



ANGRAU
ACHARYA N G RANGA AGRICULTURAL
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Lecture outlines

Theory

1	Importance of Oil seed crops, Ground Nut -Area, Production, Productivity in A.P and India, Economic importance, Climate requirements. Soils, Sowing time, Sowing method, Spacing, Seed rate, Land preparation, Important Varieties- Characters, Seed treatment, Adaptability to different seasons, Breaking dormancy.
2	GroundNut-Nutrient management(INM), Weed management, Water management, Cropping systems, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield, standards for exporting, Reasons for low production and productivity.
3	Sunflower- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements, Soils, Sowing time, Sowing method, Spacing, Land preparation, Important Varieties-Characters, Seed rate, Seed treatment, Nutrient management
4	Weed management, Hand pollination, Methods to be adopted for proper seed filling, Bird damage- Management, Water management, Cropping systems, Intercropping, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield.
5	Castor- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements. Soils, Land preparation, Important Varieties-Characters, Sowing time, Sowing method, Spacing, Seed rate and Seed treatment, Nutrient management (INM), Weed management, Water management, Cropping systems, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield.
6	Sesame- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements, Soils, Land preparation, Important Varieties- characters, Sowing time, Sowing method, Spacing, Seed rate and Seed treatment, Nutrient management (INM), Weed management, Water management, Cropping systems, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield.
7	Safflower- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements, Soils, Land preparation, Important Varieties- characters, Sowing time, Sowing method, Spacing, Seed rate and Seed treatment. Nutrient management (INM), Weed management, Water management, Cropping systems, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield.
8	Commercial crops Cotton- Area, Production, Productivity in A.P and India, Economic importance, Classification of Cotton.
9	Cotton growing zones in A.P, Climate requirements, Soils, Land preparation, Important Varieties-Characters, Sowing time, Sowing method, Spacing, Seed rate and Seed treatment, Nutrient management (INM), Weed management, Water management.
10	Micronutrient deficiencies- Management, Flowering, Bud and Boll shedding-Management, Precautions to be taken while harvesting.
11	Bt Cotton-Management of Gram caterpillar, Adopted cultivation practices in Bt cotton, Advantages of Bt Technology, Constraints in production of Bt Cotton.
12	Sugarcane- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements, Soils, Sowing time, Sowing Method, Land preparation, Sett preparation, Selection of seed, Sett treatment.
13	Types of seed materials, Bud chip method, Types of transplanting-Row transplanting, Space transplanting, Furrow transplanting, Time of transplanting, Method of transplanting, Gap filling, Varieties, Wrapping, Propping, Earthing up. Seed rate, Seed treatment,

14	Nutrient management, Weed management, Water management, Harvesting, Ratooning, Steps in jaggery making, cropping systems, Intercropping, Maturity symptoms, Harvesting, storage, Standards for export quality, crop logging, Classification of sugarcane and its characteristics.
15	Tobacco- Area, Production, Productivity in A.P and India, Economic importance, Climate requirements, Soils, Land preparation, Important Varieties- characters, Sowing time, Sowing method, Spacing, Seed rate and Seed treatment,
16	Nutrient management(INM), Weed management, Water management, Cropping systems, Maturity symptoms, Harvesting, Storage and Yield attributes-Yield.

Practical

1	Sowing of Oil seeds, fiber, crops
2	Calculation of seed rate and plant population in Oil seeds, fiber, sugar crops and tobacco
3	Raising of tobacco nursery.
4	Practice of different planting methods in sugarcane
5	Identification of weeds in Oil seeds, fiber, sugar crops and tobacco
6	Study of yield contributing characters of Oil seeds and fibers.
7	Study of yield contributing characters of sugar cane and tobacco
8	Yield and juice quality analysis in sugarcane,
9	Study of important agronomic experiments of Oil seeds, fiber, sugar crops and tobacco at experimental farms.
10	Study of maturity symptoms in oilseeds, fibers, sugarcane and tobacco
11	Visit to oil expeller unit.
12	Study of quality parameters in tobacco.
13	Visit to nearby farmers' fields.
14	Practicing of harvesting oilseeds
15	Post harvest processing and value addition of oilseeds
16	Shelling and calculation of shelling percentage in groundnut

Lecture-1

IMPORTANCE OF OILSEEDS

The crops that are cultivated for the production of oils are known as OILSEED CROPS. The Groundnut, Rapeseed and Mustard, Sesamum, Sunflower, Safflower, , Soybean, Niger, Linseed and Castor are the most important oil seed crops of India.

The oilseed crops are classified according to the nature of oil produced as edible oilseeds and non- edible oil seeds

1) **EDIBLE OILSEED CROPS:-**The oils are used for edible purpose are called as edible oils

E.g., Groundnut rapeseed & mustard, sesamum, niger, sunflower, safflower, soybean .

2) **NON-EDIBLE OIL SEED CROPS:-**The oils used for industrial purpose

E.g., Castor, Linseed.

Importance:

- 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 13% of the area and 7% of world oilseed production but the productivity in India is 935 Kg ha⁻¹.as against the world average productivity of 1632 Kg ha⁻¹..
- 2) In India oil seeds occupy nearly 13% of country's gross cropped area and contributes To 7% 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 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 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 vermifugal action & it is used in pest control 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.

India s Position in the world

First position in Caster, Safflower, Sasamme, second position in groundnut and mustard, Third position in linseed and fifth position in Soya bean, sunflower production

Botanical name : *Arachis hypogaea*
Family : Leguminosae
Common name : Groundnut, Peanut, Un predictable legume, Monkey nut, Earth nut,
Manila nut, Moong phali (Hindi).

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

Crop description

- *Arachis* species belongs to family *Leguminoceae* (*Fabaceae*) sub-family *Papilionoideae*
- Flowers borne on axils of leaves on branches
- Self-pollinated with some cross pollination (0-6%) by bees
- Elongated gynophores develop into pods
- Pods contain 2-5 seeds/kernel
- Kernel weight ranges from 0.15 to >1.3 g/kernel
- Virginia / runner types are spreading in nature and suitable for rainfed condition
- Valencia / Spanish type are erect in nature and more suitable for irrigated conditions
- Oil contents varies from 42 to 55 % of kernel/seeds

Origin Center of origin of G.nut is South America i.e., Matogrosso a place in Brazil. At the beginning of 16th century, groundnut was introduced into India.

Area and production

The production is largely confined to Asian and African countries. Asia accounts for about 50% of area and 60% of world production of groundnut with largest share of India and China (>40%) in coverage, with highest share of China (40%) in the total production of groundnut in the World. Five states namely Andhra Pradesh, Gujarat, Karnataka, Rajasthan and Tamil Nadu account for about 80% of the total groundnut area and production of the country. Gujarat alone contributes about 35% of the total production of groundnut.

Andhra Pradesh: In A.P Groundnut is cultivated in an area of 9.10 lakh ha during Kharif, 0.94 lakh ha during rabi with a production of 5.01 and 2.07 lakh tonnes during kharif and rabi respectively. Productivity of 555 and 2207 kg/ha during Kharif and rabi respectively. In A.P. Anantapur (6.04 lakh ha) is major groundnut growing district followed by Chittoor (1.29 lakh ha), Kurnool (1.10 lakh ha) and Kadapa 0.36 lakh ha).

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 B12 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% P₂O₅ & 1.3% K₂O.
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.

CLIMATE

Groundnut is predominantly a crop of the tropics. The approximate limits of present commercial production are between latitudes 40⁰N and 40⁰ S and up to an attitude of 1065 m, where rainfall during the growing season exceeds 500 mm.

TEMPERATURE

Soil temperature <18⁰C delays emergence of seedlings. The embryo is killed above 54⁰C. G.nut performs well in dry temperature range b/n 24⁰C & 33⁰C but it can survive up to 45⁰C. Ideal temperature for reproductive stage is b/n 24 - 27⁰C. Rate of pod growth will be maximum between 30⁰C & 34⁰C.

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 rainfall.

- 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.

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 PH range of 5 – 5.5.
- It is moderately sensitive to soil salinity & highly susceptible to waterlogging.

Groundnut is a most sensitive crop to moisture stress. Distribution of rainfall plays a greater role than the quantum of rains received during the crop season. Longer dry spell at the time of peg formation/penetration and grain filling is most injurious to both the yield and quality of groundnut. Therefore, protective irrigation at the time of peg formation/penetration and grain filling has a significant role in yield improvement.

Seasons

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

Rabi - G.nut cropping during *rabi* is limited to areas where winter is not severe & temp. do not grow below 15°C. 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

Region	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	15 Dec to 15 Jan.

VARIETIES

Condition	Suitable Varieties	Duration (Days)	
		<i>Kharif</i>	<i>Rabi</i>
a) For Scarce Rainfall areas	Kadiri-9, Kadiri Harithandhra, Anantha, Greeshma, Narayani, Abhaya, Dharani, ICGV-91114, Kadiri Amaravathi and Kadiri Chitravathi	105- 110	110-120
b) For excess rainfall conditions	Kadiri-7Bold, Kadiri-8 Bold	125 – 130	125-140
	Abhaya, Kadiri-9 and Kadiri Amaravathi	105 – 110	115-120
c) For assured rainfall areas with supplementary irrigations	Kadiri-7 Bold, Kadiri-8Bold	125 – 130	125-140
	Kadiri-6 Kadiri-9, Kadiri Harithandra, Greeshma Abhaya, Narayani, Rohini, ICGV-91114, Dharan, Kadiri Anantha and Kadiri Amaravathi	105 – 110	115-120
d) Varieties having tolerance to leaf spot	Kadiri-9, Kadiri Harithandra, Greeshma, Kadiri Anantha, Abhaya, Dharani and Kadiri Amaravathi	105 – 110	115-120
e) Nematode infected Areas	Kalahasti , Prasuna, Kadiri-9	105-110	115-120
f) For delayed Monsoons	Greeshma, TAG 24	90-100	100-110
	Kadiri-9, Kadiri Anantha and Kadiri Amaravathi	115-120	
g) Varieties having drought tolerance	Kadiri-9, Anantha, Greeshma, Abhaya, ICGV-91114, Dharani and Kadiri Amaravathi	105 – 110	115-120
h) For rice fallow conditions	Kadiri-6, Greeshma, Kadiri Harithandra, TAG-24, Kadiri-9	95-100	100-115
i) Coastal sands	Kadiri-6, Greeshma, TAG-24, Narayani & Dharani, Kadiri Chitravathi	105 – 110	115-120

SEED RATE AND SPACING

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

Season	Seed rate (kg/ha)		Spacing	
	Bunch type	Semi-spreading & spreading	Bunch type	Semi spreading & spreading
Kharif (rainfed)	120	100	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

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.

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 should be treated with imidacloprid 600 FS @ 1 ml / kg seed (To control sucking pests) followed by Thiram @ 3g/kg or Bavistin (2g/kg) , tebuconazole 2 DS @ 1 g or mancozeb @ 3 g / kg seed (to control seed born diseases).
- If the seed is dormant, soak it in 0.05 % ethrel solution for 12 hours followed by shade drying or spray 1.25 ml Ethephon in 5 litres of water and spray on 100 kg seed 12 hrs before sowing in air tight bag.
- *Trichoderma viride* seed treatment @ 4 g/kg seed for seed rot prone areas .

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. When both seed treatment & inoculation are essential, seeds may be treated with fungicides & rhizobium culture is sprayed into seed rows & covered with soil. Rhizobium strains for kharif - NC – 92 Tal -1000 & THA -205, Rabi – IGR – 6 , Summer – IGR – 40. Granulated Rhizobium strain can also be sown with seed in the furrows

METHOD AND DEPTH OF SOWING

Groundnut seed can sown either by using mechanical or tractor drawn seed planters or bullock drawn seed drill or by dropping the seed in ploughing 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-3

NUTRIENT MANAGEMENT

For every tonne of pods & 2t of haulms about 63 N, 11 P₂O₅, 46 K₂O, 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** and **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 (20 N) & 30 DAS (10 N)-**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. phosphorus is applied when the available phosphorus is < 35 kg/ha

Optimum doses : Rainfed – 40 kg P₂O₅ /ha , irrigated – 50 kg P₂O₅/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 groundnut 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 K₂O/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 calcium oxide or gypsum and 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 2 weeks after application then a second lighter application of gypsum is necessary around 3 weeks after first application.

K: Ca: Mg ratio

G. nut is sensitive to imbalanced nutrient supply. The K:Ca:Mg 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 50 kg/ha Zinc Sulphate once in 2 years corrects the deficiency. Wherever Zinc deficiency is observed, spray zinc sulphate 2 g/l two times with one week interval 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 & Tamilnadu. 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. Wherever Iron deficiency is noticed on crop, spray 5 g/l ferrous sulphate along with 1 g citric acid two times with one week interval.

In Andhra Pradesh

Kharif -20 -40 – 50 kg N, P₂O₅, K₂O/ha

Rabi & summer Irrigated -- 30 – 40 – 50 Kg N, P₂O₅, K₂O /ha.

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 argentea*, *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

- Spray pendimethalin 30% @ 2.5 to 3.75 l/ha or alachlor 50% @ 3.75 to 5.0 l/ha immediately or with in three days after sowing.
- For control of grassy weeds, spray fenoxaprop ethyl 9% @ 625 ml/ha or quizalofop ethyl 5% @ 1.0 l/ha or propaquizafop ethyl 10% @ 625 ml/ha as post emergence spray at 15-20 days after sowing.
- For control of grasses and broad leaf weeds, post emergence spray of imazethapyr 10% @ 625 ml /ha at 15-20 days after sowing.
- Pre-plant incorporation of Fluchloralin @ 1.25 – 1.5 kg/ha
- Pre-emergence application of Pendimethalin @0.6-1.5 kg/ha or Alachlor @ 1.5-2.0 kg/ha.

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.

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 /m³ (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 between 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 OF IRRIGATION

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.

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 varieties)
- 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 aflatoxins. 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.

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 Andhra Pradesh., are:-

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

INTERCROPPING

Imp. Cereal crops grown with g. nut are pearl millet, 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	G.Nut + Cowpea	6:1
G.Nut + Castor	5:1, 7:1	G.Nut + Pearlmillet	3:1.

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.

LECTURE-4

SUNFLOWER

Scientific Name : *Helianthus annuus*

Family : Asteraceae

ORIGIN : Southern USA (Peru) & Mexico

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

- The oil content varies from 48- 53% and it is premium oil with pale yellow in colour used for cooking and margarine.
- Sunflower is a rich source of linoleic 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.
- Sunflower oil has high oxidative stability and it is more useful as frying oil.

- Sunflower oil is used as industrial feed stock for manufacturing cosmetics, soaps and pharmaceuticals.
- Oil contains high level of alpha tocopherol, a form of vit. E.
- Oil cake contains 40-50% high quality protein and it is ideally suited for poultry and livestock.
- The roasted kernels are used as food for human beings.
- Sunflower is grown as green manure, fodder crop.
- The bast fibre of the stem is source for making rough quality paper.
- 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.

AREA AND DISTRIBUTION

- Sunflower is grown over an area of more than 25 million ha in about 70 countries with a world average yield of 1637 kg/ha.
- Russia, Ukraine, Romania, China, Kazakhstan, Spain, Bulgaria, France, India, Turkey, South Africa, USA and Myanmar are the major sunflower growing countries.
- Russia and Ukraine have the largest share of about 50% in total sunflower production in the world.

India

Area :0.57 m ha. Karnataka >Maharastra>Andhra Pradesh>Odissa

Production:0.42 M t Karnataka > Andhra Pradesh> Maharastra

Productivity : 728 kg/ha .Haryana>Punjab>West Bengal

Karnataka ranks first with respect to area (3.67 lakh ha) and production (3.08 lakh t).

Andhra Pradesh

Sunflower growing districts: Kadapa>Kurnool> Prakasam>Anantapur

V. S. Pustovit of USSR is responsible for increasing oil content of sunflower from 30% to 50% by breeding methods. Sunflower was introduced to India during 1965 as an edible oilseed crop.

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° c but it can germinate even up to 40°c.
- Night temperature of 18-20° and day temp. of 24-26°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°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 rainfall of 500-700mm upto an altitude of 2500 MSL. Latitudinal effect was more significant. Generally it is grown between 40° S to 55° N
- latitudes but most of the production is concentrated between 20°S to 50°N latitude.
- Sunflower grown in Northern USA/Canada has higher linoleic acid (poly unsaturated) due to low temperature. On contrary, sunflower grown in southern USA had high percentage of oleic acid due to higher temperature.

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 imbibe 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 (rain fed): First FN of step. - First FN 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.

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 withstand waterlogging. Good drainage is preferable for cultivation of crop. Yield and quality is drastically reduced when soil salinity reaches

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.

Seed rate

Rainfed (kg ha⁻¹)

Irrigated (kg ha⁻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 is 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 P₂O₅ and 72 kg K₂O, 9.4 kg Sulphur and 37 kg Ca. It depletes 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, P₂O₅ and K₂O / ha
½ N as basal and ½ N at 30 DAS

Irrigated crop - 80: 60: 40 kg N, P₂O₅ and K₂O / ha

Hybrids respond up to 120 kg N ha⁻¹

1/3rd N, 1 P₂O₅ & 1 K₂O 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 ZnSO₄ @ 1% is beneficial. Borax @ 0.2 % to Capitulum at ray floweret opening improves the seed filling and oil content.

LECTURE-5

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 weeding 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.

POOR SEED SETTING AND MANAGEMENT IN SUNFLOWER

Sunflower is a highly cross pollinated crop. Seed setting and filling problem is one of the most important constraints in sunflower production and often considered to be a major reason for low productivity. Besides poor agronomic management, there are several genetic, physiological and environmental factors causing poor seed setting and filling in sunflower.

S.No	Reason for poor seed setting	Management
1	Low autogamy and self-incompatibility are two major genetic reasons for poor seed setting and filling in sunflower.	Breeding plants for the characters directly associated with seed setting and filling, producing the self-fertile lines and growing hybrids can improve the yield in sunflower.
2	Poor vascularization in the capitulum, high photorespiration wastage, uneven distribution of photoassimilate and source limitation are the major physiological causes for poor seed setting and filling in sunflower.	1.Reducing the source-sink or sink-sink competition by physiological manipulation such as reduction in thalamus weight, increasing post anthesis dry matter accumulation and clipping of old leaves would help in better seed set and filling in sunflower. 2. Directed application of Tri-iodobenzoic acid 240PPM (TIBA) to head has resulted in increased filling and test weight by way of increased translocation of photosynthates to sink hence, use of growth regulator like TIBA would be beneficial.
3	Very less plant population per unit area produced large sized flower head, which remained unnourished due to source limitation and ultimately caused poor seed setting particular in the centre of the flower head.	Maintaining optimum plant stands recommended for the region is desirable
4	Nutrient deficiencies especially Boron	Following only recommended fertilizer schedule for the region is beneficial. Sunflower responds profitably to the use of secondary and micronutrient boron. Boron application at ray

		floret opening stage improved seed set and filling percentage. Hence, application of boron at this stage is suggested.
5	Moisture stress at bud formation, flowering and milking stages drastically reduced the growth and yield.	Therefore, avoiding moisture stress at these stages would be helpful in improving seed yield of sunflower.
6	Environmental factors greatly influence the seed setting and filling in sunflower by way of not only affecting crop itself but pollinators also and thus pollination.	Providing supplemental pollination, either by hand pollination or through increasing pollinators (bees) activity has increased the seed set and filling percent in sunflower. Keeping of bee hives in sunflower growing areas increases honey bee population.
7	Continuous rains and cloudy weather or very high temperature affects seed set and yield.	1. Therefore, optimum seeding period should be decided in such a way that the flowering should not coincide with extremes of temperature, heavy rainfall, fog and cloudy weather. 2. <i>Rabi</i> /summer season recorded higher seed set percent than <i>kharif</i> season in inbreds, hybrids and populations. Hence, <i>rabi</i> /summer season is more suitable for sunflower than <i>kharif</i> for higher productivity.

Irrigation management

- Sunflower is highly responsive to irrigation. The total water requirement of sunflower is 500- 600 mm.
- 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.
- Under moisture stress conditions, centre portion of head is not filled properly and reduce the yield significantly.
- 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)
- The total number irrigations depend up on seasons i.e. 3- 6 for *kharif* and 4-8 for *Rabi*.
- Irrigation should be stopped at 20 days before harvesting.
- Sunflower is an excellent indicator plant for identifying the moisture stress.
- Irrigation should be given at 50% DASM at all growth stages except at critical stage where irrigation is given at 30 DASM.
- Irrigation at IW/ CPE of .5-1.0 is ideal.
- On an average **WUE is 50 -60 kg seed ha⁻¹ cm⁻¹**.
- The crop is irrigated by ridge and furrow method.

Harvesting

- 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.
- The heads are ripe when back of the head turns yellowish brown and lower leaves become brown to dark brown.
- 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.
- 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 stearic 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 digestible and has high biological value.

LECTURE-6

CASTOR

Scientific Name: *Ricinus communis*

Family : Euphorbiaceae

Known as **Erand** in Hindi “**Amudam**” in Telugu plays an important role in country's Vegetable oil economy.

Uses

- 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 32⁰C and viscouys at high temperature.
- Used in textile soap s, cosmetics, nylon, pharmaceuticals, paints, varnishes, dying, carbon and papermaking.

- Used for production of wetting agents, detergents, sebacic acid, secondary octyl alcohol, 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.

Area and Production

	World	India	Andhra Pradesh
Area	1.5m ha	1.1 mha	0.97 lakh ha
Production	2.0 mt	0.9 mt	0.6 lakh tons
Productivity	1346 kg/ha	1666 kg/ha	593 kg/ha

- Globally, India ranks first both in area and production.
- Productivity of castor is highest in Gujarat (1987 kg/ha).

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 20⁰- 26⁰ C with low humidity throughout growing season to give high yields.
- Low temperature extends emergence, making more liable to attack by fungal diseases & insects. High temperature 41⁰ 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.

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

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 tap root system extending beyond 2-3 meters for extraction of soil moisture from deep layers, deep ploughing (<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.

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

Spacing

Region	Cultivar	Spacing (cm)
All castor areas	Varieties (rainfed)	60X60
	Hybrids	90X60, 120X60
Andhra Pradesh and Gujarat	Hybrids	90X60, 120X60
Delayed sowing (for want of rains)		60X30

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.

NIPPING

Nipping is removal of all auxillary buds as and when they emerge. This technique is preferred in intensive cultivation of seed plots and also when castor is grown as an off season crop. The primary raceme first appears in the form of a bud and develops in about 10 to 15 days. Nipping facilitates synchronous flowering and capsule development and therefore , helps in easy harvest besides reducing maturity period in the intensive cropping systems under irrigation.

Nutrient Management

Crop yielding 2000 kg seed removes around 80 kg N, 18 P₂O₅, 32 kg K₂O, 12 kg Ca, 10 kg Mg/ha. 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 P₂O₅ / ha is adequate
Improved cultivars responds upto 75 kg P₂O₅ / ha

Potassium -Tropical soils are well supplied with available K

- But application of N & P may result in increased potassium uptake
- Under rainfed : 60N+40 P₂O₅+30K₂O Kg/ha and Irrigated conditions : 80N to 100N +40 P₂O₅+30K₂O kg/ha is recommended.
- 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 bed 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. Pre-emergence application of Pendimethalin @ 1.0 kg a.i. ha⁻¹ or alachlor @ 1.25 kg a.i. ha⁻¹ (5.0 ml ltr⁻¹) with in 2-3 DAS in the presence of soil moisture + post emergence application of Quizalofop-p-ethyl @ 50 g a.i. ha⁻¹ (1.5-2.0 ml ltr⁻¹) + two times intercultivation (IC)+one hand weeding is the best IWM module to be adopted for weed management in castor.

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 usually 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 7⁰ C 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 contains 85-90% ricinolic acid which imparts high degree of viscosity and oxidative stability, four times stable than olive oil.
- Castor cake contains 6% nitrogen, 2.5% P₂ O₅, 1.5% K₂O, as it contains toxic constituents, unfit for edible purpose, except to poultry, cannot be fed to any animals. Castor seed contains an alkaloid called “ricinine” which is extremely poisonous.

Cropping systems

Castor crop is usually cultivated either as a sole crop, or inter crop with cereals and grain legumes and in some cases with commercial crops such as chillies, turmeric etc as border crop.

Intercropping combinations recommended/practiced	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

Sequence cropping under irrigated conditions:

Sorghum –Castor, Pearl millet – castor, Castor- Redgram, Castor- Groundnut

LECTURE- 7

SESAME

Scientific Name: *Sesamum indicum*

Family: Pedaliaceae

AREA PRODUCTION & PRODUCTIVITY

	World	India	Andhra Pradesh
Area (M.ha)	8.80	1.79	0.06
Production(M.t)	2.80	0.60	0.02
Productivity(Kg ha ⁻¹)	535	413	321

DISTRIBUTION

- Major sesame producing countries are India, Myanmar, Nigeria and China
- In India, major sesame cultivating states are Uttar Pradesh , Rajasthan, Madhya Pradesh, West Bengal and Gujarat,
- India stands first in both area and production.

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° S and 25° 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 C. Extremely low temperatures of 10 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 withstanding 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.

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.

SEEDS AND SEEDING

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 harrowed.

Line sowing (or) Row seeding is done with seed drills to promote higher yields.

Optimum depth of sowing is 2-3 cm.

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. :Gowri, 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.

MANURES \$ FERTILIZERS

N-P-K REQUIREMENT (kg/ha)

	Rainfed	Irrigated	Time of application
N	40	60	½ basal +½ (30-35 DAS)
P	60	60	
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 weeding, 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.

1st irrigation - at sowing

2nd irrigation - 3 WAS

3rd irrigation - 6 WAS

4th irrigation - 8 WAS

5th 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.

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 + Pigeon pea (2:1), Sesame + Soybean (2:1), Sesame + Cowpea (8:1), Sesame + Groundnut (1:1).

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- 8

SAFFLOWER

Botanical name - *Carthamus tinctorius*

Family - Compositae

Safflower is an ancient oilseed crop grown in India for the orange red dye (Carthamin) extracted from its 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* is supposed to have originated either from

Carthamus lanatus - Saffron thistle

Carthamus oxycantha- Wild Safflower

Safflower was known to ancient India and the poet laureate Kalidasa compared safflower to the “sakhis of Shakuntala” as kusum (or) kusumba in Sanskrit literature. *Carthamus* is derived from the Arabic word “Quartum”. Spiny type of Safflower has higher oil content than non spiny type. Yellow coloured flowers yield higher oil content. It is a xerophytic in nature.

ORIGIN

Decondolle – Arabia.

Vavilov – India

AREA AND DISTRIBUTION

Kazakhstan, India, Mexico, Argentina and Australia are the major growing countries. China mostly grows Safflower for medical purposes. 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 Madhya Pradesh. In A.P. it is cultivated with an area of 0.04 L.ha and production of 0.04 L.tons with a productivity of 875 kg/ha. India is the largest producer of Safflower with 54% area and 40% production.

	Area	Production	Productivity
India	1.44 L. ha	0.89L.t	533 kg/ha
A.P.	0.04 L. ha	0.04 L.t	875 kg/ha

Maharashtra and Karnataka are the first and second with reference to area and production whereas productivity is highest in Andhra Pradesh (1000 kg/ha) followed by Karnataka (2008-09). In A.P., it is cultivated in Kurnool and Anantapur AICRP on safflower- Sholapur (Maharashtra).

CLIMATE

Safflower is well adapted to wide range of climatic condition. However, the maximum production is confined up to 1000 MSL in semi arid tropic s 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 temperature s 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.

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 - 65kgN, 30 kgP₂O₅ and 40 – 45 kg K₂O 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 P₂O₅ /ha, 1/2 as Basal application. Response is 7-7.5 kg seed per kg P₂O₅ applied.
- 20-30 kg K₂O /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 minimize 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 t

he length of the rosette stage.

- PPI of Fluchoralin @ 1 kg ai /ha.or PE of Oxadiazon @ 1 kg ai /ha. Or PE of Alachlor @ 1.5kg ai /ha.or 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.

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.

CROPPING SYSTEMS

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

Intercropping

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

LECTURE: 9

COTTON

Scientific Name: *Gossypium sp*

Family: Malvaceae

Economic importance

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% P₂O₅ and 2.2% K₂O. Cotton seed and pulp obtained during oil extraction and cotton meal are good concentrated feed for cattle.

Parameter	Old world cotton	New World cotton
Species	<i>Gossypium arboreum</i> , <i>G. herbaceum</i>	<i>G. hirsutum</i> and <i>G. barbadense</i>
Chromosomal No	Diploid (2n=26)	Tetraploid ((2n = 52)
Native	Old world	New world
Centre of origin	India	Peru

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°C and 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 PH 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, Parts of A.P, Tamil Nadu, Assam, and Kerala.

Land Preparation

The black soils of central and south India are prepared for sowing of rainfed cotton by ploughing 15-20cm deep with mould board plough. The land is given deep ploughing only once in 4 – 5 years for controlling perennial weeds. There after two to four harrowing depending upon the soil type are done. After each ploughing, planning 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.

Varieties/ Bt Cotton

Desi cotton Varieties (*G.arboreum.L.*) : Aravinda, Srinandi (NDLA-2463), Yaganti (NDLA-2933).

Americian cotton Varieties (*G. hirsutum L.*) : Kanchana (LPS 141), LK-861, L-389, L 603, L 604, Narasimha (NA-1325), Sivanandi (NDLH-1755), NDLH 1938, MCU 5 VT, LRA-5166 and LRK-516.

Intra-specific cotton Hybrids : LAHH-1, LAHH-4, LAHH-5, Lam Cotton Hybrid-7, NDLHH-390, NDLHH-240 and Orugallu Krishna (WGHH-2), NHH-44, JKHy 1, Savitha, H-6, H-8 and H-10.

Inter-specific cotton Hybrids : Suvin & Jayalakshmi (DCH-32)

Bt cotton

Officially identified private *Bt.* cotton hybrids being cultivated and found suitable for the last 3-4 years. *Bt.* Cotton was released in 2002-03 for commercial cultivation in India. Since the release of *Bt.* Cotton technology, it has emerged as an effective alternative to

traditional cotton varieties by inhibiting bollworm attack, thereby improving yield and income. This has resulted in fast adoption of Bt cotton over conventional cotton. Cotton production in India has accelerated more than 4 times and reached a peak of 359.02 lakh bales during 2013-14 as compared to 86.24 lakh bales in 2002-03. Introduction of Bt cotton has played a catalytic role in enhancing cotton production in India.

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

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 (Irrigated)

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 and for Hybrids - 1

Seed treatment

1.Acid Delinting of Cotton Seed

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 H₂SO₄ 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.

Mix 400 g commercial grade concentrated sulphuric acid with 4 kg cotton seed for American cotton and mix 300 g commercial grade of sulphuric acid with 3 kg seed of desi cotton in either / plastic container by stirring it vigorously for two to three minutes with a thick wooden or glass rod. As soon as the fuzz gets dissolved, add 10 litres of water, stir well and drain out water through the perforated plastic basket. Repeat these washings three times to make the seed free from sulphuric acid residue. Dip the washed seed for about one minute in sodium bicarbonate solution (50g sodium bicarbonate in 10 litres of water) to neutralize the acid residue on the cotton – seed. Give one more washing with water and remove light, damaged and rotten inviable seeds floating on the surface. Dry the healthy fuzz free seed in the shade by spreading in a thin layer. Treat the dry seed with recommended fungicides.

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. Seed treatment with appropriate insecticide(s); imidacloprid 70 WS @ 5.0 g or thiamethoxam 70 WS @ 4.0 g or imidacloprid 48 FS @ 9.0 ml or carbosulfan 25 DS @ 40.0 g/kg of seed followed by treatment with *Pseudomonas fluorescens* @ 10.0 g or *Trichoderma viridae* or *T. harzianum* @ 10 g/kg or carbendazim 50 WP @ 2.0 g/kg or mancozeb 75 WP @ 3 g/kg or captan 50 WP @ 3 g/kg or thiram 75 WP @ 3 g/kg of seed

Nutrient management

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

Type of cotton	N/ha	P ₂ O ₅ /ha	K ₂ O/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 P₂O₅ 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 from 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.

Type of cotton	N/ha	P ₂ O ₅ /ha	K ₂ O/ha
Rainfed : Desi cotton	40	20	20
Rainfed American varieties	60	30	30
Rainfed Hybrid	90	45	45
Irrigated: American varieties	120	60	60
Irrigated: American Hybrids	150	75	75
Rice fallow cotton Variety	135	45	45
Rice fallow Hybrid	150	60	60

Bt. Cotton Hybrids

25% excess N over recommended N should be applied. The recommended N and K should be given in 3-4 splits at 20 days interval starting from 20 DAS. Foliar application of 2% Urea (20 g/l) or 2% DAP (20 g/l) or 2% KNO₃ (20 g/l) at flowering and boll development stages.

For correcting magnesium, boron and zinc deficiencies, foliar application should be given twice MgSO₄ @ 1% (10 g/l) each at 45 and 75 DAS, Boron @ 0.15% (1.5 g/l) each at 60 and 90 DAS and ZnSO₄ @ 0.2% (2 g/l) at 4-5 days interval. For correcting iron deficiency due to heavy moisture stress in early crop growth stage, foliar application of FeSO₄ @ 5 g/l along with citric acid should be done twice at weekly interval.

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. Water logging condition and prolonged drought spells leading to soil moisture stress. Adequate drainage provision is a must, especially for vertisols during periods of continuous rains (September).

Generally cotton crop requires 2-4 irrigations depending upon the soil type. Square formation, flowering and boll development stages are critical for moisture stress. Water deficits from onset of flowering to peak flowering may cause a more negative effect on the yield as compared to that occurring after peak flowering. For moisture conservation and effective weed control furrows for every row or alternate rows should be opened during the last inter cultivation operation.

For adequate stand establishment and root development, presowing irrigation is essential when stored soil water from rainfall is inadequate. Irrigation may be scheduled at

60% DASM during vegetative period. During flowering , irrigation at 75% DASM during vegetative period. Scheduling irrigation at 60% DASM during boll filling and maturation is essential for high yield and quality fibre.

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 competition. During this period, the field should be free from 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 field weed free. For effective weed control, spray pendimethalin @ 3.75-5 l/ha immediately or within 48 hours of sowing. Inter cultivation with tined harrow followed by blade harrow upto 90 DAS. For control of the grasses and broad leaved weeds post emergence spray of quizalofop ethyl @ 1000 ml/ha and pyriithiobac sodium @ 625 ml /ha is recommended. Post-emergence directed spray of paraquat @ 5.0 ml/l of water or glyphosate 10 ml + 10 g of urea or ammonium sulphate/l of water is recommended for control of the weeds in the cotton crop whenever intercultivation or manual weeding is not possible due to unfavourable weather conditions.

Topping

Cotton is indeterminate plant, to check excessive vegetative growth topping is practiced Topping refers to the removal of the terminal bud. Level of topping or at what node topping is to be done will differ 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 at 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 aggravated 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. Unfavourable Weather conditions:

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

- 2) Imbalanced nutrient supply :Reddening of leaf has been attributed to magnesium deficiency , low nitrogen content of leaves, low available soil nitrogen and sudden fall in night temperature.
- 3) Moisture deficiency or excess , inadequate number of fertilised ovules , inadequate nutrient supply ,excessive heat or cold and damage from insects and diseases increases shedding.
- 4) 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 D AS & 15 days after 1st application resulted in retention of more bolls.

Foliar Spraying of Urea or Diammonium phosphate (2%) at peak flowering minimizes leaf reddening and helps in boll retention.

Cotton- Quality parameters

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 considered 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 laboratory 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 (Staple length)

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 various methods (at 65%RH &21°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 tedious , 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 fineness 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) It is expressed in terms of weight per unit length of fibre(10^{-6} g cm^{-1} or millitex).Weight /unit length – specified number of fibre are taken with known length and weight is recorded using a sensitive balance. Lesser the weight, superior is the quality and finer the lint hair.

2) By using instrument MICRONAIRE . In this cotton plugs are prepared by using known weight of cotton lint, i.e. 3-4 gm by pressing in a specially designed cylinder. A measure of air flow through a compressed specimen of fibre that relates to fibre fineness and or maturity. 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
Very fine	< 3.0
Fine	3.0 – 3.9
Average	4.0 – 4.9
Coarse	5.0 - 5.9
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 five groups.

GROUPS	GRADE
Very strong	< 95
Strong	86-95
Average	76-85
Fair	66-75
Weak	66 and below

5. Spinning count

Spinnability of the fibre depends on length and thickness 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	Varieties
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 classified into

Mature fibres	Yellowish white fibre
Half mature fibres	Bluish or bluish green
Immature fibres	Deep blue or purple

7. 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.

8.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.

9.Ginning percentage

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

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

10.Nepiness

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

11.Lint Index

It is the weight of lint from 100seeds

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

$$100 - G.P$$

12.Seed Index

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

13.Oil content

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

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 i.e 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.

Yield attributes

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

Yields

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

Mechanical Harvesting of Cotton

Cotton is completely machine-picked in Australia, Israel and U.S.A. Over 90 % of production is machine-picked in Greece, Mexico and Spain. Almost 75 % of total production is picked by machines in Brazil. In most of other countries including China, India and Pakistan cotton pickings are done manually. In India, cotton, whether it is rainfed or irrigated, is handpicked by human labourers. Manual picking is not only tedious hard work but also costlier than other agricultural operations. Manual picking of cotton requires around 465 labour-hours per hectare. Due to non-availability of labourers in time, cotton picking get delayed causing yield loss which may be up to 15 per cent and affecting the

overall quality of cotton lint. Defoliation is done one week before use of mechanical harvesting with cotton picker. Time of defoliation can be done based on boll maturity.

Presently, the scientists are gearing up to develop suitable plant type amenable to mechanical picking and Development / identification of a mechanical picker suitable for Indian conditions is given due consideration to coincide with the advent of such a plant type. The cost of operation for mechanical picking is high because of the large initial cost of the imported cotton picker. If a cotton picker could be designed & produced in India through combined efforts of R&D organizations, users & manufacturers, then the cost of the machine might be reduced. However, the higher trash content in cotton picked by spindle type cotton pickers and lack of pre and post cleaning equipment in Indian gins, prohibits the popularization of spindle type pickers in India. Before picking, defoliation has to be done, for which additional cost is involved. Another issue is the inherent huge size of the spindle type pickers which have huge horse power requirement and pose operational difficulties on Indian farms of small holdings.

LECTURE: 11-

B.T COTTON

Bt. Cotton was released in 2002-03 for commercial cultivation in India. Since the release of Bt. Cotton technology, it has emerged as an effective alternative to traditional cotton varieties by inhibiting bollworm attack, thereby improving yield and income. This has resulted in fast adoption of Bt cotton over conventional cotton. Cotton production in India has accelerated more than 4 times and reached a peak of 359.02 lakh bales during 2013-14 as compared to 86.24 lakh bales in 2002-03. Introduction of Bt cotton has played a catalytic role in enhancing cotton production in India.

Bt cotton is one of the first genetically modified (GM) crop technologies with wide distribution in developing countries. In India and China, in particular, the area under Bt cotton has increased sharply over the last couple of years, reaching 25 million acres in 2007. Most of the Bt cotton growers in these countries are small-scale farmers; several recent studies have shown that they benefit considerably from adopting the technology in terms of reductions in pesticide use and higher effective yields. Nonetheless, concerns persist about the development of benefits over time. Pest populations might eventually become resistant to Bt, especially when refuge strategies are not enforced, as is often the case in smallholder agriculture. Moreover, secondary pests not controlled by Bt might turn into primary pests. Both factors could potentially entail diminishing pesticide savings and yield advantages over time. In addition, given that most GM crops thus far have been commercialized by private sector multinationals, there are fears that monopolistic market structures might increasingly prevail. This could lead to excessive prices charged for Bt seeds, resulting in lower farm profits and restricted technology access, especially for resource-poor farmers. Accordingly, some developing countries' governments have started to intervene in GM seed pricing. In India, for instance, since 2006 state authorities have set official maximum retail prices for Bt cotton seeds, which are significantly lower than the prices previously charged by seed companies. The broader implications are not yet fully understood.

Bt cotton was first approved for field trials in the United States in 1993, and first approved for commercial use in the United States in 1995. Bt cotton was approved by the Chinese government in 1997. In 2002, a joint venture between Monsanto and Mahyco introduced Bt cotton to India.

In 2011, India grew the largest GM cotton crop at 10.6 million hectares. The U.S. GM cotton crop was 4.0 million hectares, the second largest area in the world, followed by China with 3.9 million hectares and Pakistan with 2.6 million hectares. By 2014, 96% of cotton grown in the United States was genetically modified and 95% of cotton grown in India was GM. India is the largest producer of cotton, and GM cotton, as of 2014.

Bt cotton has several advantages over non-Bt cotton. The important advantages of Bt cotton are briefly :

- Increases yield of cotton due to effective control of three types of bollworms, viz. American, Spotted and Pink bollworms.
- Insects belonging to Lepidoptera (Bollworms) are sensitive to a crystalline endotoxic protein produced by the Bt gene which in turn protects cotton from bollworms.
- Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).
- Reduction in predators which help in controlling the bollworms by feeding on larvae and eggs of bollworm.

The main selling points of Bt cotton are the reductions in pesticides to be sprayed on a crop and the ecological benefits which stem from that. China first planted Bt cotton in 1997 specifically in response to an outbreak of cotton bollworm, *Helicoverpa armigera*, that farmers were struggling to control with conventional pesticides. Similarly in India and the US, Bt cotton initially alleviated the issues with pests whilst increasing yields and delivering higher profits for farmers.

Studies showed that the lower levels of pesticide being sprayed on the cotton crops promoted biodiversity by allowing non-target species like ladybirds, lacewings and spiders to become more abundant. Likewise it was found that integrated pest management strategies (IPM) were becoming more effective due to the lower levels of pesticide encouraging the growth of natural enemy populations.

In India alone widespread adoption of Bt cotton led to 2.4-9 millions less cases of pesticide poisoning, with similar reduction also seen in other countries.

Constrains

In India, Bt cotton has been enveloped in controversies due to its supposed failure to reduce the need for pesticides and increase yield.

The link between the introduction of Bt cotton to India and a surge in farmer suicides has been refuted by other studies, with decreased farmer suicides since Bt cotton was introduced. Bt cotton accounts for 93% of cotton grown in India

LECTURE: 12

SUGARCANE

Scientific Name: *Saccharum officinarum*

Family: Graminae

- 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 and Production

Brazil is major sugarcane producing country with an area about 90.77 lakh ha and production of about 717.46 Million ton followed by India. Sugarcane productivity is highest in Colombia (101.32 t/ha) followed by Philippines (93.71 t/ha). Amongst 10 major producing country Colombia has the highest yield of sugarcane due to the richest biodiversities in the world and has access to multiple climates.

Uttar Pradesh is the highest sugarcane producing state having area about 22.77 Lakh ha with the production of 135.64 Million ton cane followed by Maharashtra. 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).

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).

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 2 to 3 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 & 30° C

Reduction in yield of sugarcane due to rise in temperature:

The sugarcane productivity and juice quality are profoundly influenced by weather conditions prevailing during the various crop-growth sub-periods. Sugar recovery is highest when the weather is dry with low humidity; bright sunshine hours, cooler nights with wide diurnal variations and very little rainfall during ripening period. These conditions favour high sugar accumulation. The climatic conditions like very high temperature or very low temperature deteriorate the juice quality and thus affecting the sugar quality.

Favourable climate like warm and humid climate favour the insect pests and diseases, which cause much damage to the quality and yield of its juice and finally sucrose contents.

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 - Sugarcane is sun loving plant. Higher sunshine hours, favours higher cane yield, sugar recovery

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

Varieties

- a. Early maturing** Co 6907, 85 A261, 84 A 125, Co 8014, 83 A 30, 87 A 298, 99 V 30, 86 V 96, 91 V 83, 2000 V 59, 2003 V 46, 93 A 145, 2001 A 63, 2003T 121, 2005T 16, 83 R 23 , 2003A 255, 2000T 121, 2005T 16 and 2006T 3.
- b. Mid-late maturing** Co T 8201, Co A 7602, Co 7805, 83 V 15, 86 A 146, 88 A 162, 96 A 3, 97 R 129, 2000 V 48, 2000 A 225, 98 A 163, 99 A 5, 2000A 225, and 2005 T 10.
- c. Late maturing** Co 8011, Co 7219, Co 7706, 87 A 380 and Co R 8001.
- d. Moisture stress** Co T 8201, Co 6907, 87 A 298, 97 A 85, Co 7219, Co A 7602 and 83 R 23, 98A 163 and 2000A 56.
- e. Swamp water logged conditions** 84 A 125, 87 A 298, 86 V 96, 97 V 118, Co 6907, Co T 8201, Co 7219, 85 A 261, 2000 V 59, 83 V 15, Co 7706, Co A 7602, 2003 V 46 and Co R 8001.
- f. Saline – Alkaline soils** Co T 8201, 97 A 85, 93 A 145, 99 V 30 and Co 7219.

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.

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. Buds on immature part of cane germinate well than on mature part of the cane. Tops are also inferior in sugar content. As such, top setts are taken from a crop ready for harvest for planting. For planting, setts should be free from pests and diseases.

Germination of a bud is controlled by apical dominance through auxins. When this dominance is removed by clipping of the top bud, the bud below it tends to germinate. Hence, instead of planting entire cane, it is cut into three budded setts and planted. If the entire cane is used as planting material, setts from bottom mature cane germinate very late compared to setts from top cane leading to uneven crop stand and crop maturity.

2.Short crop or nursery crop - short crop or nursery crop of sugarcane aged 6 to 7 months will provide immature seed setts on large scale. Where ever land is available, it is desirable to raise separate seed, short or nursery crop.

3) **Rayungans** - These are setts with shoots produced by cutting of the tops of standing canes. This method has the advantage that it accelerates the start of buds but by topping the cane, production of more buds is stopped.

4) **Seblang**__The seblang (siblong) or Tiller separation is also an ideal method. Although, tillers get a setback as a shock of separation, if a clump with its sett intact is transplanted the survival is better and growth quicker. Where humidity is high and labour is not scarce this method is appropriate.

5) Space transplanting [STP] - In this method an area of 10x5 m (50 beds of 1.0m²) is planted at least 30 days in advance of transplanting. A total of 600-800 single bud setts are planted in a bed. Thus, only 2 tons seed material is sufficient for one ha as against 6-7 tons of cane for planting one ha.. Single budded setts from top half of cane is planted vertically with a soil cover. Normal watering and other management aspects are followed. The sprouted seedlings are planted in the main field after 3-4 weeks (3-4 leaf stage). The seed multiplication ratio in this method is 1:40 as against 1:10 in conventional planting. 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 population exceeding 1.2 lak canes /ha

6. 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.

7. bud chip / single node seedling cultivation

In sugarcane, seed cost itself accounts for 20 % of the total cost of cultivation. Generally, 10.0 tonnes of seed cane is being utilized for getting optimum cane and sugar yields. Hence, to reduce seed cost, labour cost towards planting and increase the cane production per unit area, growing of sugarcane through single bud seedlings is found to be the new innovative technology and becoming popular among the farming community.

Advantages of growing bud chip / single bud seedlings

1. Bud chip / single bud seedlings can put forth more tillers at a time which will be more homogenous and gives higher number of millable canes with higher cane weight and sucrose content. The yield increase was up to 5 tonnes per acre over traditional method of sett planting in coastal areas.
2. Easy to adopt seed treatment with required pesticides because of less quantity of seed material.
3. Saving of one month period in main field similarly, water and critical inputs can be saved during that period.
4. After removal of budchip or single bud the remaining cane can be utilized for making jaggery or sugar.
5. More time will be available for preparation of main field after harvest of paddy which ensure deep ploughing and thorough land preparation
6. Cane crop comes to maturity early by one month.
7. Mechanization can be adopted in seedling transplanted crop which will reduce cost of cultivation and increase net monetary returns.
8. Ratoon crop yields can also be improved due to maintenance of optimum population and uniform tillering.

Raising Nursery

Selection of seed cane

- For growing sugarcane seedlings high yielding varieties suitable for that particular region are to be selected. It is always better to use 6-7 months aged healthy short crop as seed material.

Preparation of single nodes from the seed cane

- Bud chip cutting machine and node cutting machines are available for removing budchips or single nodes from the cane with little or no damage to bud.
- In traditional method of 3 bud sett planting 4-6 t/ac. of seed material is required. But in bud chip seedlings planting method, only 750-800 kg of seed cane is sufficient for raising seedlings required / acre.
- Trays of 98 CC pit size and 5 cm long bud chip / cane node will give good germination and healthy seedlings.

- Selection of healthy and undamaged budchips or single buds by grading method will not only improve germination percentage but also gives strong seedlings.
- Treating the bud chips / single nodes with 0.5 g carbendazim + 2.0 ml malathion or 1 ml of imidacloprid 600 FS per litre of water for 15 minutes to reduce the incidence of pine apple disease and scale insect.
- Protrays (Plastic trays) having 50 pits can be used for sowing of budchips. For sowing of single nodes trays with large size pits are to be used.
- To get 90-95% germination, use healthy bud chips or single buds by following grading method.
- Fill the pits (half) with coco peat or well decomposed FYM / vermi compost + sand mixed in equal proportion. Then put the treated budchips or single buds at 60-70° angle and eye should be towards upward direction. Then fill the trays completely with coco peat and press gently.
- Arrange trays in a shade net in such a way that each series contains 10 trays and cover and tie with black polythene sheet tightly so that heat will be produced and germination of buds will be initiated.
- After 3-4 days, with the start of germination, arrange trays side by side in shade net and watering should be done in alternate days with rose can or sprinklers. Within one week all the buds will germinate. At 3-4 weeks after sowing every seedling will put forth 3-4 leaves with profuse root growth.

LECTURE: 13

Preparation of main field and planting

- For planting one acre field, 7,500-8,000 budchip seedlings are required (150-175 plastic trays are sufficient). Growth and vigour of the seedlings also depends on type of rooting media used. Spray 19:19:19 @ 1 g/l or vermi wash 10 ml/l to improve the seedling growth.
- Seedlings raised from single bud setts are found to be more vigorous and stronger than budchip seedlings and giving relatively higher yield.
- Main field is to be thoroughly prepared by ploughing with 2 M.B. plough or rotavator and perfect leveling should be done.
- Furrows are to be formed at 60/120 cm spacing i.e. paired rows of 20 cm depth within the row and seedlings are to be planted at 45-60 cm distance. In the inter space between rows pulse crops like blackgram, greengram and groundnut can be grown which will improve soil fertility besides suppressing weed growth to certain extent. Drip system can be installed in the pairs to improve water use efficiency. While planting, seedlings are to be planted without disturbing root mass along with coco peat which holds moisture also.
- Seedlings can also be planted with tractor drawn seedling transplanter.
- Light irrigations are to be given at 3-4 days interval at initial stages for quick establishment of the seedlings.
- Early planting in January – February is essential for good establishment of seedlings and synchronous tillering.

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 North India, 20 cm in South India. It is also practiced in Eastern UP, and 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 rainfed agriculture.

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

8. Sibling 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 Rayungan 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 bags 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 stripping 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.

Ridge and furrow method is easy and mostly followed in areas subjected to water logging immediately after planting

Farm with Drip irrigation Facility- Paired row planting

Saline soils - Modified trench method

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.

LECTURE: 14

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) Srikakulam, 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

FYM @ @ 25 tonnes per hectare or press mud cake @ 12.5 tonnes per hectare in the last ploughing.. Green manuring with legumes. Use of biofertilizers like azatobactor (4 kg/acre) , azospirillum (4 kg/acre) saves nitrogen to an extent of 25%,Use of phospho bacteria (4 kg /acre) and VAM (5kg /acre) saves phosphorus to an extent of 20 to 25%.

Secondary nutrients like Sulphur @50-100 kg/ha and micronutrients like Zn So₄ @25 kg/ha, FeSo₄ 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.

Pre emergence

Spray Atrazine @ 5 kg/ha or metribuzine @ 1.5 kg/ha in 1125 litres of water on the third or fourth day after planting, depending on soil moisture.

Post emergence

Spray 2,4-D (4 ½ kg) + Gramoxone (2.5 lts) in 1125 litres /ha at 20 & 60 DAP between cane rows with hood to protect the crop or spray metribuzine @ 1.0 kg + 2,4-D Sodium salt @ 2.0 kg /ha at 25-30 DAP as blanket application. Initial ploughing, off barring, 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.

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 P₂O₅ + 60 K₂O 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 areas.

Earthing up

Is done to check excessive tillering to prevent crop lodging & destruction of weeds. Earthing up is done 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/

CROP LOGGING

It is a record of progress of the crop from germination until harvest (clements1980).It is made up of pertinent data: chemical,physical and observational that reflect the welfare of the crop as it develops, the strategies invoked as crisis appears and the final results,good or bad, recorded for posterity.The crop log is a dynamic approach to crop production , designed to maximize yields using not only historical but also current data.

Beginning, when the crop is about 3 months old, samples of certain leaf parts are taken every five weeks and analysed for various elements and materials.Each time, the new

data are plotted to provide the grower with the information needed to guide the crop towards a successful harvest, very much as a patient's chart in a hospital helps the doctor decide what to do next.

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.

Wrapping and 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.

LECTURE-15

TOBACCO

Scientific name : *Nicotiana tabacum*, *Nicotiana rustica*

Origin : China

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 Tobago, 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

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°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°C and the crop needs 30 to 32°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.

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 deltaic 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.

Varieties

S.No.	Tobacco type	Varieties released / identified
1	Flue-cured tobacco	Chatam, Delcrest, Kanakaprabha, Dhanadayi, CTRI Special, Jayasri, CTRI Spl. (MR), 16/103, FCV special, Godavari Spl., Swarna, Mc Nair 12, Jayasri (MR), Hema, Bhavya, Gauthami, CM 12 (KA), VT 1158, Kanchan, Thrupthi, Rathna, Kanthi, Hemadri, Siri, Sahyadri, FCH
2	Bidi tobacco	GT 4, NPN 190, Anand 119, Anand 2, Spoorthy (PL 5), GT 5, GT 7, GTH1, Bhavyasree, GT 9, NBD 43, MRGTH-1, ABT 10, Vedaganga 1, GABT-11, Nadyala Pogaku-1, NBD 209
3	Chewing tobacco	Chama, Podali, DP 401, GandakBahar, Sona, Vairam, Thangam, Bhagyalakshmi, Maragadham, Prabha, PT 76, Meenakshi Vaishali Special, Lichchavi, Manasi, Abirami, Kaviri, Meenakshi (CR), Sangami, Kamatchi, Abirami (CR),
4	Hookah and Chewing (<i>Rustica</i>) tobacco	DD 437, Sonar Motihari, GC 1, GT 6, GCT 2, GT 8, GCT 3, Dharla, Azad Kanchan
5	Oriental tobacco	Tungabhadra
6	<i>Motihari</i> tobacco (West Bengal)	Manasi, Torsa
7	Natu tobacco	Prabhat, Vishwanath, Natu Special, Gajapati, Bhairavi
8	Cheroot tobacco	DR 1, Bhavani Special, Lanka Special, Sendarapatty Special
9	Cigar-wrapper tobacco	S 5, Krishna
10	Burley tobacco	Burley 21, Banket A1, HDBRG (Dark burley)

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 gravelly 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 Dinahata (West Bengal) conditions.

Seed Treatment

Seeds must be treated with dithane M-45 or Z-78 before sowing in the nursery against the seed borne diseases.

Time of Sowing

Sowing time	State	Type of Tobacco
Aug-Sep	A.P.	Cigarette, Cheerot and Bidi
April- May	Karnataka	FCV and Natu
May-June	Gujarat	Bidi
June -July	U.P.	Chewing
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 later 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 Dinahata (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. Early 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
- Northern Light soils & Karnataka Light Soils- 100cm X60cm
- Southern Light Soils & 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: 16

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

In general a normal tobacco crop removes 225 kg N, 17 kg P₂O₅, 365 kg K₂O, 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, P₂O₅ and K₂O / ha.

SLS - 60-60-60 kg N, P₂O₅ and K₂O / ha.

KLS - 50-40-80 kg N, P₂O₅ and K₂O / ha.

TBS - 45-0-0 kg N, P₂O₅ and K₂O / ha.

Bidi Tobacco - 160-0-0 kg N, P₂O₅ and K₂O / ha.

-125-60-40 kg N, P₂O₅ and K₂O / ha.

Burley - 125- 5-50 kg N, P₂O₅ and K₂O / ha.

Irrigated natu - 300-50-100 kg N, P2 O5 and K2 O / ha.

Rainfed natu - 60-50-50 kg N, P2 O5 and K2 O / ha.

Lanka - 300-50-50 kg N, P2 O5 and K2 O / ha.

Cigar: 100-50-100 kg N, P2 O5 and K2 O / ha.

Chewing - 120-50-75 kg N, P2 O5 and K2 O / ha.

Hookah - 112-50-75 kg N, P2 O5 and K2 O / 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-tynd 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, collection 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 grown in Kharif, which will reduce the seed bank.

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	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. Scheduling 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

1). One year rotation, two year rotation, long term cropping sequences, mixed cropping wherever feasible and cropping systems suitable to the region were developed.

Table - 1 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 sunhemp green manuring followed by tobacco
3. Rainfed Natu tobacco	Kharif gingelly followed by tobacco (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

TOPPING & SUCKER CONTROL

Topping 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 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 CO₂ 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 °C	3.3 - 3.8cc/g of shreds
Equilibrium moisture content at 60% R.H. and 20 °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 biochemical 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. Yellowing

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. Fixing colour

Temperature - Dry bulb: 105-120°
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. Leaf drying

Temperature: Dry bulb: 120 to
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
Wet bulb: 110 to
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 absorb 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 lose 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 2) 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 2 Grade specifications for the 10 farm grades for black soil tobacco

Grade	Color	Body	Texture	Blemish not to exceed	Corresponding Agmark grade
Farm-I	Bright lemon or orange	Thin to Medium	Soft	25%	1 to 4
Farm-II	Light Brownish yellow or Brownish lemon	Medium	Good	25% (White to yellow blemish allowed)	LB Y 1
Farm-III	Light Brown	Good to Medium	Medium	50%	LB Y 2
Farm-IV	Brown	Heavy Body	Medium to Coarse	50% (brown blemish allowed)	Brown
Farm-V	Dark Brown	Heavy Body	Medium to Coarse	50%	Dark Brown
Farm-VI	Light Greenish orange	Good	Soft to Medium	10%	LG
Farm-VII	Light Medium green	Heavy	Medium to Coarse	25%	LMG
Farm-VIII	Medium Green	Heavy	Medium to Coarse	35%	MG
Farm-IX	Dark Green	Coarse	Coarse		DG
<i>Farm-X</i>	<i>Orange, yellow green and / or brown</i>	<i>Variable</i>	-	-	<i>Pl & Bits</i>