations improve sugar recovery
- Nitrogen and potassium fertilizers are given in split doses applied in bands on either side of row
- Foliar Nutrition of urea @1- 2.5% & potassium @2.5% under moisture stress is useful to improve yield and quality

WEED MANAGEMENT

- Requires weed free for the first 90-100 days before and, most sensitive to weeds during tillering stage
- Manual weeding at 30, 60 & 90 DAP is effective to control weeds,
- Trash mulch at 45 DAP @ 7-10 t/ha,10 cm thick is effective against many weeds.
- Application of Atrazine @ 5kg/ha in 1125 litres of water to be sprayed on the third or fourth day after planting, depending on soil moisture
- At 20 and 60 days of planting spraying of 2,4-D ($4^1/_2$ kg) + Gramoxone (2.5 lts) in 125 lts/ha is recommended
- Initial ploughing, off baring, trash mulching, are the weed control methods in ratoon .

WATER MANAGEMENT

- Water requirement of cane is high and varies with region
- In Tropics, water requirement is 2000-3000 mm, in sub-tropics 1500-2000 mm
- Under severe stress the yield loss may go up to 60-70 per cent.
- For early planted cane , moisture stress coincides at grand growth phase ,affects stalk elongation ,in late planted cane, moisture stress affects the formative phase maturity and ripening phases.
- Limited stress during ripening helps improve percent sugar content in cane.
- Sugarcane grown in waterlogged areas ,damages crop and leads to 25 per cent reduction in, low sugar recovery
- Irrigate the crop depending upon the need during different phases of the crop.
- Number of irrigations required varies with varying rainfall patterns.
- Light & frequent irrigations gave higher yield, than heavy irrigations at longer
- intervals.
- In summer, irrigation interval depends up on soil type and season. Generally shorter interval in winter and in heavy soils whereas longer intervals in summer and in light soils.
- Trash mulching has to be done three days after planting @ 3 t /ha.
- Irrigation can be provided : 0.75, and 0.50 IW/CPE ratio at tillering, grand growth ,maturity. The irrigation intervals in each phase are given below.

Days of irrigation interval Stages :

	Sandy soil	**Clay soil**
Tillering phase (36 to 100 days)	8	10
Grand growth phase (101 - 270 days)	8	10
Maturity phase (271 - harvest)	10	14

Management practices for moisture stress situation

1. Choosing appropriate variety
2. Soaking the setts in saturated lime water
3. Choosing appropriate planting method
4. Close row spacing while planting
5. Basal manure application
6. Pre-stress manuring and irrigation

7. Trash mulching
8. Protective irrigation if available
9. Appropriate post-stress crop management
10. Foliar spray of urea , DAP, potash and trash mulching .
11 Inducing hardness.
12 Use of antitranspirants
13 Use of drought resistant varieties like Co -740, Co- 235, Co -997, Co -6304,

Earthing Up

- Earthing-up operation is also known as "hilling-up" converts furrows into ridges and ridges into furrows.
- Earthing-up is done at 45 - 120 DAP coincides with peak tiller stage.
- Could be done either manually or by using a bullock- drawn/tractor drawn furrower
- Earthing-up @ 120 DAP checks tillering, provides sufficient soil volume for root proliferation, promotes better soil aeration and provides a sound anchorage or
- support to the crop and thus preventing lodging
- One more earthing-up at 180 DAP may be helpful in preventing lodging.

Detrashing

- Detrashing refers to removal of unwanted bottom dry and green leaves at 150 DAP.
- Sugarcane stalk bears large number of leaves (30-35)
- Maintaining clean field
- Enhances air movement , an ideal micro-climate for unrestricted growth of cane
- More food material is made available for stalk growth
- Reduces the problem of infestation of insect- pests like scales, mealy bug, etc
- Minimizes rodents, rats, squirrels in the field which cause damage to the crop
- Detrashed trash can be used as a mulch for moisture conservation for composting .

Propping

- Operation of tying the leaves together using the bottom dry and green leaves is known as propping.
- Check lodging of cane.
- Trash without removing from cane is twisted to form sort of rope and cane stalks are tied together. This is known as trash-twist propping
- Propping can be done for each row or two rows can be brought together and tied

RIPENING

- Ultimate economic product of sugarcane is not the seed but the sugar stored in stalk.
- Accum ulation of sugars in the stalk begins soon after completion of elongation phase, when glucose produced during photosynthesis is converted to sucrose stored in stalk.

- Ripening occurs between rapid growth and ultimate death of cane
- As the cane is ripened sheath moisture should dropdown from 85 to 72% and nitrogen index from 2 to 1.25%.
- **Maturity stage:** when sucrose exceeds 16% juice purity increases over 85% - cane is mature
- When **cane stalk is cut** with a knife at above the middle portion, it end looks watery cane is unripe, if it sparkles slightly it is ripening
- **Trial boiling of juice:** To judge maturity is common among farmer, if the gur is set well in boiling, gur making continued, if not the cane will be tested after a few days
- **Top Bottom ration:** top portion of cane accumulates sugar rapidly than bottom portion. If the ratio of sugar content of top1/3 to bottom one third is less than one cane is unripe when ratio is more than one – cane is ripe.
- **Invert sugars** : Content of invert sugar in juice can also assess cane ripening
- **Hand Refractometer:** is to assess the maturity of standing crop by Brix reading
- Juice Brix refers to the total solids present in the juice expressed in percentage.
- Brix includes sugar's as well as non sugars.
- Brix is measured using Brix Hydrometer & necessary corrections with temperature are made & true Brix is obtained
- Juice sucrose percent is the actual cane sugar percent in the juice
- Juice sucrose percent is determined by Polarimeter that's why sucrose percent is referred as Pol%.
- "Seurolyser" is latest instrument used to analyse sucrose percent.

FACTORS AFFECTING RIPENING

1. **Location :-** cane growing countries in tropics characterized by higher juice quality than others regions.
2. **Low temperature :-** Ripening is fast during October - November but when temperature lowers the ripening rate slows down & maturation comes to stand still. Colder the spells deeper the fall.
3. **Max. temp**. between 23^0 & 32^0C & minimum temp. between 7-14^0C are favorable to steady rise in juice quality
4. When **hot weather** sets in may-june quality goes down, because of extreme heat, drought.
5. **Varieties :-** Early varieties [Co- 8336 Co -8341 Co -T 64] attain sugar levels & purity at an earlier period than late varieties.Jan- Feb planted crop will have higher juice quality compared to April-May planted crop

6. **Fertilizers :-** Excessive and late application of N fertilizers, delays ripening Fertilizers should be applied within 1-3 months only. Phosphorus deficient soils are known to produce cane of low sucrose content Potash fertilizers increases extraction percent juice from cane.
7. **Intercropping :-** Intercropping usually practiced in autumn planted crop, as cane growth during winter is lesser and not affected by competition. Intercropping in Feb planted crop however has an adverse effect on juice quality
8. **Irrigation:-** Irrigation favors early growth, leaf development, stalk formation, prolongs growing period resulting in higher potential of sugar formation & storage. Warm weather irrigations after rainy season improves sugar formation, irrigation in mid November may not improve juice quality in cool parts of N. India

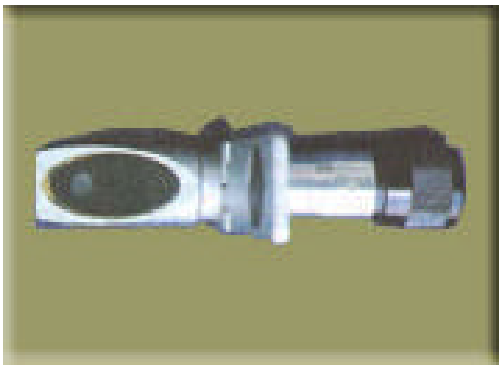
9. **Lodging :** Strong winds accompanied by heavy rainfall during sep-oct causes lodging of the cane . Even inclination of stalk causes proportionate reduction in sucrose & purity of its juice. When stalks are laid flat deterioration is more
10. **Earthing** up and propping ,can minimize lodging by keeping the cane erect.
11. **Flowering :** Flowering often takes place when crop starts ripening. Flowering is not a sign of ripening. Prevention of flowering by appropriate techniques combined with artificial ripening may help to increase the yield and juice quality

Artificial ripening :

- N.East and S. East regions of India need artificial ripening. Some promising repencer are –Polaris -1 to 1.5 kg/ ha, ethrel @ 1 to 1.5 kg/ ha or Cycocel @ 4 kg/ha, Glyphosate compounds like sucrose polado & Round up 0.6 to 1 kg /ha, improve sucrose content of mature stalks are called as sucrose loaders .
  New product like, Fusillade super is more effective than polada, ethrel.

Collecting Juice For testing Brix

Brix Hydro meter



Polarimeter For Testing Pol

Harvesting

- Harvesting the crop at proper time is very important
- Immature crop gives lesser sugar per cent and low yield
- Cane should be harvested in proper time of maturity,
- **Constraints – Quality & Sugar recovery,**
- Harvesting canes 5-10 days before its supply to mills
- Limited crushing capacity of mills,
- stalking of canes at mill yard
- Inordinate delay in transport of harvested cane from field to mills
- Week end shut down of the factory and unforeseen circumstances .
- Post harvest losses - sucrose conversion process after harvest & delay on delivery of cane to factory
- Weather parameters like high temp & humidity leads to greater deterioration.
- Levels of maturity, cane harvest, method of harvest also affect cane deterioration

Products from sugarcane juice

1) Jaggery
2) Juice concentrate
3) Powder jaggery
4) RAB
5) Vinegar

Harvesting

Lecture No.25

Ratoon Management

- The number of succeeding cane crops raised from single planting is "Ratoon"
- Ratoon occupies 50-55% of total cane area in India
- In India one or 2 ratoons are taken .
- The crop raised from planting cane setts is "Plant crop"
- Plant crop is harvested the under ground portion of stem stubble are left in the field.
- Harvesting close to the ground level is most important for good rationing
- If harvesting is done unevenly stubble shaving should be done.
- After harvesting of plant crop, trash left in the field, should be burnt, to clean the field and destruction of eggs and pupae of pests
- Soil compaction affects ratoon growth , to improve soil physical conditions, off barring and ridge flattening is necessary where ridges are broken by ridger - improves soil organic matter, through decay of old root mass and promote quick emergence of roots from stubble.
- Intensity of gaps in ratoon is 10-30 per cent
- Gap filling is done with young sprouts from stubbles or in poly bags or nursery with 30-35 day old.
- Trash mulching suppress weed growth and aids in moisture conservation besides increasing fertilizer use effect.
- **Varieties** Early varieties are poor ratoons than mid late or late varieties
  Thin or mid thin varieties are better ratooners than thick varieties .
  Plant crop should be harvested in Feb – March to ensure favorable re-growth of ratoon sprout
- **Fertilizers :-** 200 N + 60 P_2O_5 + 60 K_2O are recommended for good ratoon crop
- Nitrogen should be applied in 2 splits at ratoon initiation and 60 days after root initiation.Entire dose of P & K should be applied at ratoon initiation
- **Irrigation :-** Ratoon crop require more frequent irrigations than plant crop, because of shallow root system. Irrigation at 40% DASM is ideal for ratoon crop
- Irrigation at 12-15 days interval in subtropical regions and 8-10 days in tropical ares.
- **Earthing up :** Is done to check excessive tillering to prevent crop lodging & destruction of weeds.
  Earthing up is down twice first before onset of monsoon and 2nd at start of monsoon
- **Propping** is done by tying the cane together using dry leaves or green leaves, to prevent the crop lodging due to heavy winds and keep the field open for better aeration. Usually trash is twisted to form a rope and cane stalks are tied together – trash twist propping.

- **Weeding :** Pre-emergence application of Atrazine [1.0-1.5] followed by one hoeing – 45 days after ratoon initiation is effective and economical for weed control. Manual weeding at 0, 45 & 90 days after ratoon initiation is more effective.
- Application of cycocel [CCC] or etherel to foliage before 30 days of cane harvest, can promote bud sprouting in ratoon crop.
- **Plant Protection :** Ratoon crop needs more plant protection care than plant crop. Grassy shoot disease, ratoon stunted disease and smut are major diseases associated with ratooning
- **Advantages:-**
- Operational cost on seed and preparatory tillage is reduced by 25-30% by ratooning
- Ratoons mature earlier than plant cane .
- Ratoons can be harvested easily, field will be available for next crop
- Ratoons give equal or more yield than plant crop
- Ratoons give better quality cane with improved sugar recovery
- Cost of production per ton of ratoon crop is less than plant crop.
- The deeper root system thus obtained facilitates optimum utilization of the nutrients and moisture available in the lower soil layers and provides good support for growth of the ratoon crop

JAGGERY MAKING

Step 1. Cutting sugar cane from fields

Step 2. Feeding the grinder to extract juice

Step 3. Boiling the juice

Step 4. Adding Ingredients

Step 5. Tray Feeding

Step 6. Jaggery output

Step1: Fresh sugarcanes are cut from the fields, canes are cut in such a way that the head and tail are chopped off. They are carefully brought in a plastic sack, to the place where they are made juice.

Step2 : To extract juice from the sugarcane, they use a power run machine, where at one side four or five canes are fed, and at the other end, extracted sugar cane juice is directly feed to the vessel.

Step3 : Next step involved is boiling the extracted juice, juice is feed to a large big iron vessel, which is usually called as kadai as the below. heating unit of the vessel is set up in such a way that, at a single stretch two vessels are boiled, heating unit is nothing but a small pit above which this vessel is placed, there is a man who keeps on adding fuel to the heating unit from a small opening, the extract which is obtained after juice has been taken from the canes, these extract are dried in sunlight and used as a fuel for heating. The juice is boiled in the vessel for at least three hours, until the liquid juice becomes a semisolid paste.

Step4 : When juice becomes a semisolid paste, small quantity of sodium carbonate is added as a reducing agent, which helps in making Jaggery balls.

Step5 : After stirring well until the juice becomes a semisolid paste, the paste is fed to a iron tray. With the help of a long wood stick, at one end which contains a flat block they stir well again in the tray, until more thickening comes.

Step6 : With help of a wet cloth, hot Jaggery paste are made as balls precautions are taken, to prepare the balls as fast as possible, as the paste gets to the solid state with in a short span of time.

For a single feed of vessel, they get approximately around 100 kg of Jaggery, they get around fifty Jaggery balls, Jaggery are stored and sold as a complete bulkcart. For a single bulk cart they get a market price of approximately Rs.20,000/-.

Lecture No : 26 **SUGARBEET**

Origin and history

There is no distinct record regarding the origin and history of surgarbeet but in 1747 it was found for the first time that beet roots are rich source of sucrose and it took nearly 50 years for developing a successful method to extract beet root juice and its crystallization in the form of sugar. F.C. Achard was the first man to set up a sugar factory for processing of beet-roots and making sugar out of their pulp. From European countries it was introduced in USA as a sugar crop in early 18th century and first sugar factory was built in Northampton, Massachurits with great problems. Thereafter another factory was established in California (USA) in 1870 after rectifying the defects and it started working successfully since then.

Distribution:-

Sugarbeet is essentially a crop of temperate countries like USA,USSR, Sweden, Denmark, Germany, Belgium, Netherlands, France etc. Now in countries like Syria, Iraq, Iran, Algeria and Israel sugar-beet is fast assuming its commercial importance. It is now being introduced in Pakistan. Today sugarbeet is contributing to about 40 percent of the world sugar production.

Until recent past sugarbeet was famous as a "Salad" crop for table purposes in India but it is now in the experimental and semi-commercial testing in sub-tropical parts of the country. In Kashmir Valley sugarbeet is grown as a promising rainfed spring season crop. In Sriganganagar area of Rajastha n it is grown on commercial scale after producing first beet-sugar in 1968 by Ganganagar Sugar Mill.

A considerable research work has been done on its varietal performance on yield at G.B. Plant University of Agriculture and Technology, Pantnagar (Nainital) and the National Sugar Institute, Kanpur, has been actively involved in processing and manufacture of sugar from beet-pulp, although sugar beet is yet to be accepted as a commercial crop in India because it is at testing stage in some of the suitable Northern parts of India viz. Jullundhar, Karnal. Muzaffarnagar, Shahjahanpur, Lucknow, Gorakhpur, Pusa, etc. The crop is being tested for its suitability as a sugar crop and its performance as compared to sugarcane. In Kashmir Valley and Himanchal Pradesh it holds out a promise as a rainfed spring sown crop. The crop, in general. May be very successfully grown in Punjab, Haryana, Rajasthan and U.P.

Area, Production and Productivity :

World : Area = 8.6 m ha. ; Production=261 mt. ; Productivity=30.2 t / ha.

Botanical description of Sugarbeet

Sugarbeet is herbaceous, dicotyledonous biennial plant belonging to family Chenopodiaceae and as its nature the plant produces large succulent root in the first year and flowers and sets into seeds in the second year. Sometimes, due to unfavourable climatic conditions, the plants give out seed-stalks in the first year itself which is technically called as **bolting.**

A beet plant consists of three parts viz. the crown, the neck and the root. The crown produces leaves which are arranged in a close spiral below which is the most smooth and broadest part that is technically called as 'neck'. The roots are cone-shaped which end into a slender tap form. Sometimes roots are flattened on two sides which are more or less grooved.

The seed-stalk bears racemes of imperfect regular flowers which have no petals in them. The fruits consist of 2 to 5 seeds which are shiny, having lentil like structure and are about three mm long.

Varieties

Sugarbeet, being a recently introduced crop into India as a commercial sugar crop, has most of the foreign varieties. Theses varieties are mostly from Germany, U.S.S.R., U.S.A., U.K., Denmark, etc. Following are the important varieties which have been observed doing well under Indian conditions:

Erotype E from West Germany.
Romoskava from U.S.S.R.
U.S. 35 from U.S.A.
U.S. 75 from U.S.A.
Maribo Anglo Poly from Denmark.
Maribo Magna Poly from Denmark.
Maribo Resista Poly from denmark.
Triplex from U.K.
Bush E from U.K.

Now the diploid multigerm variety "Romoskava 06" is presently recommended for commercial cultivation. The variety gives higher yield with superior quality besides a better resistance to important beet-root diseases. In addition to this two other Danish polyploids multigerm varieties viz. "Meribo Magnapo" and "Maribo Magapoly" have also proved to be the most promising. The seeds of the varieties are under multiplication by a joint venture of N.S.C. and the Government Department of Agriculture, Himachal Pradesh.

Climate

The sugarbeet needs high moisture associated with cold climatic conditions throughout its growing period. The best germination has been observed when the seeds are sown at a soil temperature of 15.5°C and it is interesting to note that sugar accumulation in beet-roots drops when atmospheric temperature reaches to 30°C Or above. The commercial cultivation of the roots is possible on the plains during winter season but the seed formation becomes impossible because of unfavourbale climatic conditions.

Therefore, seed production is done on the hill of Himachal Pradesh by the Government of H.P. with an associated efforts of the National Seed Corporation. Sugarbeet prefers loam to clayey loam soils with good inherent fertility and sufficient organic matter having a near neutral reaction through it has a high tolerance, to soil alkalinity and salinity. The acidic soils are not at all good for the crop. The crop cannot withstand waterlogging and hence poorly drained soils are unfit for beet-root production.

Land Preparation

The land is prepared to a good tilth by repeated ploughing and planking operations. After obtaining a fine tilth, the field is finally divided into ridges and furrows or simple flat beds based on method of sowing to be adopted. Usually sowing on the ridges is preferred over flat bed planting. Ridges of 10 to 12 cm height are prepared at a distance of 50 cm between them by the help of ridger after mixing manures and fertilizers in the field.

Lecture No.27

Manures and fertilizers and methods of Application

Organic manures such as compost or F.Y.M. at the rates of 20 to 30 tonnes per hectare should be applied before the ridging is done. The crop should be supplemented with 100-120 kg. of nitrogen, 80 kg of P_2O_5 and 100 kg of potassium per hectare. It is advisable to apply nitrogen in three equal splits, namely first at sowing, second after thinning and third after earthing up operation but never beyond December as it lowers the quality of beet-roots.

After every top-dressing the crop should be given a light irrigation. Form the experimental results it is observed that the crop responds equally to all the sources of nutrients but, if possible, fertilizers containing chloride ions should not be chosen for the application in the crop. Deficiency of micro-nutrients has not been noticed but the studies are in progress at various sugarcane research centres in North India.

Seeds and Sowing

Seed rate = 10 kg / ha.

In the North Indian plains sugarbeet is grown as a rabi season crop and the most ideal time for sowing is October. It is observed that if sowing is delayed beyond October the yield and quality (sugar content) are found to be affected adversely. There are two commonly adopted methods of sugarbeet sowing viz. ridge sowing and flat bed sowing. The depth of sowing should be 4-5 cm with row to row 50 cm and plant 10-15 cm spacings. This requires about 10 kg seed/ha. Generally, sowing is done by dibbling manually or by drilling with cotton seeds-drills. Indian Institute of Sugarcane Research, Lucknow, has designed and fabricated a push-type drill for sowing sugarbeet.

Seed treatment: It is noticed that seed soaking for 4 or 5 hours in plain water helps in getting higher germination of beet seeds. To get still better germination the seeds may be soaked over night in 0.25 per cent solution of a mercurial compound or Aretan or Agallol. This is done by putting the seeds in a cloth bag and dipping the seed bag in the chemical solution until the seeds soak up the chemical. The seeds are then spread open for drying after which they may be used for sowing.
Spacing : 50 cm X 20 cm

Sowing method : Drilling or by Dibbling in 2 to 3 cm deep

Sowing time : Mid October to Mid November

Irrigation

The crop cannot tolerate drought and hence it is very sensitive to inadequate water supply but at the same time excessive irrigation is highly detrimental to the root quality of the crop. The frequency and the number of irrigation depends on various factors viz. seasonal variation, type of soil, organic matter content of the soil, etc. but, in general, a 2-2-4 irrigation schedule at the critical growth stages like formative, leaf growth and root development stage respectively holds a promise in beet-root production. On an average, 15-20 days interval between two subsequent irrigations is supposed to be an ideal. This way the crop needs about 8 to 10 irrigations during its growing period.

Intercultural Operations

Critical period of weeds is upto 60 days i.e at formative phase. Requires 2-3 intercultivations , first at 15-20, 2nd at 10-15 days interval. Spraying of pretilachlor 50 EC @ 0.5 Kg ai/ha or Pendimethalin @3.75lit /ha can be dissolved in 300 litres of water and sprayed with hand operated sprayer on 0- 2nd day after sowing, followed by hand weeding on 25th day and 50th day after sowing. The soil should be little loosened and earthing up of the crop should be done by December after finishing the last top-dressing of fertilizer.

Thinning

The sugarbeet seed is a "multigerm" which gives out four seedlings per "glomerule" (seed ball). To avoid the competition among them and to maintain a single robust plant per glomerule it is necessary to pluck off remaining ones. The thinning should be done when the seedlings are having three to four leaves in them. Thus a uniform spacing of 20 to 25 cm between the plants should be maintained. For keeping a uniform plant population, sometimes gap filling is needed which should be done by sowing the fresh seed instead of transplanting the seedlings because transplanting results in production of malformed or "fongy" roots having poor weight though transplanting is common in some areas. Gap filling should be done soon after germination.

Crop rotation

Sugarbeet is susceptible to various soil borne diseases and their chemical control becomes very costly and difficult, therefore, a suitable crop rotation of long duration should be adopted. It is observed that any rotation of three to five years duration is best for production of a healthy commercial beet-root crop in the country. Some of the best rotations are;

Cowpea (fodder) – sugar-beet-cotton-sugarcane (plant)-sugarcane (ratoon);

Maize (early) or early paddy-sugarbeet-Sanai or dhaincha (green manure)-potato-sugarcane (plant)-sugarcane (ratoon);

Guar+sugarcane (companion cropping)-sugarcane (ratoon)-sugarbeet-jowar (fodder)-maize-sugarbeet.

Inter-cropping of sugarbeet with autumn planted sugarcane is economically feasible and good for higher yield of both the crops.

Harvesting

Sugarbeet Matures in 5 to 6 months.

An October sown crop becomes ready for harvesting in March to May. Signs of maturity : yellowing of lower leaves and root bricks values indicate 15 to 18. At the time of harvesting there must be enough moisture to facilitate the harvesting but the field should not be wet. The harvesting may be done by running a country plough along the rows on both the sides and lifting of the roots by a slight pull of **Kudali.** The adhering soil should be cleaned of the roots by a thorough shaking but the roots should not be washed in water for cleaning as it causes a rapid deterioration. The roots should be topped at the leaf-crown because allowing the leaves to remain on the roots affects the recovery of sugar adversely.

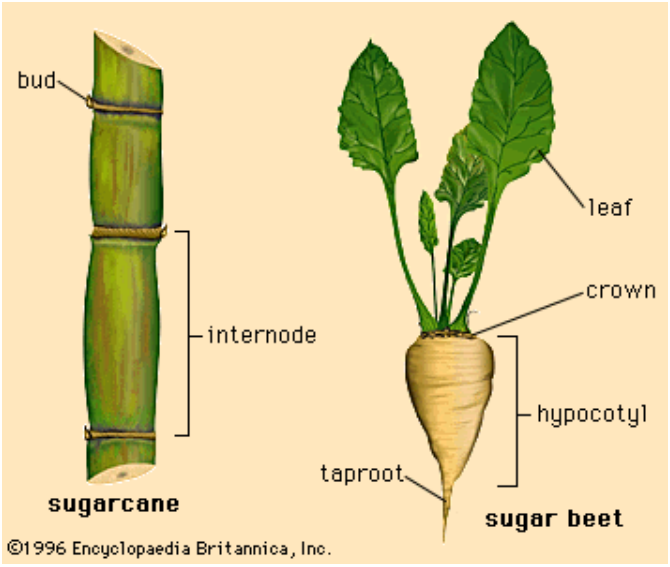
Yields :

A good crop of one hectare area yields about 300 to 500 quintals of beet-root having a sucrose per cent of 15 in March and 17 in May.

Post harvest management

- Stop irrigation 15-20 days prior to harvest. This allows sugar accumulation
- Just hand pulling and keeping the tops, store in a shaded conditions
- Roots of sugarbeet reach the factory within 48 hours for processing
- Yield 80 to 100 t/ha, Sugar recovery- 15 -16%

Comparison between sugar beet and sugarcane



Character	**Sugar Beet**	**Sugarcane**	
Soil Red	Sandy loam.	loamy soil	
Duration	6-7	10-12	Brix
reading	23-24 %	18-20 %	Pol
%	20-22 %	13-16 %	Sugar
recovery	15-16 %	11-12 %	Avg
sugar rec	10-12 %	8-10 %	Yield
(t/ha)	60-80	100	Water
reqt	1/3rd of S-cane	Through outYear	
	400-500	1800-2000	

- Ethanol Prod (Lt) 2800-3500 1700-2700 Alcohol Yield Pot. 2800–4100 Lts/ acre 1700-2400 lt/ac

Seed production in sugæetrb

The seed production of beet-root is not possible on the plains because of very high atmospheric temperature. On commercial scale the seed production is undertaken in Kashmir and Kalpa Valleys by National Seed Corporation and Government of Himanchal Pradesh. For producing the seed healthy roots are selected, they are cut-off about 1/3rd of their tapering length and again planted in nicely prepared and fertilized plots. An efficient plant protection measure and appropriate isolation from their variety are maintained and the seed is produced. The seed production industry has a very wide scope in India.

Sugar manufacture from beet-root

Sugarbeet gets spoiled very fast and hence it has to be processed in sugar mills within 48 hour of its harvesting; therefore, a well co-ordinated plan of harvesting and processing has to be followed. Thus the beet roots must be grown near and around the sugar mills only. The best sugar is extracted through extraction process by using special diffusers based on the counter current technique. The beet juice characteristics necessitate the adoption of carbonation process only for clarification and hence clarification with diffusers and related accessories are essential to process sugarbeet in the traditional sugarcane based sugar mills in the country. Huge quantity of fuel is needed for heating the juice.

Sugarbeet by-products and their utilization

One hectare beet crop produces about 5 to 10 metric tones of beet tops which may be used as cattle feed for the milch cattle to increase the yield of milk. Freshly harvested tops contain Oxalic acid and hence they are contra-indicated when fed fresh. This bad effect may be counteracted by the addition of 60.0 g of finely ground lime per 100 kg of tops. Under abundant supply of beet tops they may be used as green manure and the tops of one hectare usually add 100 kg of nitrogen to the soil.

Beet pulp, after extraction of sugar may be used as cattle feed, either fresh or dried. The beet pulp may easily replace the grain from the feed concentrates. Mixing of molasses with pulp may easily replace the grain from the feed concentrates. Mixing of molasses with pulp improves its palatability and taste. Sugarbeet molasses is extensively used as a raw material for various special fermentations. Besides, being a rich source of lactic acid and vitamins it is also used in many pharmaceutical preparations.

Lecture No: 28

Tobacco

Origin:

The information available on the origin and history of tobacco suffers generally from ambiguity and contradictions. According to one source, tobacco was in existence in Asia even during the 12th century, when it was not known elsewhere. It was not only used as an intoxicant but also as a cure for all kinds of ills and paying homage to deities. However, it was Christopher Columbus who discovered the narcotic qualities of tobacco accidentally in the course of his American voyage in 1492. On landing in the Islands of Tobag, Columbus and his men were taken by surprise to find the natives either sniffing a powdered dry leaf with evident pleasure or smoking roughly made roll of dried-up leaves. On trying these themselves, Columbus and his men were satisfied with the intoxicating effect. They took along with them some quantity of dried leaves and seeds and that was how tobacco got introduced into Europe.

The Red Indians, according to another version, used tobacco for both medicinal and ceremonial purposes. They used to inhale its smoke from burning leaf through the nostrils by means of a hollow forked cane and the name of the instrument was given to the plant which came to be known as `Tobaco' in Spanish and `Tobacco' in English. The plant was first introduced into Europe in the year 1560 by a Spanish physician sent to Mexico. About this time, Jean Nicot, the French Ambassador to Portugal came to know of tobacco in Lisbon and introduced it to the French Court. The botanical name of the plant, *Nicotiana* and the word nicotine have been derived from his name. The habit of smoking spread to several countries during the 17th century.

Tobacco is said to have been introduced into India in the beginning of 17th century. As elsewhere in the world, it has thrived in spite of considerable neglect and social disapproval.

Distribution:

Leading tobacco growing countries are China, India, Brazil, USA, Zimbabwe and Turkey

Types Of Tobacco

With its rich agro-climatic diversity, India has the unique position of growing different types of tobacco which are broadly classified as:

1.	FCV tobacco	Andhra Pradesh & Karnataka
2.	Bidi tobacco	Gujarat, Nipani area of Karnataka & Nandyal area of Andhra Pradesh
3.	Cigar & Cheroot tobacco	Tamil Nadu & West Bengal
4.	Hookah tobacco	Assam, West Bengal, Bihar, UP & Gujarat
5.	Chewing & Snuff tobacco	Tamil Nadu, West Bengal, Bihar, Assam & Uttar Pradesh
6.	Natu, Burley, Lanka & HDBRG tobacco	Andhra Pradesh & HDBRG
7.	Pikka tobacco	Orissa

Botanical Classification Of Tobacco

The genus *Nicotiana* is one of the five large genera of Solanaceae and is represented by about 68 recognized species.

Description is available for all the 68 species, which are grouped in three sub-groups:

- Sub-genus - Rustica
- Sub-genus - Tabacum
- Sub-genus - Petunioides

The original habitat of the genus is considered to be South America, particularly the regions surrounding the Andes. There are, however, several species in Australia and South Pacific Islands that do not occur in the new world. They are considered to be derivatives of the South American stock. Out of the 68 species, only two species, i.e. *Nicotiana tabacum* and *Nicotiana rustica* are cultivated extensively. India grows both the species, but by far the largest area is under *N. tabacum*. Since *N. rustica* requires cooler climate, its cultivation is confined mainly to the northern and north-eastern areas of the country, i.e. Uttar Pradesh, West Bengal, Bihar, Assam & Gujarat.

The *N. tabacum* varieties known as desi types have tall plants with broad leaves and have usually pink flowers. The *N. rustica* varieties known as `vilayati' and `calcuttia' are characterised by short plants with round puckered leaf and yellow flowers. Specific varieties in *N. tabacum* have been developed for cigarette, cigar and cheroot, bidi, hookah and snuff tobaccos. The varieties developed in *N. rustica* are used for only chewing, hookah and snuff tobaccos. In addition to *N. tabacum* and *N. rustica* which are commonly cultivated, many species of *Nicotiana*, such as *N. affinis*, are grown for ornamental purposes.

ANDHRA PRADESH:

Other Tobacco's	**Area (ha)**	**Production (M Kg)**	**Yield (Kg/ha)**
Bidi Tobacco	5000	5	1000
Irrigated Natu	10000	25	2500
Rainfed Natu	10000	10	1000
Lanka Tobacco	4000	10	2500

FCV Tobacco in INDIA:

	Area (ha)	**Production (M Kg)**	**Yield (Kg/ha)**
A.P.	141	204	1447
Karnataka	90	114	1267
All INDIA	231	318	1376

ALL INDIA:

	Area (ha)	**Productionm (M Kg)**	**Yield (Kg/ha)**
FCV Tobacco	231000	318	1376
Bidi Tobacco	75000	150	2000
All Tobacco's	420000	700	1665

* Source: CTRI annual report 2009-10

Tobacco Varieties Released In India

Variety	Year of rele ase	Developed at	Cured leaf yield (kg/ha)	Area of adoption and salient features
FCV tobacco				
Chatam	1950	CTRI, Rajahmundry	1100	For TBS
Delcrest	1960	CTRI, Rajahmundry	1200	For TBS
Kanakaprabh a	1971	CTRI, Rajahmundry	1500	For TBS
Dhanadayi	1972	CTRI, Rajahmundry	1520	For TBS
CTRI Special	1976	CTRI, Rajahmundry	1365	For TBS
16/103	1976	M/S ILTD Co., Rjy	1717	For NLS
Special FCV	1976	M/S ILTD Co., Rjy	1118	For TBS and KLS
Jayasri	1979	CTRI, Rajahmundry	1990	For TBS
CTRI Spl.(MR)	1980	CTRI, Rajahmundry	1200	For TBS and SLS; Resistant to TMV
Godavari Spl.	1982	CTRI, Rajahmundry	1525	For TBS and SLS; Resistant to TMV
Swarna	1984	CTRI Res. Stn., Hunsur	1450	For KLS; Resistant to powdery mildew
Mc Nair 12	1986	CTRI, Rajahmundry	1880	For NLS; Tolerant to black shank
Jayasri (MR)	1986	CTRI, Rajahmundry	1503	For TBS and SLS; Resistant to TMV
Hema	1987	CTRI Res. Stn., Guntur	1560	For TBS
Bhavya	1988	CTRI Res. Stn., Hunsur	2000	For endemic black shank areas of KLS; resistant to black shank and tolerant to root-knot nematode
Gauthami	1992	CTRI, Rajahmundry	2000	For TBS and SLS
CM 12(KA)	1993	CTRI, Rajahmundry	2000	For NLS; Tolerant to black shank
VT-1158	1993	CTRI, Rajahmundry	2000	For TBS; Resistant to TMV
K-326 (NLS-4)	1998	CTRI, Res. Stn., Jeelugumilli, CTRI Res. Stn., Hunsur	2000	For NLS and KLS; Tolerant to black shank and nematodes
Trupthi (KST-19)	1998	Reg. Res. Stn., Navile	1800	For KLS
Ratna	2000	CTRI Res. Stn, Hunsur	2000	For KLS

Kanti (CY-79)	2001	CTRI Res. Stn, Kandukur	1600-2000	For the SLS & SBS of Andhra Pradesh
Hemadri (II-1624)	2002	CTRI Res. Sta., Guntur	2500	For Traditional black soils of AP.
Bidi tobacco				
Keliu 20	1956	BTRS, Anand	1550	For Gujarat
Anand 2	1969	BTRS, Anand	2555	For Gujarat, Karnataka, Maharashtra & Andhra Pradesh
Anand 3	1966	BTRS, Anand	2500	For Gujarat
Anand 23	1969	BTRS, Anand	2477	For Gujarat ; Tolerant to leaf-burn disease
Anand 119	1969	BTRS, Anand	2625	For Gujarat, Karnataka, Maharashtra & Andhra Pradesh
GT 4	1976	BTRS, Anand	2605* 2841@	For Gujarat Drought tolerant
NPN 190	1979	ARS, Nipani	1964	For Karnataka and Maharashtra
PL 5	1984	ARS, Nipani	2000	For Karnataka and Maharashtra
GT 5	1986	BTRS, Anand	3301	For Gujarat; Tolerant to root-knot and high nicotine
GT 7	1993	BTRS, Anand	2535	For rainfed areas in Gujarat; drought tolerant
GTH 1	1995	BTRS, Anand	3644	For Gujarat; Tolerant to root-knot and high nicotine
Bhavyasree (NPN-22)	2000	ARS, Nipani	1420	For Karnataka
Chewing tobacco				
Chama	1956	CTRI Res. Stn, Dinhata	1800	For North Bengal (clay soils)
Podali	1956	CTRI Res. Stn, Dinhata	1600	For North Bengal (sandy soils)
DP 401	1958	CTRI Res. Stn, Pusa	2000	For Bihar
Gandak Bahar	1976	CTRI Res. Stn, Pusa	2280	For Bihar
Sona	1977	CTRI Res. Stn, Pusa	3178	For Bihar
Vairam	1977	CTRI Res. Stn, Vedasandur	2800	For pit-cured tobacco growing areas of Tamilnadu
Thangam	1980	CTRI Res. Stn, Vedasandur	3226	For smoke-cured tobacco growing areas of Tamilnadu
Bhagyalakshmi	1980	CTRI Res. Stn, Vedasandur	3532	For sun-cured tobacco growing areas of Tamilnadu

Maragadham	1981	CTRI Res. Stn, Vedasandur	3013	For smoke-cured tobacco growing areas of Tamilnadu
Prabha	1981	CTRI Res. Stn, Pusa	2200	For Bihar
GT 6	1986	BTRS, Anand	2712	For Lal and Kala Chopadiu tobacco
PT- 76	1990	CTRI Res. Stn, Pusa	2600	For Bihar
Meenakshi	1992	CTRI Res. Stn, Vedasandur	4000	For sun-cured areas of Tamilnadu
Vaishali Special	1993	CTRI Res. Stn, Pusa	2778	For Bihar
Abirami	2001	CTRI Res. Stn. Vedasandur	4000	For southern, central and western zones of Tamil Nadu except Coastal belt
Dharla	2001	CTRI Res. Stn. Dinhata	2700	North Bengal zone
Lichchavi (PS-14)	2001	CTRI Res. Stn. Pusa	3000	North Bihar

Rustica tobacco

DD 437	1977	CTRI Res. Stn, Dinhata	1865	For Motihari areas of West Bengal
Sonar Motihari	1977	CTRI Res. Stn, Dinhata	1690	For Motihari areas of West Bengal
GC 1	1981	BTRS, Anand	2693	For *rustica* areas of Gujarat
GCT 2	1994	BTRS, Anand	3512	For *rustica* areas of middle Gujarat

Natu tobacco

Prabhat	1977	CTRI Res. Stn, Guntur	1500	Natu areas of Andhra Pradesh; suitable for cigarette natu, resistant to TMV
Vishwanath	1986	CTRI Res. Stn, Guntur	2429	Suitable for cigarette natu areas of Andhra Pradesh
Natu Special	1992	CTRI Res. Stn, Guntur	1600	Suitable for cigarette natu areas of Andhra Pradesh
Pyruvithanam	2001	NRPT Centre, Berhampur	1250	Pikka tobacco growing areas of Orissa
Bhairavi (NG73)	2002	CTRI Res. Stn., Guntur	2600	Suitable for cigarette natu areas of Andhra Pradesh

Cheroot tobacco

DR 1	1960	CTRI, Rajahmundry	2620	For river-side Island of East Godavari district of Andhra Pradesh; strong,

				pungent and aromatic
Bhavani Special	1980	CTRI Res. Stn,, Vedasandur	2837	For Bhavani area of Coimbatore district of Tamilnadu
Lanka Special	1981	CTRI, Rajahmundry	2780	For river side Island of East Godavari district of Andhra Pradesh; strong, pungent and aromatic
Sendarapatty Special	1986	CTRI Res. Stn,, Vedasandur	2100	For Salem area of Tamil Nadu
Cigar-wrapper tobacco				
Krishna	1986	CTRI Res. Stn,, Vedasandur	2250	For cigar-filler area of Tamilnadu
Burley tobacco				
Banket A1	1994	BTRC, CTRI, Jeddangi	1800	For light soil agency areas of East Godavari,Visakapatnam, Vijayanagaram districts of Andhra Pradesh. Resistant to TMV
Sweta (BSRB 2)	2002	BTRC, CTRI, Jeddangi	2000	For light soil agency areas of East Godavari,Visakapatnam, Vijayanagaram districts of Andhra Pradesh. Resistant to TMV

TBS: Traditional black soils of Andhra Pradesh; NLS: Northern light soils of Andhra Pradesh; SLS: Southern light soils of Andhra Pradesh; KLS: Karnataka light soils,
* Rainfed, @ normal conditions; BTRC, Burley Tobacco Research Centre.
CTRI RS: Central Tobacco Research Institute Research Station

Preparatory cultivation

In all the tobacco growing soils, deep summer ploughing is invariably recommended. This practice is found highly beneficial in minimizing weeds and *Orobanche* menace, reducing insect pest and disease problems and improving water and nutrient conserving capacity of the soil.

Pre-planting tillage operation includes one or two ploughings with mould board or disc plough followed by two cross ploughings with cultivator followed by planking for levelling the field. Use of single *patela* helps in collection and removal of weeds and stubbles from the field. The tillage operation must be completed before planting time.

Soils:

Tobacco is very sensitive to the physical and chemical properties of the soil. Soils which are open, well drained and properly aerated are the best suited for tobacco cultivation. The plant is highly susceptible to injury from flooding or inundation of the soil. The desirable soil pH is 5.0 to 6.0. But, in many parts cultivation is successful where the pH is 8 or more.

In India, cigar, hookah, chewing, bidi and FCV tobacco in some areas are grown on sandy loam to clay loam soils. The crop is raised either as irrigated in Tamil Nadu, U.P. and Northern light soils (NLS) of Andhra Pradesh or as semi-irrigated crop i.e. in Bihar, West Bengal and Karnataka or as a dry crop in Andhra Pradesh except in NLS.

Flue cured virginia tobacco is grown in India in four agro-climatic zones namely Traditional black soils (TBS), Northern light soils (NLS) and Southern light soils (SLS) in Andhra Pradesh and Karnataka light soils (KLS) in Karnataka. Soil characteristics, cultivation practices and quality of the tobacco grown vary from one region to the other. The different styles of tobacco produced in different zones meet the demands of the customers of different countries.

The Traditional black soils are clay loams, silty clay loams and clays, highly clayey (50-80% clay) throughout the profile, slightly alkaline in reaction (pH 7.5 to 8.8), calcareous, low in organic carbon, rich in fertility, high in available soil moisture with very poor drainage. Tobacco is grown on conserved soil moisture as post monsoon crop during winter.

Northern light soils (East Godavari, West Godavari and Khammam districts of A.P.) are sandy loams to loamy sands, slightly acidic, very low exchangeable cations, low water holding capacity, poor fertility status with very good drainage. Tobacco is grown in these soils under irrigated conditions during winter.

Southern light soils (Prakasam and Nellore districts of A.P.) are red loamy soils, neutral in reaction, low to medium fertility status, moderately well drained, moderately low permeability, with moderate water holding capacity and low to medium cation exchange capacity with more than 75% base saturation. Tobacco is grown during winter on conserved soil moisture from North East monsoon rains.

Karnataka light soils (Transitional belt of Karnataka) are red soils which are yellow to deep red in colour, loamy sands and sandy clay in texture (clay content varies from 10 to 25%), low in inherent fertility, slightly acidic in reaction with fairly good water holding capacity. The soils are well drained and highly leached. The clay complex of red soils consists of a mixture of Illite and Kaolinite with traces of Montmorillonite. Tobacco is grown as a monsoon crop during south west monsoon period.

Burley tobacco:

The burley tobacco is grown during monsoon season in Agency areas in East and West Godavari districts of Andhra Pradesh and the soils are generally sandy loams on the surface and loams at the sub-soil level and neutral to acidic in reaction (pH 5.5 to 6.5). The soils are very low in soluble salts, chlorides and light in texture. The organic matter content, available nitrogen and available phosphorus status are low. This tobacco is used for blending in cigarettes.

***Natu* tobacco :**

The crop is raised on medium to heavy black soils of pH ranging from 7.0 to 8.5 in Guntur, Krishna, Kurnool, Khammam and Warangal districts of Andhra Pradesh on the conserved soil moisture. These soils are poor in available nitrogen, organic carbon, medium to high in phosphorus and high in available potash. Some *pati* soils are also used for growing *natu* tobacco. The unirrigated crop grown on black soils is given a moderate manuring.

Lanka tobacco:

Lanka tobacco is exclusively grown on the banks and delta ic islands of Krishna and Godavari rivers in Andhra Pradesh. The soils which are sandy to loam in textures are derived from the recent alluvium deposited annually by the rivers Krishna & Godavari during floods. Some of these soils, which are submerged during floods every year are silty in nature and therefore highly fertile.

Bidi tobacco:

In Gujarat, bidi tobacco is grown in Charotar area comprising of Anand, Petlad and Nadiad taluks of Kheda District and the soils in this tract are mostly sandy to sandy loam called "*Goradu*" and in some parts of Vadodara District which are medium clay soils. Soils are deficient in organic carbon and medium in available phosphorus and potassium.

In Karnataka, bidi tobacco is mainly grown in Nipani area of Belgaum District on the banks of river Krishna and its tributaries. Hence, the crop is grown on black silt loams which have good moisture retentive capacity. Bidi tobacco is also grown to some extent in Koraput District of Orissa and in Kurnool District of Andhra Pradesh.

Chewing and hookah types of tobacco

Chewing and hookah types of tobacco are grown on different types of soils ranging from sandy loam upland soils of Vaishali, Samastipur, Muzaffarpur to medium and heavy paddy growing soils of Purnea, Katihar and Saharso. Most of the tobacco growing soils are low in organic matter, available N and P, medium in K content and mostly alkaline in reaction (pH 8.2 to 8.4). Illite and muscovite are the dominant minerals responsible for the enrichment of such soils. Available phosphorus content in these soils is low. Well drained, neutral to slightly alkaline soil with good nutrient supplying capacity is considered ideal for chewing and hookah tobacco cultivation.

Chewing tobacco cultivation in Tamil Nadu is concentrated in the districts of Dindigul, Erode, Coimbatore, Madurai, South Arcot, Nagapatnam, Salem, Thanjavur, Kanyakumari and Tirunelveli in an area of about 20000 ha. Chewing tobacco is grown in a wide range of soils which are alkaline in nature and with irrigation waters having high salt content.

Country Cheroot tobacco

Two types of country cheroot tobaccos i.e. the narrow leaf type and broad leaf type are cultivated, the former confined to Erode district and the later in Salem districts of Tamil Nadu in an area of about 5000 ha. This tobacco is cultivated in both heavy and light soils as an irrigated crop. The produce finds its way for the manufacture of hand made country cheroots for consumption in Tamil Nadu as well as adjoining States of Kerala and Karnataka. Part of the produce is also consumed locally as well as in Karnataka as chewing tobacco.

Wrapper, filler, jati & motihari tobacco of North Bengal

Motihari (*N. rustica*) and jati, wrapper and filler (*N. tabacum*) tobacco types are cultivated in a total area of about 14,000 ha concentrated in Cooch Behar, Jalpaiguri, Mushidabad and Malda districts of North Bengal region. Soils of the area are alluvial flood plains in origin, formed from the deposits of Ganga and Brahmaputra river waters. These soils are sandy loams and silt loams, light in texture, whitish grey to greyish in colour, well-drained and well-aerated.

Cigar filler and binder tobaccos are grown on sandy to loamy, well drained, red and brown soils of Coimbatore and Madurai districts of Tamil Nadu. The crop is heavily irrigated, about 20 times. From well water.

Climate

Besides soil, the other important factor which affects tobacco growth is the climate. Rainfall, temperature, relative humidity, wind and sunlight have a profound influence on growth, flowering and metabolism of tobacco plant. To maintain turgidity and expansion of leaf area, tobacco plant needs considerable amount of water. On the other hand, tobacco plants are very sensitive to flooded/water-logged condition of soil because of deprivation of oxygen in soil essential for the development of a fibrous root system.

Tobacco is tropical in origin, but it is grown successfully under tropical, sub-tropical and temperate climates. Normally it requires about 100 to 120 frost-free days with an average temperature of 80^{o}F, to mature. Ideal conditions required for successful production of high quality leaf are 1) a liberal and well-distributed rainfall during active vegetative growth stage 2) long day lengths and 3) a high relative humidity of 70-80%. In India, tobacco is grown under a very wide range of conditions from the coast-line to an altitude of 3,000 feet. In the South, the crop is raised in winter from October to March when the temperatures are moderate. But in Punjab, it is grown as an early summer crop. In the eastern and western parts of the country, it is grown between September and January.

Andhra Pradesh and Karnataka

The annual rainfall through South-West and North East monsoons is around 800- 1000 mm starting from June to October and Nov. – Dec (North East monsoon). The crop is exclusively grown on conserved soil moisture during rabi season extending from October-November to February-March. Occasionally, the North- East monsoon becomes active and unprecedented rain during the crop season through cyclonic storms boosts the yields. The crop requires good sun light, low evaporation, high relative humidity, sustained soil moisture and free from wet footing and cyclonic storms.

Lanka tobacco crop needs 80 to 90% relative humidity during plant growth period that is from mid October to November ending with a mean day temperature of about 26.7^{o}C and the crop needs 30 to 32^{o}C so that the leaves on the plant will come to maturity with raising temperatures.

Bidi tobacco

The bidi tobacco in Charotar area of Gujarat is grown with few irrigations while in Nipani area of Karnataka it is not irrigated. A less irrigated bidi tobacco is more prized than a more irrigated crop. In Gujarat the crop comes to maturity during winter due to which the leaf thickens and becomes rugged. This is desirable feature for bidi tobacco.

LECTURE NO : 29 C.No: AGRO -301 CROP PRODUCTION -II

NURSERY MANAGEMENT

Tobacco seeds are very small and egg-shaped with thick seed- coat. They are about 0.75 mm long, 0.53 mm broad and 0.47 mm thick. Depending on the variety and the conditions under which the seed is produced, the size and the weight of the seed vary considerably. In *N. tabacum* the average weight of the seed is 0.08 to 0.09 mg and there are 11,000 - 12,000 seeds per gram. In *N. rustica*, the seed is larger and about three times heavier. The emerging seedlings are tiny and delicate and therefore, the seeds are unsuitable for sowing directly in the field. Hence, they are sown in nurseries initially and tended carefully till the seedlings attain a particular size before transplanting in the main field. For successful raising of nurseries, proper location, good preparation and manuring, adequate facilities for watering and timely controlling of pests and diseases are essential.

Site Selection:

Generally tobacco nurseries are grown on sandy or sandy loam soils. The cigarette-tobacco growing areas of Andhra Pradesh are an exception in that the crop is grown on a heavy black soil and the nurseries are generally raised on sandy to gravely loams. Raising of nurseries on heavy black soils is hazardous due to poor internal drainage due to clay content, heavy rainfall, high temperatures and pre-disposing the crop for disease like damping off.

Sterilisation / Rabbing:

The nursery site should have a good internal as well as surface drainage and should be situated at an elevated place. It is desirable to change the nursery site every year as it would minimise incidence of pests and diseases and also eliminate contamination by other varieties. If it is not possible to change the site, old site can be used after sterilizing by rabbing, i.e. by burning any of the slow burning waste materials like, tobacco stalks, paddy husk, sugarcane-trash, etc. For the best results this operation should be done at the right moisture content, after the final preparation of the seed bed and a few days before sowing.

Seed bed preparation:

Systematic layout of nursery on raised beds with intervening channels helps in quick drainage of rain water. The beds of 1.0 m to 1.22 m width facilitate hand weeding and watering with rose cans. The beds can be of any convenient length along the slope but generally not more than 10 m. Channels should be 50 cm wide and 10 cm deep. Mixing of sand at 100 to 200 tonnes/ha in the preparation of the beds, helps in improving the drainage in heavy soils.

Manures and fertilizers:

Application of FYM or filter press cake @ 25 tonnes/ha by mixing well in the top layers atleast 20 days before sowing is beneficial in obtaining more number of transplantable seedlings. Growing of a green manure crop like dhaincha or sunnhemp for 6 to 7 weeks and ploughing it is also practiced in places like Dinhata (West Bengal). Basal application of 50 g of ammonium sulphate, 50 g of potassium sulphate and 300 g of super phosphate and 100 g of dolomite per 10 sq.m. bed is recommended. After germination of seed, top dressing of ammonium sulphate @ 25 g/10 sq.m. twice at 4 days interval and thereafter @ 50 g/10 sq.m. thrice at 4 days interval and potassium sulphate @ 25 g/10 sq.m. twice is recommended. After each pulling top dressing with ammonium sulphate @ 100 g/10 sq.m. is to be applied to boost the growth of remaining seedlings.

Seed rate:

Seed rate is actually dictated by climatic conditions and the optimum seed rate is 3-5 kg/ha (0.4 g/sq.m). A seed-rate of 3 kg/ha for *N. tabacum* and 6 kg/ha for *N. rustica* was found to be optimum under Dinhata (West Bengal) conditions.

Seed Treatment:

Seeds must be treated with dithane M-45 or Z-78 before sowing in the nursery agains t the seed borne dideases.

Time of Sowing:

Sowing time	State	Type of Tobacco
Aug-Sep	A.P.	Cigarete, Cheerot and Bidi
April- May	Karnataka	FCV and Natu
May-June	Gujarat	Bidi
June-July	U.P.	Cheewing
Aug-sep	Bihar	Hookah and Chewing
Dec.	UP	Chewing

The sowing time of FCV tobacco of Karnataka is March-April and FCV and other tobacco types in different areas are 1st to 2nd fortnight of August. The first ten days of nursery period is most critical and if the afternoons are hot, missing even one watering inhibit germination of seed. Almost all the sowings are done when the day temperatures are high. Provision of covers and mulches over seed beds is found beneficial as they help in conserving moisture during germination and la ter protect the tender seedlings from scorching sunlight and beating rains.

In order to prevent desiccation of seedlings due to intense heat and beating rains, under Dinhata (West Bengal) conditions, bamboo mats or jute-stick covers are placed directly on the beds. In Pusa (North Bihar), the seed beds are covered with grass *thaties* or dry grass. At Hunsur, paddy-straw cover gave adequate protection to seed beds. Covering nursery beds with coir mat pandal gave 21.9% increase in transplantable seedlings over geotextile or paddy straw and also saved two waterings per day.

Covers are gradually thinned or removed when seedlings appear on the surface, otherwise they become etiolated and lanky for want of sunlight. It is also advantageous to transplant 3 to 4 weeks old seedlings on another bed i.e., resetting, to ensure sturdy growth of seedlings by the time of planting. A week to ten days before planting, seedlings are hardened by withholding water. Such seedlings withstand the shock of transplanting better than normal seedlings.

Seedlings of pencil thickness and of 10 to 15 cm length are normally preferred. Shorter seedlings may establish well under optimum conditions in heavy soils. In light soils longer seedlings are preferred for planting. Normally, the seedlings are ready for planting by the end of 7th week and in the first picking 30 to 40% of the total seedlings are available. The seed bed is top-dressed after each pulling to make the remaining seedlings grow to transplantable size.

When planting is delayed due to unfavourable field conditions, the overgrown seedlings in beds are clipped without damaging the growing point in order to retard the growth.

Transplanting In The Mainfield

The optimum time for planting is primarily determined by the weather conditions prevailing during certain stages of the crop.

In Andhra Pradesh, the normal period of planting is from mid-October till mid-November. Earlyr plantings are damaged by heavy rains and late plantings suffer from deficiency of soil moisture.

In Tamil Nadu, plantings are done after sufficient rains augment the water supply in the wells. Planting of cigar or chewing tobacco up to 1st week of November is better than later plantings. In Karnataka, time of planting ranges from April to May-June depending on the rainfall.

In the northern parts of the country, planting is mostly governed by the time when cool weather prevails as well as duration of winter. In West Bengal, Jati tobacco is planted earlier than Motihari, both after the rains, as the former is of a longer duration. In Punjab and parts of U.P. the planting is done in February-March as a summer crop.

For bidi-tobacco, last week of August to first week of September is the optimum planting time in the Charotar area of Gujarat and the middle of August in the Nipani area of Karnataka.

Method of planting

Dry Planting:

Planting of 8 to 9 week old seedlings done by pot watering at the intersections of marking in Andhra Pradesh and Nipani tract. Planting of bidi-tobacco in Charotar area of Gujarat and hookah-tobacco in Bihar is generally arranged on a cloudy day.

Wet Planting: Followed in Tamilnadu. The field is irrigated prior to planting and seedlings are planted in the saturated soil.

Spacing:

Soil properties and tobacco type influence the selection of spacing between plant in the field. Generally, spacing is wider in soils of low fertility than in soils of high fertility. Broad-leaf type varieties are spaced wider than narrow-leaf types. Due to different spacings adopted for various tobacco types grown in India, the plant densities vary from 12,345 to 37,037 plants/ha. Wide-spacing allows the maximum expansion and thickness of the leaf; narrow-spacing tends to produce small and thin leaves, generally lacking in body.

Spacings recommended for various tobacco's in India
FCV
NLS & KLS- 100cm X60cm
SLS & TBS- 70 cmX50cm
Bidi Tobacco- 90cm X 60cm to 100cm X75 cm
Natu Tobacco- Irrigated- 90cm X90 cm
Rainfed- 60cm X60 cm
Burley Tobacco- 80cm X40 cm
Lanka Tobacco- 60cm X60 cm

Lecture No: 30

Manures And Fertilizers

Application of organic manures is essential for maintenance of soil health. Organic manures improve the soil health, increase yields by 10-15% and also enhance the flavour and taste of tobacco. The requirement of organic manures in addition to inorganic fertilizers has been worked out for each type of tobacco by Central Tobacco Research Institute, its Research Stations and AINRP(T) Centres and recommended to the farmers.

Nutrient content and Removal:

Nutrient	Leaf (%)	stalk (%)
N content-	2.0 -5.0	2.5-4.0
P content	0.5-0.7	0.5-0.9
K content	2.5-7.0	2.5-5.0

Ingeneral a normal tobacco crop removes 225 kg N, 17 kg P_2O_5 , 365 kg K_2O, 135 kg CaO and 17 kg MgO from 1 Ha.

Fertiliser doses for different types of Tobacco's and soils

For FCV Tobacco :

NLS - 115-60-120 kg N, P_2O_5 and K_2O / ha.
SLS - 60-60-60 kg N, P_2O_5 and K_2O / ha.
KLS - 50-40-80 kg N, P_2O_5 and K_2O / ha.
TBS - 45-0-0 kg N, P_2O_5 and K_2O / ha.

Bidi Tobacco : 160-0-0 kg N, P_2O_5 and K_2O / ha.
125-60-40 kg N, P_2O_5 and K_2O / ha.
Burley : 125- 5-50 kg N, P_2O_5 and K_2O / ha.
Irrigated natu : 300-50-100 kg N, P_2O_5 and K_2O / ha.
Rainfed natu : 60-50-50 kg N, P_2O_5 and K_2O / ha.
Lanka : 300-50-50 kg N, P_2O_5 and K_2O / ha.
Cigar : 100-50-100 kg N, P_2O_5 and K_2O / ha.
Chewing : 120-50-75 kg N, P_2O_5 and K_2O / ha.
Hookah : 112-50-75 kg N, P_2O_5 and K_2O / ha.

METHOD OF APPLICATION:

Depending on the type of tobacco and soil type, the dose, time and method of application of fertilisers are recommended for better fertiliser use efficiency. In heavy soils like vertisols and red clay loams, fertilisers are applied before planting in plant row plough furrow (PRPF) method. In this method, furrows are opened with a plough in the planting row and fertilisers are applied in the furrow and land is levelled with a plank. Later the planting is done on the same line which helps in better utilization of fertilisers. In light soils(sands to loamy sands), fertilisers are applied in two or three splits by dollop method or double band placement. Fertilisers like ammonium sulphate, diammonium phosphate, urea, calcium ammonium nitrate as sources of nitrogen, super phosphate and diammonium phosphate as sources of phosphorus and potassium sulphate as source of potassium are used for tobacco. As the chloride ion affects burning fertilizers like muriate of potash are not applied to smoking types.

Interculture and weed Management

Intercultivation is done with a three-tyned hoe two or three times at fortnightly intervals by working the hoe in cross directions. The first cultivation usually commences about 10 to 15 days after planting by which time the plants are well established. In vertisols, the final cultivation is done deep with country plough to prevent cracking of the soil. For each interculture, the soil around the plants is loosened with a hand-weeding tool. These operations help in eradication of weeds, mulching the surface soil and promoting rooting at deeper layers by driving out the moisture at the top. In the case of irrigated crop, soil in the furrow which has the tendency to form a hard crust is broken by harrow and ridges are reformed to increase the height with each progressive irrigation.

These regular intercultural operations will keep the field weed free and conserve the moisture. Orabanche is found to be attached with the roots. For managing them, coleection and destroying as soon as they are seen in the field. Deep summer ploughing buries seeds in deeper layers. Preplanting application of EPTC @ 6.0 kg/ha is recommended. Growing trap crops like Jowar, Gingelly, Sesame, Blackgram etc. should be gropwn in Kharif, which will reduce the seed bank.

Lecture No:31

Irrigation

Tobacco cannot tolerate with water logging under any circumstance. FCV tobacco grown in Blackcotton soils rarely requires irrigation. However, grown in light soils requires regular irrigations. Irrigation through all furrow system is a general practice, but it consumes more water and requires more labour; and leaching losses of nitrogen and potassium are also more. The alternate skip furrow method of irrigation is more economical and checks the wastage of irrigation water, electricity and time. It improves the leaf quality and gives 10-20% higher yield than all furrow irrigation.

Irrigation schedule for Northern light soils FCV Tobacco

At the time of planting in plough furrow	15 mm
1st irrigation 15-20th day after planting by surface irrigation, if needed	24 mm
2nd irrigation 30-35th day after planting as surface irrigation	24 mm
3rd irrigation 40-45th day after planting all furrow irrigation immediately after ridge formation	48 mm
4th irrigation 50-55th day after planting all furrow irrigation	48 mm
5th irrigation 65-70th day after planting by alternate skip furrow method	24 mm
6th irrigation 80-85th day after planting by alternate skip furrow method	24 mm
7th irrigation 95-100th day after planting by alternate skip furrow method	24 mm
8th irrigation 115-120th day after planting by alternate skip furrow method	24 mm

In alternate skip furrow method, in the subsequent irrigations, first irrigated furrows are avoided and the unirrigated furrows are irrigated. The same order is followed in consecutive irrigations.

Critical stages:

Critical stages for irrigation is knee height to bloom. Schdulling at 50 % DASM is ideal for Tobacco. Quality of water for irrigation to tobacco in respect of chlorine content is paramount important. Limit of is up to 30 ppm and should not exceed 50ppm.

Crop rotation

Monocropping of tobacco is always discouraged as it leads to development of pest and disease complex in addition to decreasing soil fertility. Crop rotation not only gives additional returns to farmers but also improves soil fertility and maintains soil health. Suitable crop rotations have been worked out for different types of tobacco without jeopardising the tobacco quality (Table 6). One year rotation, two year rotation, long term cropping sequences, mixed cropping wherever feasible and cropping systems suitable to the region were developed.

Table - 6: Cropping sequences recommended for different types of tobacco

Type of tobacco	Crop rotation recommended
1. FCV tobacco:	
a) Northern Black Soils	Kharif Blackgram or Dry paddy followed by Rabi tobacco.
b) Central Black Soils	Kharif gingelly followed by Rabi tobacco, sorghum alone once in 4 years
c) Southern Black Soils	Kharif gingelly or groundnut followed by Rabi tobacco.
d) Northern Light Soils	Groundnut- redgram (1st year), Gingelly-tobacco (2nd year)
e) Southern Light Soils	Gingelly or groundnut in Kharif and tobacco in Rabi
f) Karnataka Light Soils	Ragi or Gingelly in Rabi followed by FCV Tobacco in Kharif
2. Irrigated Natu tobacco	Redgram or sunnhemp green manuring followed by tobacco in Rabi
3. Rainfed Natu tobacco	Kharif gingelly followed by tobacco in Rabi
4. Lanka tobacco	Tobacco - Maize - Paddy - Tobacco - Maize
5. Cigar and Cheroot tobacco	Pearl millet-Ragi-Tobacco
6. Bidi tobacco	Tobacco - Bajra (1st year) followed by Hybrid cotton - tobacco (2nd year).
7. Chewing tobacco	Cropping sequences, Maize-tobacco-greengram, Sesame-tobacco-sunflower/onion, Maize-tobacco-sesame and Intercropping of Chewing Tobacco+potato, Tobacco+ papaya, Tobacco + sugarcane, Tobacco + garlic and Tobacco + rajmash in Bihar; Onion as intercrop and Ragi-chewing tobacco rotation in Tamil Nadu.
8. Hookah tobacco	Cropping sequences, Aus paddy - Aman paddy – Motihari tobacco, Jute-Aman paddy- Motihari tobacco and intercropping of Tobacco+potato, Tobacco+garlic or onion
9. HDBRG	Blackgram or gingelly followed by tobacco.

Topping & sucker control

Toping is the process of removal of flower head alone or with few top leaves. Removal of the flower bud (topping) arrests the apical dominance and buds in the top 3 to 4 axils grow rapidly to replace the plants reproductive capabilities. The primary buds get stimulated initially and removal of these primary buds, in turn, stimulates secondary buds. Topping is associated with improvement of root system, leaf thickness and leaf weight. Topping increases the nicotine and nitrogen contents of the leaf.

Topping and removal of subsequent suckers form a composite operation. If suckers are not removed there is no use of topping. The management aspects of topping and desuckering are specific to tobacco types.

Sucker control can be done either manually or by applying chemicals. Application of neem oil emulsion 15-20% in the top 5-6 axils controls the suckers considerably.

Harvesting

Priming:

Harvesting two to three well-matured and ripe leaves is is termed as Priming as followed in FCV tobacco. Ripe leaves have greenish-yellow colour, with a velvety feel, losing much of the stickiness. They have a tendency to lie horizontally or bend slightly down the plant and the leaf-tips are slightly dry. As a general rule, leaves are harvested from bottom lower leaves on slightly greener side, middle leaves when they are ripe and top leaves when they are fully ripe. Harvesting must be done on a clear weather day and on an average, not more than three leaves are harvested at a time. Immediately after rains or irrigation, harvest is to be delayed by 2 - 3 days.

Stalk cut method:

Cigar, cheerot, chewing and hookah types are harvested by stalk cut method. In this method plants are cut close to ground with the sickle and generally left in the field over night for wilting.

Bidi Tobacco:

Harvesting of bidi tobacco normally commences in the months of January-February in Gujarat and December-January in Karnataka and Maharashtra. Harvesting of bidi tobacco is done at an advanced stage of maturity. The maturity is judged by pronounced development of brown spots called 'spangles'.

i) Whole plant harvest: The mature plants are cut at the base, inverted and left in the field for about three days. The drying is considered to be complete when the lamina close to the lower half of the midrib becomes brittle.

ii) Leaf-wise harvest: Mature leaves exhibiting full spangle development are plucked and left in the field with the upper surface facing the ground for drying. Dried leaves are collected in a tarpaulin and the lamina (*bhuka*) are stripped off from the midribs. After about 4 days, pieces of lamina and veins adhering to midribs are separated and kept in a separate heap. Midribs are exposed to the sun further for about a fortnight for drying.

iii) *Gugro* method: This method is practiced in seasons of deficient rainfall when leaves do not mature well and there is drying of leaf along with midrib. Green lamina of the mature leaf of the standing crop is stripped from the midrib by passing the thumb and the index finger from the base to the top of the midrib.

In Karnataka and Maharashtra, harvesting of bidi tobacco is done by stalk cut method. Whole plants are cut and kept inverted in the field for 6-7 days for sun curing and the lamina is separated out from the main stem after drying. Midribs are further dried to remove the remaining portion of the lamina. This is *Angad* tobacco sold in the market.

CURING:

Curing is essentially a drying process whereby most of the moisture in the green leaf is removed. However, this process of drying is conducted in such a way as to produce certain well-defined and desirable qualities in different types of tobacco. A bad leaf produced on field cannot be

improved by curing; but a good leaf can be spoiled by bad and defective curing. The process of curing has an intimate bearing on the quality of the final produce. During the progress of curing, some important biochemical changes take place. The curing operations followed in India are dependent on several factors, such as tradition, convenience, market value of the crop, consideration of economic production, etc. Depending on the type of tobacco, four principal methods of curing can be distinguished, namely, i) flue-curing, ii) air-curing, iii) fire-curing and iv) sun-curing.

Quality Characters:

The concept of quality in flue-cured tobacco has attained a new dimension in the present day context because of higher mobility in international market, ever-growing sophistication among smokers taste and increasing automation in cigarette industry. While overall monetary return is a good enough criterion of quality to a farmer, visible quality like colour, is very important for marketing purposes; but to an industrialist, those manufacturing qualities which maximise profit are most desirable features provided tobacco possesses satisfactory smoking quality which in turn depends upon chemical composition of the leaf material. Flue-cured tobacco quality thus is made up of many complex components, viz. physical, chemical, organoleptic and also economic attributes. Smoking quality plus manufacturing capacity equals the suitability of tobacco. So the quality characters of FCV tobacco are divided into visual characters, manufacturing characters and chemical characters.

The visual characters are colour, body, texture, maturity/ ripeness, graininess, hygroscopicity, shatterability, blemish, elasticity, fluffiness, aroma, leaf size, vein colour etc. These characters are subjective based on which the tobacco leaf is graded and purchased by the trader. Objective quality criteria have been developed for manufacturing characters and chemical characters. The manufacturing characters are filling value, equilibrium moisture content, pore volume, elasticity, shatterability, combustibility, lamina-midrib ratio (strip yield), number of leaves per kg, lamina weight per unit area etc. Though, tobacco leaf contains hundreds of chemical constituents, only few have a dominating influence on quality. Nitrogenous and carbohydrate fractions are the two groups of chemical constituents having profound effect on the smoking quality. Chloride in leaf is also very important as it influences the combustibility and keeping quality of leaf.

Physical Properties:

Tobacco buyers evaluate tobacco by its visual characteristics. Such a system of subjective quality evaluation varies with personal fancies and hence cannot be considered as precise. The necessity of objective laboratory tests to evaluate physical qualities has become essential.

Filling value

Filling value is the volume occupied by unit weight of cut tobacco at predetermined moisture level under a specific stress. Filling value may be taken to be a measure of the relative number of cigarettes of a given firmness that could be manufactured from a unit weight of tobacco.

Shatterability

Another important economic factor in tobacco quality is its resistance to breakage during handling. Tobacco is a fragile material that tends to shatter to a greater or lesser degree with handling. Breakage becomes accentuated under the stress of mechanical processes in the factory. Tobaccos do differ in their relative brittleness due to various factors. Strength in tobacco leaf is dependent on calcium pectate, the cementing material in the cell wall.

Strip yield

Strip yield in flue-cured tobacco is important to manufacturers since it is the lamina portion of leaf that is normally used in cigarette making. Because of the low utility of midrib, a large bulk of exportable flue-cured leaf is despatched only in the form of strips. This makes strip yield an important criterion in developing varieties, as higher the strip yield, greater is the economic return. Strips constitute, on an average, about 75% of leaf by weight, ranging from 70-80%. Within this range, higher the strip yield, better is the usability of tobacco.

Elasticity

Elasticity is the ability of the leaf, when moist, to undergo stretching without breaking. Such tobaccos after being compressed, as practiced during cutting in the manufacture of cigarettes, will spring back immediately.

Texture or porosity

Leaf structure or texture is an important physical property of flue-cured tobacco. Texture and grain are synonymous for cigarette tobacco. Graininess in flue cured tobacco is a measure of porosity of leaf which regulates its capacity to absorb and retain additives in the intercellular air chamber.

Hygroscopicity

Hygroscopic properties of cured leaf as judged by equilibrium moisture content is an important technological criterion for judging quality. It is the moisture absorbing capacity of leaf which depends on the relative humidity of the surrounding environment. Cured leaf low in hygroscopicity is very difficult to get to `order' or `condition', with the result the leaf handling is difficult. High hygroscopicity on the other hand, entails operational difficulty in the cutting and making machines.

Combustibility

Combustibility or burning quality of tobacco involves several criteria like fire holding capacity, rate of burn, evenness or completeness of burn and character of residual ash. Leaf burn is very commonly used to determine the burning quality of cured leaf.

Chemical Characters:

Total nitrogen

It is generally considered that flavour and taste of smoke is correlated with nitrogenous constituents. Flue-cured tobacco containing 1.6 to 2.3% total nitrogen gives the most satisfying smoke. Higher nitrogen content of tobacco would result in, apart from curing difficulty, deep brown coloured trashy leaf which shatters readily and it has flat-insipid tasting smoke. Generally high level of nitrogen is associated with high level of nicotine. Lower nitrogen content would result in `washed out', pale coloured leaf, lacking in rich colour characteristic of good tobacco.

Nicotine

Nicotine content of tobacco is an important constituent because of its stimulatory effect on the smoker. In FCV tobacco, a nicotine level of 1.7 to 2.0% is desirable and nornicotine should not exceed 5% of total alkaloids. Higher proportion of nornicotine leads to abnormal and objectionable smoke due to pyrolysis of nornicotine into myosmine.

Nitrogen / nicotine ratio

The ratio of nitrogen to nicotine is assumed to give some chemical balance within the leaf. Tobacco with higher ratio is less desirable because it tends to be light bodied. A ratio of about 1.35 results in pale colour, slick texture, poor physical characters and deficiency in aroma. In fact, a value exceeding 1.0 has been ascribed as unbalanced. Low value (below 0.5) is considered undesirable because the tobacco is heavy bodied and associated with high nicotine content and low level of reducing sugars. Ratio in the range of 0.6 - 0.7 is adjudged as most desirable in medium to light bodied matured tobacco.

Reducing sugars

Higher content of reducing sugars in flue cured tobacco is undesirable as it imparts an acidic character to the smoke. Lower content imparts alkalinity to smoke due to high nitrogenous constituents. During smoking, sugars yield CO_2 and water as pyrolysis products, thus helping to neutralise free base and increase moisture content in smoke and serving as an emollient.

Reducing sugars / nicotine ratio

The ratio of sugar to nicotine would give a balance of opposing effects and thus serve as an index of smoking quality. Higher ratio indicates mildness and smoothness while a very low ratio reflects the harsh and irritating smoke. If cured leaf is low in nicotine and sugars, as generally is the case with Indian flue-cured tobaccos, the ratio appears to be acceptable. Higher sugar content consistent with nicotine level is the most desirable feature for smoking quality in flue-cured tobacco and the desirable ratio is 7-13.

Carbohydrate / protein ratio

The ratio of carbohydrates to proteins is known as Shmuk number and the ratio of carbohydrates to total nitrogen is known as Kovalenko coefficient. These ratios also give similar indications as in the case of reducing sugar to nicotine.

Chlorides

Higher level of chloride in leaf inhibits leaf burn or combustibility. The chloride content of leaf must be preferably less than 1.5% but should never exceed 2%. Chloride content is positively correlated with deterioration of colour. High chloride content in leaf leads to dull muddy orange colour with sour or linoleum smell. Further, such leaf due to its moisture holding capacity bruises easily and tends to develop `off-colour'. These characteristics render this type of leaf to be of low value for cigarette manufacture. Chlorine acts as a negative combustion catalyst in tobacco.

Potassium

Potassium content in the cured leaf improves the burning quality of tobacco. An adequate level of potassium in cured leaf tends to off-set the deleterious effect of chloride on burning quality.

Potassium acts as a mineral catalyst and oxygen carrier in promoting leaf burn. Cured leaf with low potassium content is trashy and dull which may not have any commercial value.

Acceptable limits for the important quality constituents and quality indices in flue-cured tobacco.

Constituent/Quality Index	Acceptable Limits
Total Nitrogen (%)	1.0 - 3.0
Nicotine (%)	0.7 - 3.0
Total Sugars (%)	10.0 - 26.0
Reducing Sugars (%)	8.0 - 24.0
pH	4.6 - 5.5
Reducing Sugars/ Total N	7 - 13
Reducing Sugars/Nicotine	7 - 13
Total N/ Nicotine	< 1.2
Chloride (%)	< 1.5
Filling value at 60% R.H. and 20 ^{0}C	3.3 - 3.8cc/g of shreds
Equilibrium moisture content at 60% R.H. and 20 ^{0}C	11 - 15%
Pore Volume	0.13 - 0.18 ml/g
Combustibility	2.5 - 3.5 mm/min
Leaf burn	3 - 6 sec.
Shatterability Index	> 3

Note: The individual chemical constituents alone should not be taken into consideration for quality evaluation. The ratios of the constituents are also very important and should be taken into consideration for quality appraisal of tobacco.

In the case of non-FCV tobaccos, all the visual characters mentioned in the case of FCV tobacco are also important. Nicotine content is considered to be an important chemical constituent determining quality. Nicotine contents of different tobaccos produced in India are presented below.

Tobacco Type	Nicotine (%)
Virginia tobacco	1.2 - 3.6
Bidi tobacco (Anand)	9.7
HDBRG (Guntur)	3.9
Natu tobacco (Black soils)	2.8
Natu tobacco (Light soils)	3.5
Burley tobacco	1.3
Chewing tobacco (Tamil Nadu)	2.9
Cigar tobacco (Tamil Nadu)	1.2
Chewing tobacco(Bihar)	3.7

Cigar filler (West Bengal)	2.0
Cigar wrapper (West Bengal)	1.4
Jati-Chama (West Bengal)	3.7
Jati-Podali (West Bengal)	4.0
Motihari-Hemti (West Bengal)	4.8
Motihari-Bitri (West Bengal)	6.6

METHODS OF CURING

Air curing

The matured leaves are primed and kept around the plant. The primed leaves are tied in to bunches of 8 to 10 leaves and cured on bamboo splinters in curing sheds for 4 to 6 weeks. Various indigenous tobaccos are subjected to air-curing. Most prominent among them are; wrapper tobacco of West Bengal, lanka tobacco and Burley tobacco grown in Andhra Pradesh. The process is rather slow and takes 6-8 weeks. Generally air-cured tobacco is dark brown in colour with lower levels of sugars and rich in nitrogenous constituents.

Pit Curing

Bundles of shade-cured leaves are pit cured in the pits of 8 feet diameter and 3 feet depth by keeping them in circular layers up to half of the pit and then covered by palmyrah leaves and soil to make it air tight. After 24 hours, the leaf is transferred to another pit of the same dimensions, filled and covered in the same way as the first one and kept for 48 hours. Later, the leaf is transferred to the 1st pit in the same way and kept for 24 hours. This transferring process is done at nights to avoid loss of moisture. Eg. Lanka Tobacco in A.P. and Hookah Tobacco in Punjab.

Sun-curing

In India, a number of tobaccos are Sun-cured. In this method construction of costly structures are avoided. The process is relatively quick (2-3 weeks) and there is little interference from weather changes. After initial wilting in the field , Leaves are stung to bamboo poles and sun cured for 15 to 20 days. There are many modifications of Sun-curing.

a. Curing whole plant on racks: Cigar and chewing tobaccos of Tamil Nadu.
b. Curing leaves together with pieces of stalk on racks: Natu tobacco in Andhra Pradesh.
c. Curing whole plant on the ground: Bidi tobacco of Gujarat, Hookah and chewing tobacco in Bihar.
d. Curing primed leaves on the ground: Chewing tobacco in Uttar Pradesh and Hookah tobacco in West Bengal.

Fire -curing: (Smoke curing)

Important type of tobacco that is fire-cured is Jaffna tobacco of Ceylon and Tamil Nadu used for chewing purpose. The leaf is harvested by either priming or stalk-cutting each leaf together with a portion of the stem.

The leaves are wilted for four hours in the field, tied into bundles and hung of laths in smoke huts. They are then smoked for 12 hours by burning coconut husks, leaf stalks and palmyrah nuts, stacked for 3 days and again smoked. Alteration of firing and stacking at an interval of few days helps in making the colour of leaf uniform. During the smoke treatment, creosotic substances are deposited on leaf surface imparting a peculiar taste. After smoking, the leaves are bulked for 3-4 weeks and treated with salt water/jaggery prior to sale.

Flue-curing of Virginia Tobacco

Harvesting

Harvesting of two or three well-matured and ripe leaves is termed as **priming** which is essential for production of quality tobacco. Ripe leaves have greenish-yellow colour, with a velvety feel, losing much of the stickiness. They have a tendency to lie horizontally or bend slightly down the plant and the leaf-tips are slightly dry. As a general rule, leaves are harvested from bottom lower leaves on slightly greener side, middle leaves when they are ripe and top leaves when they are fully ripe. Harvesting must be done on a clear weather day and on an average, not more than three leaves are harvested at a time. Immediately after rains or irrigation, harvest is to be delayed by 2 - 3 days. Under normal conditions, harvests are carried out at weekly intervals. Leaves should be plucked against the direction of the sun for better judgment of the colour of matured leaf. While picking, midribs should not be bent down, but they have to be bent side-ways. A well-matured leaf will snap crisply with a characteristic sound. The leaves are to be carried carefully without pressing to one end of the field and placed carefully in a wide basket with tips upward. The basket has to be taken to the tying shed as early as possible to minimize wilting in the field.

Green-leaf grading:

In spite of utmost care, there is a chance that immature and over mature leaves are harvested. The over ripe (yellowish white) and under-ripe (dark green) leaves have to be sorted out and tied separately so that each stick contains leaves of uniform colour.

Tying the leaves:

The leaves are to be tied to sticks by handling gently in a shaded place avoiding wilting and bruising. A bruised leaf (physically damaged) does not cure well in the barn. About three leaves are tied in a bunch, back-to-back, with a jute twine loop on a stick. About 90-100 such leaves are tied in separate bunches with a series of loops on a stick approximately 130 cm long. The leaves are distributed uniformly all over the length of the stick to avoid over crowding.

Loading the barn

For a satisfactory curing, the whole barn should be loaded with the freshly harvested leaves from a single priming. The un-ripe leaves (green) are placed on the top tiers, the over-ripe leaves (yellowish-white) leaves on the bottom tier and well-matured leaves (greenish-yellow) in the bulk of the intermediate tiers. The sticks are placed on the tiers at a distance of 20-25 cm so that the leaves from the adjacent sticks slightly touch each other without pressing. A 5m x 5m x 5m barn is usually loaded with 750 sticks with the above spacing. The barn should not be over loaded while curing the bottom and middle leaves since slow rate of drying affects leaf quality. Top leaves may be crowded slightly by closer spacing without affecting grade outturn.

Curing practice

Curing virginia tobacco according to fixed schedule is not possible always because of the variability in green leaf due to various factors like weather condition, plant position, leaf maturity, disease prevalence and in such cases, slight adjustments are necessary.

Curing principle

In the early stages of flue-curing biological activity continues in the leaf involving destruction of chlorophyll, conversion of starch to simple sugars and leaf proteins to soluble nitrogenous constituents. These cellular reactions take place in fully turgid leaf cells in aqueous medium and for completion of enzymatic reactions, thermal deactivation of these enzymes must be prevented. High humidity and low temperature in the barn are favourable for these reactions during this period leaf turns yellow with higher levels of soluble sugars. Now, further breaking up of sugars by respiratory enzymes has to be prevented to ensure optimum concentration of sugars in the cured leaf. Browning reaction caused by enzymes like polyphenol oxidase which turns the yellow colour of the leaf to brown has to be avoided. Similarly bio-chemical conversion of soluble nitrogen to ammonia has to be arrested since some of these soluble nitrogenous constituents transform into aroma-bearing constituents at a later stage. These are achieved by thermal desiccation at the subsequent stage of curing by progressively raising the temperature of the barn and lowering relative humidity by adjusting ventilators. However, since all these biological reactions are a sort of continuous process, changing the temperature and humidity of the barn must necessarily be slow and progressive; abrupt change in temperature and humidity should never be made in the barn while curing is in progress. Details of the improved curing method are given below:

1. <u>Yellowing:</u>

Temperature: Dry bulb: 85-105°F,
Wet bulb: 82-94°F.

Time: 36-48 hours.

Furnace is charged after loading the leaf and temperature is raised by 5 to 6°F above outside temperature. Top ventilator is left very slightly open, especially during the cooler hours of the night, bottom ventilators are left open with slight gaps so that upward movement of air continues in the barn.

Temperature is raised by not more than 1 to 2°F per hour up to 105°F when the leaf becomes yellow and is ready for fixing. Top and bottom ventilators are gradually opened to 3" .

2. <u>Fixing colour</u>

Temperature: Dry bulb: 105-120°F
Wet bulb: 94-98°F
Time: 5-10 hours
Progressive total time: 39-47 hours.

Utmost care is required in raising the temperature during this stage. It is raised by not more than 1 to 2°F per hour. Bottom ventilators are opened to 3" to 5" at the base. Top ventilator is raised to a height of 3" to 5" from the roof. It is not necessary to raise the top ventilator completely.

3. <u>Leaf drying</u>

Temperature: Dry bulb: 120 to 145°F
Wet bulb: 98 to 110°F
Time: 36-48 hours

After attaining 130 °F, the top ventilators are gradually closed and subsequently the bottom ventilators are closed. At 140°F all the ventilators are closed.

4. Midrib drying

Temperature: Dry bulb: 145 to 160°F
Wet bulb: 110 to 114°F
Time: 24-36 hours
Progressive total time: 88 to 101 hours.

Temperature is raised and maintained at a maximum of 160°F until the stem is dry. The ventilators which have been closed during the later part of the leaf-drying stage continue in the closed position.

Unloading the barn:

After the curing is over, the fire is put off. The barn is allowed to cool down keeping the ventilators closed. The leaf has to attain proper condition for handling. For this, all doors and ventilators are kept wide open at night so that leaf will absorbs moisture from the atmosphere and becomes pliable. In dry weather, wet gunny bags are put on the flue pipe with very slow fire in the furnace to build up humidity inside the barn for few hours just enough for leaf handling. The sticks are removed from the barn and kept in the racks. The leaf is untied from the sticks when there is proper condition preferably in early morning hours and bulked.

Bulking the cured leaf:

Bulk must be made for efficient grading. If space is not a constraint, leaves of different varieties and stalk positions must be bulked separately. However, when space is limited, leaves may be bulked together with adequate identification marks for each priming (paper markers may be placed in between two primings). The bulk must be about one meter high on a raised platform. The bulk should never be on the floor or near any material, likely to give offensive odour, like insecticides, fungicides or fertilisers. When leaf is being bulked, a close watch should be kept on moisture condition. Bulking too dry makes the leaf shattery and over-conditioned leaf, may loose colour and become moldy. The correct condition can be judged by handling a bunch of cured leaves and pressing them tight in the fist of the palm and if after release of pressure, the leaves spring back, if it is over-conditioned. If it breaks while squeezing, it is under-conditioned. The bulks have to be covered with polythene sheets (or some other suitable covering e.g., tarpaulin) and sufficient weight is to be applied to compact the bulk without damage to prevent gain or loss of moisture. Bulks are to be examined from time to time and turned for approximately 2-3 times prior to grading depending on the moisture content.

Grading:

Grading is the sorting of cured leaves basing on plant position, colour, blemish, damage, texture, leaf length and ripeness. It is also governed by the tobacco type and market requirements. In black soils farm grading (Table 7) and in light soils plant position grading is practiced.

Grading is one of the important production practices in flue-cured Virginia tobacco production. Proper grading at farmer's level helps the growers to realise more income for his produce. It obviates the need for grading at traders level thus reducing the marketing cost and saving time.

Table 7: Grade specifications for the 10 farm grades for black soil tobacco

S. No.	Grade	Color	Body	Texture	Blemish not to exceed	Corres-ponding Agmark grade
1	Farm-I	Bright lemon or orange	Thin to Medium	Soft	25%	1 to 4
2	Farm-II	Light Brownish yellow or Brownish lemon	Medium	Good	25% (White to yellow blemish allowed)	LBY 1
3	Farm-III	Light Brown	Good to Medium	Medium	50%	LBY 2
4	Farm-IV	Brown	Heavy Body	Medium to Coarse	50%(brown blemish allowed)	Brown
5	Farm-V	Dark Brown	Heavy Body	Medium to Coarse	50%	Dark Brown
6	Farm-VI	Light Greenish orange	Good	Soft to Medium	10%	LG
7	Farm-VII	Light Medium green	Heavy	Medium to Coarse	25%	LMG
8	Farm-VIII	Medium Green	Heavy	Medium to Coarse	35%	MG
9	Farm-IX	Dark Green	Coarse	Coarse		DG
10	Farm-X	Orange, yellow green and / or brown	Variable	-	-	Pl & Bits