Lesson 1
Oil seeds and their importance

What is fat penalty?

- Oil seeds are energy rich crop
- 1g of photosynthate is converted as:
  - 0.70 g of cereal
  - 0.64g of pulses
  - 0.42g of oil / fat
- Energy content MJ/kg
  - Oil - 39.8
  - Protein - 23.9
  - CHO - 16.8

Oil seed production & vegetable oil availability in India (Million)

Year	9 oilseeds M ha	Domestic Veg Oil (M t)	Import Veg Oil (M t)	Total
2004-05	**24.8**	**7.50**	**5.25**	**12.75**
2003-04	**25.1**	**7.79**	**4.62**	**12.41**
2002-03	**15.1**	**5.15**	**5.39**	**10.54**
2001-02	**20.7**	**6.72**	**4.81**	**11.53**
2000-01	**18.4**	**5.85**	**5.09**	**10.94**

Share of vegetable oil consumption in India

- 70's
  - Peanut – 53%
  - Rapeseed – 25%
  - Cotton seed oil – 9%
  - Palm, soybean, & sunflower – 4%
- 1999-2000
  - Palm – 38%
  - Soybean – 21%

Historical oil seeds in India

- Coconut, sesame, mustard, cotton seed, linseed, castor, Niger, safflower

Newly introduced oil seeds

- Groundnut, soybean, sunflower, oil palm

Byproducts of cultivated crops

- Rice bran, tapioca seed, maize germ, tobacco seeds, rubber seeds, tung (Aleurites fordii), jute seeds, spent coffee grounds, tea seeds
- Plus many more

Lesson 2

Groundnut

Arachis hypogaea

Origin

- South America
- Brazil is considered as centre for many wild spp
- Native of new world crop
- Cultivated extensively in Meso-Amrica & South Amrica
- Remnant pericarp tissue from Peru dates 3900-3750 years before

The word *Arachis hypogaea* (groundnut) has been derived from two Greek words, Arachis meaning a legume and hypogaea meaning below ground (referring to the formation of pods in the soil). Groundnut has never been found in the wild state anywhere and its origin has, therefore, been a matter of considerable speculations and even controversy. There are tow school of thoughts about its origin-one supporting the view that groundnut had originated in Africa and the other tracing its origin to Brazil in South America. According to some literatures it is clear that from the beginning of the sixteenth the west cost of Africa an naturally they introduced it from Brazil into Africa. De Gandolle (1825) stated its origin to be in Brazil (South America). Its introduction in India is considered to be through Jesuit Fathers (Missionaries) who followed Vasco De Gama shortly after his first landing in India i.e. in the first half of the 16th century.

Distribution

- Throughout the tropics and subtropical zones
- India, China, Sudan, Nigeria, Senegal, Zaire, USA
- In India
  - Gujarat
  - AP
  - TN
  - Karnataka
  - Maharastra

Spread in India

- Commercial cultivation from early 19th century
- Largest area in South Arcot in 1840 of Tamil Nadu
- Possible way of entry from New World, South America via Philippines or China or Java
- Ground nut oil production was from 1840 only

- Today it is cultivated and consumed as largest crop

World - Area, production and productivity (million hectares and million tonnes)

Country	Area	Production	Productivity
India	8.50	8.40	0.99
China	3.62	9.72	2.69
Nigeria	1.48	1.20	1.15
Sudan	1.09	0.81	0.74
Senegal	0.89	0.68	0.76
Ziare	0.66	0.55	0.83
USA	0.65	1.94	3.00
World	**22.89**	**31.59**	**1.38**

Oilseed scenario of the world

- Until mid 80's
  - Soybean > Cotton seed oil > groundnut
- Today
  - Soybean > Cotton seed oil > rapeseed oil > peanut > sunflower

Ground nut area, production and productivity in India (Million ha & Million t)

State	Area	Production	Productivity
Gujarat	1.99	2.38	1.20
AP	2.17	1.77	0.82
TN	1.15	1.84	1.60
Karnataka	1.21	0.95	0.79
Maharastra	0.60	0.63	1.04
All India	**8.50**	**8.40**	**0.99**

Classification

- Bunch
- Semi spreading and
- Spreading
- Also Virginia, Spanish and Valencia
- All are compatible for crossing purpose

Climate

- Adapted to wide range of climate
- However plant gets affected when
  - Low light intensity during early growth & flowering
  - Cloudy weather at flowering
- A temp range of 25-30°C
  - < 20°C and > 35°C growth gets retarded
- Once established
  - It can tolerate drought
  - Also flood for a week if drained properly

- A rainfall of 500-1000mm is fair but can produce a good crop with 300-400mm well distribution

Soil

- Well drained soil is so ideal
- Light colored loose, friable, sandy loam
- Soil with well supplied calcium and moderate amount of organic matter
- Sandy loam is more suited than clay
    - Since penetration of peg is easy and viable
- A soil pH of 6.0 to 6.5 (ranges 5 to 7)
- Saline soils are less suitable
    - since has low salt tolerance

Growth stages

Vegetative
VE – Emergence of cotyledons near the soil
V0 – Cotyledons are flat and open
V1 - First tetra foliate leaf one
Reproductive
R1 – Bloom one
R2 – Peg one
R3 – Pod one
R4 - Full pod one
R5 – Beginning seed one
R6 – Full seed one
R7 – Beginning maturity one
R8 – Harvest maturity
R9 – Over matured pod

Growing seasons

In India grown in four seasons
Kharif
85%
Rainfed
Second fortnight of June
Rabi
where winter is very mild – usually in rice fallows
Sep-Dec
Summer
II FN Dec- I Week Feb
Spring
I FN Feb – I Week Mar
In Tamil Nadu
Rainfed
Apr-May - (Pollachi, Theni, Tenkasi)
Jun-Jul - (NEZ)
Jul-Aug – Most dts
Oct – NEZ & Kanyakumari
Irrigated

Summer – All districts
Dec-Jan – All dts
Feb-Mar - New delta

Varieties in Tamil Nadu

- TMV 2 – cosmopolitan – bunch (360g)
- TMV 7 – Bunch (360g)
- TMV 10 –semi spreading (540g)
- JL 24 – Bunch - rainfed / irrigated (460g)
- VRI 2 – Spanish bunch (500g)
- VRI 3 – Bunch (350g)
- VRI 4 – Bunch (408g)
- CO 1, 2, BSR 1 – Bunch

Seeds and seed treatments

Dormancy

- Varieties differ for seed dormancy
- It is common in Virginia types
- Dormancy may go if harvest delayed
- Normally it may go off during storage

Selection of kernel is important

- Sound matured bold seeds
- Discard shriveled, broken, disease affected
- Hand decorticated is preferable

Treat with bio-fertilizers – Rhizobial cultures

- Before sowing *Trichoderma viride* @ 4g /kg

Seed management

- Selected seeds are soaked for 6 hrs with 0.5% CaCl2 solution in 50% by volume
- Spread the seeds in moist gunny bag and cover with moist gunny bag for 20-24hrs
- Seeds with viable expression of radicle is alone selected and shade dried to sowing moisture
- Unviable seeds are discarded
- Germination is ensured by 95%

Seed rate

- 140 kg for rainfed
- 125 kg for irrigated
- Increase by 10% if bold seeded (like JL 24, CO 2 & TMV 10)

Spacing

- 30 cm x 10 cm
- 15 cm x 15 cm wherever ring mosaic is prevalent

Field preparation

- Fine tilth to be obtained
- Chiseling for soil with hard pan
- Amendments for soil surface crusting
    - Lime 2t /ha along with FYM / compost
- Farm beds and channels

- 10 to 20 m-2

Sowing

- Rainfed
  - Use seed drill or gorru
  - Can also be sown behind country plough
  - Pre-monsoon sowing is also a way
- Irrigated
  - Dibbling at 4cm depth with adequate soil moisture
  - Can also be sown behind country plough
  - Irrigation may be after sowing if sown in dry soil

Nutrient management

- Rainfed
  - 10 : 10: 45 kg N, P_2O_5, K_2O / ha
- Irrigated
  - 17 : 34 : 54 kg N, P_2O_5, K_2O /ha
  - Sulphur sludge 60 kg /ha
- Gypsum to groundnut
  - 400 kg for all non calcareous soils at 40-45 DAS
  - Apply by the side and irrigate

Irrigation management

- Irrigation at 25% depletion of ASM
- IW/CPE ratio
  - 0.5 up to 40 DAS
  - 0.75 later
- Total water requirement 400-600mm
- Sowing or pre-sowing irrigation
- 20 days after sowing
- At flowering 2 irrigations
- At pegging one or two
- In pod development 2-3

Weed management

- Stirring the soil to remove weeds also aerates
  - Aeration is more essential for peg formation
- Fluchloralin 2 lit
  - pre-sowing incorporation or
  - Pre emergence application as spray
- Metalachlor 1 kg
  - Pre-emergence and hand weeding
- If no herbicide applied two hand weeding on 20 & 40 DAS

Peg formation

- No of pegs developed are higher in bunch
- Daily min temp is positively correlated
  - But maximum temp negative
- High light intensity affects pegging
- Soil moisture if goes to wilting

        - Process of peg formation stops
        - Formed pegs may dry
    - Early formed flowers may inhibit the later to form peg
    - Auxin and GA produced by pro-embryo promotes growth
    - Length of peg is generic
    - Strength of peg is a concern for management

Harvesting & Processing

- Maturity
    - Yellowing of foliage
    - Spotting of leaves
    - Dropping of leaves
    - Hardening and toughness of pods
    - Dark tannin discoloration inside the pods
    - Unwrinkled kernels and coloration of testa

Harvesting & Processing

- Delay in harvest causes 5-15% reduction
- Bunch type usually matures in about 100-105 days
- Spreading 130-150 days
- Uprooting is the way in bunch
    - Blade harrows, tractor drawn diggers
- In spreading types by digging
- Storage:
    - Plant with pods dried for two days
    - Pods separated and dried in open sun for 2-3 days
    - Proper drying of the pods may be judged by
        - Pods should give rattling sound when shaken
        - When the kernel is pressed between thumb and index finger it should split into 2 cotyledons
        - When the surface of the kernel if roughed hard a portion of the testa should come off.

Cropping systems

- Row Intercropping
    - Peanut + sorghum / ragi /redgram /chilli /cotton, sunflower /castor etc in different proportions
- Mostly mixed crop with pulses
    - Groundnut – wheat
    - Rice - groundnut
    - Rice – rice - groundnut

Economic uses

- Edible oil (50% oil)
- Haulms are palatable fodder to cattle
    - May be as hay or silage
- Groundnut kernels have high protein
    - 1.3% times higher than meat
    - 2.5 times higher than egg
    - 8 times than fruits

- Numerous industrial uses
    - Preparation veg oil (vanaspati)
    - Low quality oils for soap
    - For beauty aids, shaving cream, cols cream
    - For medical aids – plasters, ointments
    - Cake powder for laundry starch and manufacture of paper, gummed tapes and plastics
    - Activated carbon
- Oil cake - Good organic manure and cattle feed
- Cake flour is easily blends with wheat and others to bakers, confectioners, candy makers and ice cream manufactures

Lesson 3

Sesame

Sesamum indicum

Importance

- It is regarded as *queen* of oilseeds
  - Because of its quality (fatty acid composition)
  - Its resistance to oxidation and rancidity
- India is considered as basic centre of origin
- Very ancient crop

Economic Importance

- 38-54% high quality oil
  - Containing 1-15% protein
- 75% sesame is used for oil
- 20% for domestic including sweets, candies and condiments
- 2-3% for next sowing
- It is nourishing food, as flavoring agent and for medicinal purpose
- Manufacture of soaps, cosmetics, perfumes, insecticides & pharmaceuticals
- Sesame cake is good livestock feed
- Also an ingredient to poultry feed

Distribution

- A crop of tropics and sub-tropics
- But it is grown up to 40°N in China
- India is the major producer

Sesame - World - Area, production and productivity
(Million hectares and million tonnes)

Country	Area	Production	Productivity
India	2.13	0.50	0.24
Sudan	1.05	0.25	0.25
China	1.00	0.56	0.62
Burma	0.87	0.21	0.25
Nigeria	0.25	0.08	0.30
World	**6.57**	**2.27**	**0.35**

Sesame – Indian scenario (Million ha & million t)

State	Area	Production	kg/ha
Gujarat	0.30	0.09	0.29
Rajasthan	0.21	0.02	0.07
Tamil Nadu	0.17	0.09	0.54
MP	0.17	0.04	0.21

UP	0.16	0.03	0.19
Maharastra	0.13	0.04	0.30
WB	0.01	0.09	0.85
India	2.13	0.50	0.24

The plant

- It is erect, branched annual
- Multi flowered, fruit is capsule with small oleaginous seeds
- Leaves are most variable in shape and size
- Lower leaves tend to be broad
- Upper leaves are more narrow and lanceolate
- Flowers arise in the axils of leaves & on the upper portion of the stem

Seed

- Small, ovate 3g/1000
- Testa color varies black, white, yellow, dark grey
- Dry matter content in the seed increases rapidly between 12-24 days in parallel with oil content
- A capsule may contain 50-100 seeds

Climate

- Requires fairly high temp
- 2700 heat units are normally required
- 27-33°C is found to be optimum
- < 10°C growth process stops
- > 40°C can affect fertilization
- A rainfall of 500-650mm
- Heavy rain at flowering affects yield
- Extremely susceptible to water logging
- It is drought resistant, can withstand drought
    - Except establishment period
    - A crop for SAT regions
- Susceptible to wind damage & hail
- Heavy storms can virtually strip off leaves

Soils

- From sandy to clay soils
- Thrives well under well drained moderately fertile soils of medium texture
- Soils with impervious sub-soil are not suitable
- Soils with neutral pH
- Sesame grows with a range of 5.5 to 8.0 soil pH
- Many soils where sesame cultivated are saline

Land preparation

- Fine tilth by deep ploughing
- Land should be leveled properly
- Beds and channels is more suitable
- In heavy rainfall areas broad bed furrows
- Ridges may be to drain the excess rainfall

Improved varieties

- CO 1
- TMV 3, TMV 4, TMV 5, TMV 6
- Paiyur 1
- SVPR 1 (white)
- VRI 1

Duration

- 80-85 days

Oil content

- 44-56% mostly 50%

Season

- In Tamil Nadu
  - Jun15-Jly 7
  - Nov 30 Dec 15
  - Feb 15 - March 30
- In North
  - Kharif - according to monsoon set
- Bihar, WB & Orissa:
  - Irrigated - March

Seed rate & spacing

- Seed rate - 5 kg /ha
- Spacing
  - 30cm x 30cm (11 plants m-2)
  - Broadcasting and thinning to - 11
- Spacing adapted in other states
  - 30x15 (AP, Assam, Karnataka, Orissa, WB)
  - 45 x 10 in Kharif and 45x15 in Rabi in Gujarat

Seed treatment & sowing

- Treat the seeds with Trichderma @ 4g/kg
- 3 pockets of Azospirillum /ha
- Mix the seeds with four times its volume of dry sand and mix
- Drop / broadcast uniformly
- Depth of sowing 3cm

Transplanting of gingelly

- Transplanting is possible
  - In light textured soil
  - Nursery
    - Raised bed, 300 m-2
    - Seed rate : 1.0 to 2.0g seeds m-2
  - Seedlings of 15-20days old
  - Irrigate and transplant
  - Transplant at late afternoon
- Optimum population with equidistance gives yield advantage

Manures & Fertilizers

- FYM/composted coir pith 12.5t/ha
- Blanket - N:P2O5 :K2O kg /ha
  - Tamil Nadu
    - Rainfed - 23:13:13
    - Irrigated – 35:23:23
    - If Azospirillum applied, N may be reduced by 5-10 kg
  - Other states with higher recommendation
    - Gujarat – Irrigated: 50:25:25
    - WB – Irrigated: 50:25:25
- Apply all basal
- 5kg MnSO4 in Mn deficient soils
- 5kg ZnSO4 for Zn deficient soils
  - Micronutrients should be broadcast with sand after sowing

Water management

- Irrigate at sowing
- Life irrigation 7 days later
- Light irrigation at short interval is better than heavy
- Heavy irrigations reduce seed weight and oil content
  - Irrigation at flowering critical
  - Soil moisture should be low at maturity
- Irrigation at 25% ASM
- IW/CPE ration of 0.4
- Total water requirement- 250-350mm

Weed management

- Thinning, hoeing and weeding are important cultural practices
- Hoeing & weeding twice at 15 & 30 DAS
- Herbicides
  - Pre-emergence application of Alachlor @ 1.25 kg/ha
  - Or Fluchloralin 1kg/ha
  - Herbicide application to be followed with hand weeding on 30th day

Maturity

- 25% of bottom leaves dropped
- Top leaves loose their green color – turn to pale yellow
- The colour of the stem turns yellow
- Capsules up to middle of the stem turn yellow
- Examine the 10th capsule for seed color
  - If the color is black then ready for harvest

Harvest

- May be cut to ground or uproot
  - Preferably in the morning
- Stack in the open one over other in circular heap
- Keep the top inside and roots out
- Cover top of the heap with straw and tie or add weight
  - Humidity and temp increases

- Heap for 3-5 days
- Open the heap and keep the stacks drying
  - Dry it for 2 or 3 days
  - Shake the plants after drying to separate the seeds
  - Dry the plant again and separate the seeds

Yield

- Vary very widely
  - Few 100 to 3000kg
- Rainfed in India
  - 375-500 kg
- Irrigated (rabi)
  - 500-575kg
- Transplanted gingelly may give higher yield of 2.0 tonnes

Cropping system

- As pure crop
  - Rice-gingelly
  - Sesame-wheat
  - Sesame-chickpea/ rapeseed/lentil/pearlmillet
- Mixed / inter crop
  - Yield is poor but area is more
  - Sesame +mungbean
  - Sesame +groundnut
  - Sesame +maize

Storage

- Clean and dry
- 5% moisture for storage
- Containers should be tight tipped

Lesson 4

Sunflower

Helianthus annuus

About sunflower

It was an ornamental before 1969 in India
It is popular oil seed crop today
Its name is with reasoning
Annual but there are perennials
Competing with 4 major oil seeds of the world after mid 19th century
Soybean, rapeseed, cotton seed, peanut
Soybean and cotton seed has other values as protein meal and fibre

Specialty of sunflower oil

Among the vegetable oils most suitable to coronary system
High level of linoleic acid and absence of linolenic acid
PUFA (Polyunsaturated fatty acid) – Linoleic content is more (67%) and about 90% unsaturated (+monounsaturated 21%)
Major ingredient in margarine and shortening products

Origin & spread

Probably from South - West America
Sunflower was introduced into Europe in 16th century
Reached Europe from Mexico via Spain
It was ornamental
Reached Russia via Holland in 18th century
First commercial production for oil -1830-40
After second world war introduction of Russian varieties such as Peredoviv, Mennonite & Sunrise led to the development of this crop in Europe & America
In India it was only ornamental till 1969
Introduction of Peredoviv, Armveski varieties from Russia in 1969 led for the spread

Sunflower world scenario in 1999 (Million ha & million t)

Country	Area	Production	Productivity
Russia	3.98	4.20	1.05
Argentina	3.79	6.50	1.72
Ukraine	2.78	2.75	0.99
India	2.25	1.25	0.56
USA	1.39	1.99	1.41
Romania	1.04	1.21	1.17
Spain	0.87	0.56	0.64
China	0.86	1.55	1.80
South Africa	0.82	1.21	1.46
France	0.80	1.87	2.34
Turkey	0.55	0.86	1.58
World	**22.84**	**1.25**	**28.48**

Indian Scenario of sunflower in 1999 (million ha & million t)

State	Area	Production	Productivity
Karnataka	0.88	0.36	0.41
Maharastra	0.52	0.32	0.62
AP	0.29	0.22	0.75
Punjab	0.10	0.16	1.54
Haryana	0.06	0.11	1.76
UP	0.03	0.04	1.46
TN	0.02	0.02	1.17
India	**2.25**	**1.25**	**0.56**

Favourable features for growth of sunflower in India

Wide adaptability
Photoperiod insensitiveness
Shorter duration (60-100 days)
High quality edible oil (PUFA)
High seed multiplication ratio (>1: 80)
Easier & cheaper cultivation
Remunerative market price
Suitable for mechanization

The plant

- Erect, tall usually un-branched
- Plant height, head size, days to flowering & maturity are all vary due to environment
- Root – tap root - but thick root mat with short tap root is common
    - May be problem in light soil to heavy mass - lodging
    - Limitations in the exploitation of soil moisture & nutrients
    - Earthing-up interferes with roots
    - Irrigation frequency should be short to meet the demand
    - Waterlogging adversely affects the crop due to weakening of anchorage and proliferation of fungal diseases
- The stem
    - Mostly unbranched
    - Branching is not desirable
        - Basal branching may be useful
        - Leaf axil branching problem
        - N triggers branching
    - Green stem contributes for photosynthesis
    - Ht varies
        - 80-120 short can accomododate more plants
        - 120-150 medium
        - 150-180 tall

- The leaf
    - Varies with plant type and environment
    - Limited to number of nodes
    - 8 to as many as 70
    - Arranged alternate at right angle
- The inflorescence
    - Capitulum borne terminally
    - Surrounded by one or more whorls of bracts called involucre (modified leaves)
    - Head diameter is yield deciding factor
- Anthesis and fertilization
    - Flowering from periphery
    - Outermost opens first
    - Daily 1-5 rows continues up to 5-10 days
- The seed
    - Seed is called 'achene'
    - Seed size 7-25mm long, 4-13m long,3 -7.5mm thick
    - Dormancy normally 10-45 days
    - Oil content 36-37%
    - 1000 seed weight 43-45g

The climate

Temp range 8-34°C
Optimum 20 & 25°C
Requires cooler (15-20°C) growing period and warmer maturing period (20-25°C)
Base minimum is 10°C
High temp (>38°C) in post-anthesis inhibit quantity and quality of oil
Rainfall of 500mm, with 300 mm it can yield
Avoid flowering coincide continuous drizzle

Soil

- Can be in wide range of soils
- Any soil with good drainage is more important
- Neutral to moderately alkaline soils
- pH ranges 6.5 to 8.0
- Complete failure in sandy soil with pH 4.6

Varieties

CO1, CO2, CO 3, CO 4
Modern, K2, K1, BSH 1
EC 68415

Hybrids have advantage than varieties

- High yield potential
- Uniform crop stand
- More self-fertile, less problem of seed set
    - MSFH 1, BSH 1

Seasons

Rainfed

June-July, Kharif in North

Oct-Nov

Irrigated

- Dec - Jan
- April – May

Field preparation

- Fine tilth
- Apply FYM / Compost incorporate
- Ridges and furrows

Spacing

- 30 to 60cm according to variety
- 10 to 15 cm for short & medium stature
- 15 to 30 cm for tall (>120cm)

Seed rate

- @ 2 seeds per hole
- Seed weight of 45g/1000
  - 30 x 10 30 kg
  - 30 x 15 20kg
  - 30 x 30 10kg
  - 60 x 30 5kg

Seed treatment

- Trichderma 4 g /kg
- Azospirillum 600 g to one ha
- Soaking the seeds
  - 2% ZnSO4 for 12hrs and
  - Shade drying for rainfed sowing is desirable

Sowing

- Well prepared deep, friable seedbed is more preferable
- Depth of sowing 3-5cm

Plant population

- 55,000 to 98,000 /ha almost same yield
- If the head diameter is <10cm more population
- If >20cm less population

Thinning

- Highly sensitive to intra-specific competition

Nutrient management

- Fast growing high oil yielding thus requires more nutrients
- Low yield in India is attributed to poor fertile soil, cultivated in rainfed conditions
- A crop yielding 2 t seed, 3.2t stover and 0..8t root uptakes
  82 kg N, 13 kg P, 60 kg K, 9.4 kg S, 37 kg Ca and 21 kg Mg.

State wise nutrient recommendation

- TN 40-20-20
- UP 80-60-40
- AP - Rainfed 60-30-0
  - Irrigated Hybrids 60-90-30 ; Variety 30-60-30

Weed management

- Fluchloralin / Pendimethalin
  - 2.0kg as pre-mergence
  - High volume spray
- Hoeing and weeding on 15th day & 30th day
- Within three days irrigate the filed

Water management

- Immediately after sowing
- 4-5 days later once
- Interval of 7-8 days
- Seeding, flowering and seed development stages are critical

Seed setting and filling

- Problem is seen with poor seed setting
- This problem is more in warmer regions
- In India seed filling under good management is only 75%
- It will be as low as 10-20%
- Reasons
  - Genetic
  - Environmental
  - Physiological
  - Availability of pollinators

Maturity

Physiological maturity (30-40% seed moisture

When the back of the head turns green to lemon yellow

There will be 5-6 green leaves at this stage

Harvest maturity (10-12%)

Delay beyond harvest maturity severe yield loss

Cropping systems

Sequential cropping

- Southern India
  - Rainfed - Sunflower – millets/pulses
  - Irrigated- Rice – sunflower
- North
  - Rainfed - SF – wheat / chickpea

- Row intercrop
  - Groundnut + SF
  - Pigeanpea + SF
  - Castor + SF
  - Pulses + SF

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Lesson 5

Rapeseed-Mustard

Brassicas sp.

Brassicas are grown next to peanut in India. Rapeseed-mustard is a common name to three Genera :

- *Brassica*
- *Eruca*
- *Sinapsis*

  - Brassica is more important

Importance of Brassicas in India

- It is main Rabi season crop in India
- Green tender plant is used as vegetable
- Whole seed is for preparing pickles and flavoring vegetables and curries
- Oil for cooking, frying and pickles
- Oil is also used for vegetable ghee, hair oil, soap, lubricating oil, and tanning industries
- Seed & oil have peculiar pungency
  - Due to presence of glucose sinigrin
- Oil cake is a cattle feed to be fed at smaller quantity

Canola

- It is a trade name to rapeseed oils which possess
  - <2% erusic acid
  - Solid components should contain
    - <30 micromoles /g of glucosinolates
- May be Canadian oil like "Mazola" (maize oil – Corn oil), "Sanola" sunflower oil (again brand name for PUFA content)
- Of late refers to 'generic' but
  - Those rapeseed varieties metingabove the specification

  (Erusic acid causes heart lesions and
  Glucosinolates cause thyroid enlargement)

Brassicas grown in India

Taxonomic name	Common name	Hindi	Oil Content
B. Campestris	Turnip rape	Brown sarson	Kali sarson
Var. *brown sarson*	Brown sarson	Kali sarson	43%
Var. *yellow sarson*	Yellow sarson	Peeli sarson	45%
Var. *toria*	Indian rape	Toria	35%
B. napus	Swede, summer, winter rape	Gobhi sarson	Oilseed
B. Juncea	Indian mustard Mustard	Rai, Raya Laha	35%
B. toumefortii	Wild mustard	Jungli rai	18%

B. carinata	Ethiopian mustard	Karan rai	Oilseed
B. nigra	Black mustrad	Banarsi rai	29% Condiment
B.Oleratea			Vegetables
Eruca sativa	Rocket	Taramira	28%

Rapeseed vs. Mustard

Character	Rapeseed (Sarson/Toria/Lahi)	Mustard (Rai, Raya, Laha)
Plant height (cm)	45 – 150	90-200
Leaves	Sessile, leaf lamina claps the stalk	Leaves stalked but do not clasp
Siliquae (pod)	Short or thicker	Long & slender
Pollination	Cross pollinated	Self pollinated
Seed coat	Smooth	Rough

Brown sarson vs. Yellow sarson

Character	Brown sarson	Yellow sarson
Leaves	Pale, thin	Dark green and fleshy
Branching	Erect, spreading	Erect
Siliquae (pod)	Thin, narrow	Thick and broad
Seed coat	Dark brown to reddish brown & mucilaginous	Yellow & non mucilaginous

Origin

- Rai – China
- Toria – East Afghanistan
- Brown sarson – E. Afghanistan & adjoining Indian sub-continent
- Yellow sarson – N.E. India

Rapeseed-Mustard : Area cultivated in the world (1997) – (Million ha & million t)

Country	**Area**	**Production**	**Productivity**
India	6.81	6.96	1.02
China	6.79	9.54	1.41
Canada	4.84	6.19	1.29
France	0.99	3.49	3.53
Germany	0.92	2.84	3.10
World	**24.2**	**35.15**	**1.45**

Rapeseed-Mustard : Area in India (1997) **(Million ha & million t)**

State	Area	Production	Productivity
Rajasthan	2.96	2.65	0.99
UP	1.43	1.47	1.03
Gujarat	0.34	0.47	1.37
Haryana	0.61	0.89	1.46
MP	0.82	0.75	0.91
WB	0.32	0.28	0.89
Assam	0.28	0.14	0.51
Punjab	0.09	0.11	1.27
India	**6.81**	**6.96**	**1.02**

Brassicas Area in India

- Till independence area remained constant (2.0million ha)
- From 50's area rose steadily
    - Due to increase in irrigated area
    - Increased productivity, varieties and agronomic practices
    - Maximum area was in 6.87 million ha -96-97
- Major states growing are
    - Rajasthan, UP, Gujarat, Haryana, MP, WB, Assam & Punjab

Climate

- A crop of temperate
- Can be in higher elevation of tropics
- Rabi season crop in India,
    - Sep-Oct to Mar-Apr
- Temperature range 3 to 40°C
- Optimum 18-25°C with cool, dry clear weather
- High RF, high humidity, cloudy atmosphere at flowering undesirable
- Most susceptible to frost

Season

- Sowing starts from August ends in November
- Sowing of rapeseed is ahead of mustard
- Taramira is sown from mid-Sep to Oct end
- Region wise season varies

Varieties

- Mustrad
    - Varuna (T 59), TM 2, TM 4, Seetha
- Brown sarson
    - KNS 3, KOS 1
- Yellow sarson
    - PUSA GOLD, YS 93
- Toria
    - Jawahar Toria, Panchali, TS 29
- Taramira
    - RTM 13, TMC 1

Soil

- Varying soil from sandy loam to clay
- Thrives well in light soil
- Mustard on any soil but rapeseed in light
- Well drained soil is more suitable
- Waterlogging should not be
- Saline alkaline soils are unsuitable
- pH 6.5 to 7.5, neutral soil is ideal

Land preparation

- Fine seed bed since seeds are small
- Flat bed to perform ferti cum seed drill

Seed rate & spacing

- 4-6 kg depending upon seed weight
    - 3-5 g/1000 depending upon crop and variety
- 30 x 10 to 30 x 15cm
    - 22.2 to 33.3 plants m-2

Sowing

- Treat the seeds with fungicides well before sowing
- May be behind the country plough
- Ferti cum seed drill
- Depth of sowing 3-4cm
- Avoid shallow sowing
- Cover the seeds after sowing
- Sowing may be on conserved soil moisture

Manuring

- Oil seed crops removes huge nutrients
- S is removed in large and needs return
- General recommendation varies to States
- 60-40-40 for irrigated
    - Half N 30 DAS
    - If SSP is applied S is taken care, if not
    - 20-40kg elemental sulphur, if soil analyzed with <10ppm
- 30-20-20 for rainfed (half of irrigated)
    - All basal
- Nutrient requirement may be calculated by critical concentration
    - 6.07 – 6.62% N in top 2-3rd leaf at 60 DAS
    - 0.408 – 0.412% S in 4-5th leaf from top
- Integration with biofertlizer ‘Azotobactor’ is desirable

Irrigation

- Total water requirement - 400mm
- Moisture at pre-flowering and pod filling stage is critical
    - Two irrigations for mustard
        - One at rosette stage (20-30DAS)
        - Another at siliqua atage (50-60DAS)

        - In light soils three irrigations, the third at 90DAS
    - IW/CPE ratio of 0.6 is optimum

Weed management

- Dominant weeds
    - *Chenpodium album*
    - *C. murale*
    - *Convolvulus arvensis*
    - *Melitotus alba*
- Intercultural operation 5-10days after 1st irrigation
    - Hand hoeing is desirable, it aerates the soil
    - Soil aeration is to conserve soil moisture
- Herbicides can also be used
    - Pendimethalin pre-emergence 0.5-1.5 kg/ha based on soil
    - Fluchloralin 1.25kg pre-plant incorporation
    - Post emergence Isoproturan 0.75 kg /ha for
        - Wheat+mustard mixed systems

Harvesting maturity

- Color of leaves, stem and silique turn green to pale yellow
- Lower silique looks – dried appearance
- Upper may be green
- Seeds in the silique makes rattling sound
    - Silique with 2 carpels and a false septum
    - During over maturity the two carpels split and seeds shed
    - Premature harvest leads to shriveled grains

Threshing

- After sun drying for few hours
- Beating pods along with the plants
    - Either manually
    - Machine
    - Walking bullocks, or running tractor
- Cleaning and drying to 8-10% moisture for storage
- Average yield
    - Irrigated rapeseed 1.5 to 2.0 t
    - Rainfed rapeseed 1.0 to 1.5t
    - Irrigated mustard 2.0 to 2.5 t
    - Rainfed mustard 1.5 to 2.0t

Cropping systems

- Fallow / millets / pulses – mustard
- Rice – rapeseed
- Intercroppings
    - Mustard + chickpea
    - Mustard + sugarcane
    - Mustard + barley / wheat / chickpea
    - Potato + mustard

Lesson 6

Safflower

Carthamus tinctorious

Economic Importance

- Rich in PUFA (78%) – to reduce blood cholesterols
- Used for preparation of:
  - Margarine, and salad dressing
  - Varnishes, paints and surface coating materials
- Oil (28-32%) is also used in:
  - Infant food and liquid nutrition formulations
  - Effective non-allergenic dispersant for injectable medicines
  - Charred oil is used to heal sores and rheumatism
- Flowers
  - For dye extraction –red dye
  - Cosmetics preparations
  - Petals reported to have effects on circulatory systems
- Cake (30%)
  - Un decorticated cake as manure
  - Decorticated fed to ruminants and mono-gastric animals
  - Can be as human food, if bitter principles and phenolics are removed
- Hulls (40%)can be used for manufacture of
  - cellulose, insulations, abrasions, hard boards and as fuel
- Thinned young plants are used as vegetables
  - since contains carotene, riboflavin and vitamins
- It is crop as border against animals

Origin and distributionsr

- *Vavilow(1926):* India, Afghanistan or Ethiopia
- *De Candole (1886):* Arabia
- Modern assessment:
  - Area encompassing S. USSR, W. Iran, Iraq, Syria, S. Turkey, Jordan and Israel
- Distributed now:
  - Between 14° & 45° N and 15° & 35° S

World scenario –safflower (million ah & million t)

Country	Area	Production	Productivity
India	0.704	0.43	0.67
Canada	0.097	0.16	1.69
USA	0.095	0.20	2.05
Ethiopia	0.069	0.04	0.51
China	0.011	0.02	1.91
Australia	0.034	0.02	0.59
World	**1.039**	**0.93**	**0.90**

India Scenario – safflower (million ah & million t)

State	Area	Production	Productivity
Maharastra	0.49	0.23	0.48
Karnataka	0.19	0.08	0.42
AP	0.02	0.01	0.38
Gujarat	0.01	0.01	0.60
MP	0.01	0.01	0.58
India	**0.70**	**0.43**	**0.67**

Climate

- A day neutral plant
- But short day can prolong rosette stage
- Temp is more important than day length
  - Thermo-sensitive
    - Extremes of cold and heat not suitable
  - Tolerance to low temp at vegetative
  - But susceptible to high temp during flowering
  - For germination 15°C
  - Vegetative : 20-21°C
  - Flowering: 24 to 32°C
- Rainfall at flowering affects pollination
- Excessive humidity at any stage affects
- More suitable for rabi season in India

The Plant

- Highly branched, herbaceous
- Annual height varying from 30-150cm
- Well defined fleshy tap root system
- Stem is stiff cylindrical fairly thick at base and thin at top
- Central stem branches at 15-20cm to secondary
- Each branch terminates in a flower head
- The angle of branching is varietals but can be by environment also
- The leaf deeply serrated on lower stem, short, stiff, ovate at the inflorescence
- The inflorescence – numerous florets
- Flower color may vary from whitish yellow to red-orange
- The capitula, head size may vary from 1.25 to 4.0 cm
- The fruit achene, resembles small slightly rectangular sunflower seeds
- Seed weighs 250 – 800mg/grain

Soils

- Fertile, fairly deep and well-drained
- pH range of 5-8
- Shallow soils irrespective of fertility seldom produces high yield
- In traditional belts it is black cotton soil
- On heavy soils
  - This crop follows early Kharif crops
  - Or may often single crop in Rabi

- It is considered as salt tolerant next to cotton
- Tolerant to Na salts but < to Ca & Mg
- Salinity reduces seed size and oil content

Seeds and sowing

Varieties

- K1 120 days, CO 1 125 days
- Bhima (33% oil) - Maharastra
- JSF 1 (30%) – Rajasthan & MP
- Manjira - AP
- Nira – (30%) Maharastra & TN
- HUS 305 (35%) for Peninsular India

Seed rate

- 7-20 kg depending upon spacing and variety

Spacing

- 45 x 15 cm in TN
- 45 x 20 cm
- 60 x 30 cm etc

Seed treatment

- Pre-sowing seed hardening
- Use fresh seeds every year

Sowing

- From last week of Sep to end of Oct
- Early sowing has advantage
- Line sowing using improved seed drill
- Ferti cum seed drill is more desirable
- Seeds can be sown behind the plough also
- Small furrow may be opened and seeds dropped and half coved
- Depth of sowing may be 5-7.5cm
- Light planking for the soils which looses moisture

Nutrient management

Rainfed crops

- N ranges from 25 kg N to 50 kg
- P_2O_5 – 20 to 50 kg
- K_2O – Mostly not recommended
- General: 40:20:0

Irrigated

- 60:30:20 (Chatisgarh) to
- 75:75: 35 (Karnataka)

Time of fertilizer application

- Rainfed – basal – deep placed by ferti-cum seed drill
- Irrigated 50% N+ full P & K as basal
- Remaining half N at 5th week during 1st irrigation

Water management

- It is deep rooted xerophytic plant, can thrive under scarce soil moisture
- One or two irrigations (25 & 75 DAS) is optimum
- Sensitive to excess moisture at any stage
- If the soil profile contains 250mm ASM
    - ET of the season is 250-300mm- no response to irrigation
- Under irrigated condition the crop may be sown under Broad beds of 1.35 to 1.8m and furrow
    - To drain the excess water
- Points to remember:
    - If one irrigation is possible , provide it at critical period
    - Avoid contact of above ground parts with irrigation water

Weed management

- Being wider spaced
    - critical periods for weed management extends up to end of rosette (25-50DAS)
- Hand weeding and hoeing
    - at 20 and 35 DAS is good
- Herbicides
    - PPI – Fluchloralin 0.75 to 1.0 kg
    - PE – Oxadiazone – 0.75 -1.0 kg or
    - PE – Pentimethalin – 0.75 kg

Important intercultural operations

- Thinning to single plant and filling the gap at the early stage (before 15DAS)
- Nipping of central shoot to induce branching
- Bird damage:
    - By parrots at Isolated pockets
    - Cultivate in contiguous block
    - Bird scaring - morning and evening during
        - Seed filling to physiological maturity

Harvesting

- Duration of the crop varies due to regions
    - 115-140 days
    - 120-125 days in TN
    - Gujarat & Orissa – 140-150days
    - In cooler regions 150-180days
- Maturity
    - When the lower leaves and most of the bracteoles dry and brown
    - Harvest in the early hours
        - Shattering minimum
        - Spines relatively soft
    - Combine harvester is becoming popular now since
        - Manual harvesting, bundling, threshing are all becoming problematic
- Duration of the crop varies due to regions

    - 115-140 days
    - 120-125 days in TN
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        - Shattering minimum
        - Spines relatively soft
    - Combine harvester is becoming popular now since
        - Manual harvesting, bundling, threshing are all becoming problematic
- Yield
    - In improved agro-techniques are used
        - Under scanty moisture – 800-1200kg/ha
        - Under favourable 1500-2000 kg
        - Under irrigated – 1800-2800kg/ha
- Storage
    - 5% moisture, clean and dry

Cropping system

- It is potential crop to replace dry rabi crops
    - Wheat, coriander, linseed, chickpea, pulses
- In traditional areas it is raised as intercrops
    - Sorghum, wheat, linseed, chickpea, coriander etc.
- Sequence cropping
    - Farmers rarely raise more than one crop due to non availability of moisture
    - There is scope for double cropping either preceding with Kharif crop or after rabi by irrigation

Lesson 7

Castor

Ricinus communis

Importance

- It was poor man's crop
- Globalization changed the scenario
- Now it is one of the most commercial non-edible oil seed
- Its stem, leaves, seeds, oil and cake are useful
- Oil - variety of uses
    - Industrial
    - Lubrication- including 'aero-engines'
    - Medicine- both human and veterinary
- Oil cake - manure
- Stalk - fuel or thatching
- Leaves - used for rearing silk worms
- Castor oil
    - Purgative as medicinally as cathartic & obstetrics
    - Skin ointment
    - Soothing agent to eye applied after removal of foreign bodies
    - As resins
        - Surface coating to household articles, furniture, refrigerators
        - Base materials for several paints, enamels & varnishes of super quality
    - Manufacture of leathers, adhesives, synthetic perfumes & flavors
    - Variety of rubber goods, hair oils
    - Clear bright colors in dying fabrics
    - For soaking raw skins in fur trade

Origin

- Indigenous to Eastern Africa
    - Most probably in Ethiopia
    - There are four large centres based on wild varieties
        - Irano-Afghanistan-USSR region
        - Palestine-SW Asia
        - India China
        - Arabian peninsular

World scenario of castor – (million ha & million T)

Country	Area	Production	Productivity
India	1.05	1.00	0.95
China	0.24	0.28	1.17
Brazil	0.12	0.05	0.37
Thailand	0.02	0.02	0.79
World	**1.58**	**1.42**	**0.90**

Indian scenario of castor – (million ha & million T)

State	Area	Production	Productivity
Gujarat	0.37	0.74	1.99
AP	0.24	0.06	0.25
TN	0.04	0.01	0.32
Orissa	0.02	0.01	0.31
Rajasthan	0.04	0.05	1.36
Karnataka	0.02	0.02	1.00
India	**1.58**	**1.42**	**0.90**

The Plant

- Can be divided into 2 groups
  - Tall – Giant - like tree, tap roots
  - Short - Dwarf – tap root less apparent
- Stem
  - Round glabrous & covered with waxy bloom
- Leaves
  - Dark glossy green
  - Palmate with 5 -11 lobes
- Inflorescence
  - The capsule contains three seeds
  - Seeds may vary greatly in size
  - 1000 seed may vary from 100 to 1000 g but most dwarf weighs around 300g
  - Inflorescence
    - Pyramidal raceme – 'spike' or candle
    - Male flowers in lower raceme
      - Number influenced by climate
      - High temp causes maleness
    - Female flowers in upper
    - May reach 100cm
    - Flowering may continue
    - Fruit is globular capsule, spiny to some degree, becomes hard & brittle when ripe
    - Shattering at maturity in giants but not in dwarf

Climate

- Hardy perennial
- Adapted to tropics to sub-tropics
- Now grows under warm temperate
- Temp ranging from 20-26°C with low humidity, long, clear, summer days throughout the growth favors high yield
- Frost free for dwarf is must
- It is long day crop
  - Short day (<9hrs /day) increases male flowers ratio
- Drought tolerant since deep rooted crop

Soil

- All soils
  - except clay and poorly drained
- Grows well in light sandy soils
- Deep moderately fertile with acidic (pH 5.0 to 6.5) are more ideal
- It can tolerate up to pH 8.0
- Soil with high fertility un desirable
  - since excessive vegetative growth & poor yield
- It can be in soils where other commercial crops are not possible

Filed preparation

- Deep ploughing is beneficial for rainfed crop for moisture conservation
- Chiseling in sandy soils
- Beds and channels in rainfed crops
- May be ridges and furrows in irrigated

Season

- Onset on SW monsoon
- Depends upon the date of receipt in different states
- During winter when the soil temp is
  - <10-12°C

Method of sowing

- Sowing behind the furrows –in AP
- Dibbling in lines
  - May be placed between 5-6cm
  - Germination is epigeal, can break surface crust also

Varieties

- During 70's
  - SA 2, V 19 & RC 6
- Hybrids
  - GCH 3, GAUCH 1, GCH 2
- In TN
  - SA1, 2, TMV 4, 5, 6, TMVCH 1, CO 1

Spacing (cm)

- 90 x 90
- 90 x 60
- 60 x 45
- 60 x 30

Seed rate

- 10kg
  - depending upon seed weight and spacing

Manuring

- In TN
  - 30:15:15 kg NPK
- In Gujarat
  - For rainfed - 40:40:0
    - N in two equal splits
    - Basal + 30-35 DAS

- Irrigated - 40:40:40 as basal
  - + 10 kg N after each picking
  - from 90DAS at 30 days interval
- There is N usage up to 150 kg in Gujarat

Irrigation

- Mostly as rainfed
- During prolonged drought
  - 2-3 supplemental irrigations
- Rabi & Summer crops require
  - 6-8 irrigations
  - Less number of irrigations in heavy soils
  - High moisture during maturity leads to
    - New leaves and delaying maturity

Weed management

- Weed free situation is 45-50days
- Early suppression by weeds
  - Intercropping is a solution
  - Summer ploughing, deep ploughing are to reduce the weed
- Herbicides
  - Fluchloralin 1.0 kg PPI
  - Pendimethalin – 1.5 kg PE (1-2 DAS)

Maturity and harvest

  - Harvesting in stages
  - 2-6 stages depending upon duration and spike opening
  - Capsules are picked when the spike turn yellow to black
- Drying
  - Sun drying the capsules and threshing

Yield

- Yield
  - 0.8 to 1.0 t in rainfed and
  - 1.5 to 2.0 t in irrigated
- Oil yield 50%
  - Oil extraction
    - Kernel pressing followed by solvent extraction

Cropping systems

- Crop rotation is very useful to control wilt
- Castor after pulse
- Castor followed by winter wheat
- Intercrops
  - Castor + peanut 1:3
  - Castor: blackgram 1:3
  - Castor : Pigeonpea 1:1

Lesson 8

Linseed

Linum usitatissimum

Linseed

- It is dual purpose crop like soybean and cotton. It is called 'Old world fibre'. Of late in India it is used primarily for oilseed.
- Linseed fibre or FLAX first of the vegetable fibres spun to cloth
- Oil in seed was used only later
- When grown for fibre called as Fibre flax
- When identified for oil then
    - Oil flax or
    - Seed flax or
    - Linseed
- Linola – (Edible linseed)

Importance of Linseed

- It is primarily considered for fibre - FLAX
- In India primarily for oil seed
- Entire plant has usage
- Oil
    - 80% for industrial purpose
    - Very small scale for direct consumption
    - Rich in Linolenic acid (66%)
        - Perfect drying oil, used in paint & varnish industry
    - Used for manufacture of lithographic inks and soaps and coating of high ways
    - After hydrogenation, substitute for tallow (hard fat from animals)
- Oil cake good for milch animal & as manure
- Stem yield good quality fibre (linen) having strength and durability
- Fibres are lustrous and blend well with wool, silk, cotton
- Strong canvas, suiting, shirting and various indispensable products for defense purposes
- Woody matter for high quality paper
- Demand is increasing, as a result import is going on

Problems and prospects for linseed in India

- As fibre there is scope, even today, but farmers' preference is for oilseed.
- As oil seed also its is importance for industry is declining due to:
    - Paint industries are relying on synthetic and petroleum based alternatives
- Expansion of area is limited to cooler regions only

World Scenario – Linseed - 1999-2000 (million ha & million t)

Country	Area	Production	Productivity
India	0.80	0.28	0.34
Canada	0.79	1.05	1.32
China	0.57	0.20	1.30
Ukraine	0.21	0.30	1.41
UK	0.21	0.30	1.41
Germany	0.20	0.34	1.69
USA	0.16	0.20	0.39
Russia	0.11	0.03	0.25
Argentina	0.10	0.09	0.84
World	**3.48**	**2.98**	**0.86**

Indian Scenario – Linseed – 1999 -200 (Million ha & million t)

State	Area	Production	Productivity
MP	0.40	0.13	0.34
UP	0.13	0.06	0.47
Maharastra	0.13	0.04	0.30
Bihar	0.06	0.03	0.57
India	**0.80**	**0.28**	**0.34**

Linseed is also cultivated in Assam, HP. J&K, Karnataka, AO, Nagaland, Orissa, Rajasthan, WB, and Punjab in India.

Origin

- No clear centre
- May be from Ethiopia
- Persian gulf
    - The Caspian sea and Black sea
- Possibilities of introduction to India
    - By Aryans from Central Asia
    - From Europe sources
    - Aryan materials crossed with other species
    - Independent origin of Peninsular linseed in the South and Gangetic linseed in the North

The plant

- Annual herb
- Tap root system
    - Gangetic group – shallow with secondary roots
    - Peninsular – deep tap root – drought tolerant
- Stem either erect or procumbent
    - Fibre varieties are thin, tall growing, less tillering
    - Oil seed are dwarf, highly tillering and branched
- Leaves
    - Attractive
    - Linear to lanceolate

    - Smooth, margin entire, tapering to blunt apex
    - Green to bluish green with variable size & thickness
- Inflorescence
    - Carymbose, with single flower
    - Petals 5, varying colors
    - Ovary is 5 celled, each locule divided into two by false septum thus making 10 roomed capsule with each with one ovule
    - The fruit is capsule of 5-10mm diameter
    - Mature capsule is dehiscent
- Seeds
    - Oval, smooth, shiny and pointed
    - Seed color varies from pure yellow, yellowish with brownish tinge, light brown, to deep brown
- Pale yellow – edible
    - Linola, Linoleic is higher
- Brown – industrial purpose

Climate

- Requires moderate to cool temp during vegetative
- Dry weather during maturity
- Crop for oil seed
    - Moderate cool climate
- Crop for fibre
    - Cool and moist climate
- Susceptible to frost
- Fairly resistant to drought
- Well distributed rainfall, but not heavy rains
- Also grown as irrigated in dry regions

Soils

- Variety of soils except sandy and poorly drained soils
- Well drained fertile, medium heavy soils, silty loam, clay loam and silty clay are best
- Soil pH 5.0 to 7.0
- Acid range 6.0 is more suitable
- Oil content decreases but iodine increases under saline

Management

- Field preparation
    - Beds and channel
    - For rice fallow in standing crop
- Varieties
    - For ‘Rice fallow’ – R 552
    - For ‘ Rainfed’ – Kiran, Sheetal
    - For Irrigated – Jawahar 23
    - For both rainfed & irriagted situation of Assam, Bihar, WB & Punjab:
        - Shubra, Himalini
- Season

    - Oct – Nov 15th
    - Middle of October is best suitable
- Seed rate
    - 25-50 kg varies due to
        - States
        - Varieties
        - Methods
    - Bold seeded 50 kg
    - Rice fallows
        - 35kg cuscuta free seeds
- Spacing
    - Drill seeding
        - 20-30cm row
        - Plant to plant 7-10cm
    - Rice fallow
        - Broadcast seeding
- Depth of sowing
    - 2-3cm, shallow seeding is good
- Seed treatment
    - With fungicides before sowing

Nutrient Management

- Irrigated crop
    - Seed purpose: 90:30:30
    - Double purpose: 120:40:40
    - Apply N in 2 splits
        - Basal
        - At first irrigation – 25-30DAS
- Rainfed
    - 40:20:20 all basal
- Rice fallow / Utera / Piara
    - Management starts with previous rice
    - Nutrients applied to rice
    - Leveling, weed management and water management all like rice fallow pulse of Tamil Nadu

Water Management

- Responds well to irrigation
- >90% is rainfed even then one or two irrigations will enhance the yield
    - Two irrigations at 35 & 75 DAS
    - In light soils 3-4 irrigations
    - Drought during after flowering reduces the seed yield
    - Moisture stress at stem elongation benefits seed yield
    - With more (>4) number of irrigations
        - WUE decreases
        - Oil content decreases

Weed Management

- Crop-weed competition is – 20-45 DAS

- Hoeing and aerating 15 and DAS
- Herbicides:
    - PPI – Fluchloralin @ 1.0 kg
    - PE – Methabenzthiozuran @ 1kg
    - Post Emergence – Dichlofop-methyl @ 0.7 kg at 30 DAS
- Cuscuta is menace with linseed
    - Crop rotation with non-host cereals
    - Herbicides:
        - Pronomide @ 1.5kg as post-emergence at 2-3 weeks stage
        - PPI of Fluchloralin itself is sufficient to reduce infestation

Maturity

- When the stem become
    - Woody
    - Capsules turn hard
    - Leaves dry
    - the capsules turn brown and
    - the seeds become shiny

Harvest

- Sickle the entire plant

Threshing & Post harvest processing

- Cut crop is field dried for 3-4 days
- Plants with secondary and tertiary branches to be separated with capsules for seed
- After threshing for seeds stalk are processed for fibre

Retting

- It is a process of fibre extraction
- Kinds of retting
    - Hot water, cold water, snow, dew retting
    - Temp decides duration of retting and quality
    - Standing warm water is more suitable than running cold water
    - Double retting is in practice in cold countries
    - Retting period is 4-6 days
- After retting cleaned in running water, dried and ready for scutching
    - To separate the valuable fibers of (flax, for example) from the woody parts by beating
- Rainfed areas in India water availability is problem hence they are not opting to fibre flax

Oil quality

- Depends up on hull thickness
- Yellow seeds possess thin hull and more oil
- Refining the pigments are necessary to improve the quality

Fibre

- Great strength, fineness & durability
- Less stretchy, more durable and better resistant to environmental fluctuations than cotton and jute

Double Purpose Linseed

- Looking for fibre and oil is advantageous

- Varieties needed for this purpose
- Double purpose varieties may show differential response
    - In temperate region with long growing period, controlled supply of N can do the need
    - Extraction of fibre requires cooler climate for retting
    - This is a major limitation in our country
    - Of late invention on development of dry scutching machine may be a boon to produce fibre from oil seed stems too

Cropping systems

- As pure crop
    - Cultivation is restricted to areas where no other crop is possible
    - Productivity under the situation is very low & subject to pests and disease outbreak
- As sequential crop
    - Hybrid maize – linseed + wheat
    - Groundnut – linseed + wheat
    - Rice (early) – linseed
- An intercrop
    - Linseed + chickpea / wheat / potato / safflower

Linola

- A new crop developed
- Low linolenic acid mutants
- Have elevated levels of linoleic acid, 65 - 76%.
- Reduction in linolenic acid greatly increases the oxidative stability of the oil
- It becomes an edible PUFA oil equal to sunflower in fatty acid
- The colour of the seed is also changed, with edible linseed being a pale yellow colour enabling it to be distinguished from non-edible linseed, which is brown

Development of edible linseed is a joint venture between

- CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) and United Grain Growers Ltd of Winnipeg, Canada (UGG Ltd)
- This crop has been named Linola.
- Linola is a registered trademark of CSIRO
    - Specialty of Linola – it's oil quality
    - Mostly cultivated in Australia & Canada
    - 60-130 thousand ha =(0.06 to 0.13 m ha)

Fatty acid composition of Linola with 5 major vegetable oils (%)

Crop	Saturated	Mono unsaturated	PUFA		P/S
		Oleic	Linoleic	Linolenic	
Linola	10	17	71	2	7.3
Safflower	10	14	76	Trace	7.6
Sunflower	12	16	71	Trace	6.0
Maize	13	29	57	1	4.5
Soybean	15	23	54	8	4.1
Canola	7	61	21	11	4.6

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Lesson 9

Niger

Guizotia abyssinica

Niger

- An oil seed for poor soils and coarse texture
- It is the crop suits in soils wherein all other crops are not possible
    - Like Horsegram in the tropics
- It is a minor oil seed cultivated in smaller area of the world

Importance of Niger

- Primarily (75%) for oil extraction
- Also used as food including confectionaries (18%) in India
- It is feed to birds in western countries
    - Export value for India
- Plant is feed to sheep but only silage to cattle
- Cake is valuable cattle feed
- Seed contains 35-40% oil
- Oil is pale yellow with nutty taste and a pleasant odour
- Keeping quality is poor due to oxidative rancidity
    - Olieic acid 38%, Linoleic acid 52%
- Oil is used for
    - Culinary purpose
    - For anointing the body
    - Manufacture of paints and soft soaps
    - Lighting and lubrication
- Niger oil is a good absorbent of fragrance
    - Used in perfume industries

- Oil a substitute for sesame oil in pharmaceutical purpose
- Niger based agar medium
  – to distinguish *cryptococcus neoformans*, a fungus that causes a serious brain ailment

Distribution and area of Niger in the world

Major countries:

- World area is around 1.0 million ha
- India & Ethiopia posses the major area
  - In Ethiopia it is cultivated in water logged soils where most other crops fail to grow

Other Countries:

- Sudan, Uganda, Zaire, Tanzania, Malawi, Zimbabwe, Pak, West Indies, Nepal, Bhutan & Bangladesh

Niger area in India (million ha & million t)

States	Area	Production	Productivity
MP	0.20	0.043	0.215
Orissa	0.15	0.047	0.309
Maharastra	0.06	0.019	0.280
Karnataka	0.04	0.008	0.182
All India	0.52	0.150	0.286

Other states which also cultivate niger are Bihar, AP, Assam & WB

Origin

- From the highlands of Ethiopia
- From Ethiopia migrated to East Africa
- During the beginning of 2nd millennium BC to India

The Plant

- Annual dicotyledonous herb
- Seedlings
  - Pale green to brownish hypocotyls and cotyledons
  - The cotyledons remain on the plant for long time
- First leaf is paired and small
- Successive leaves are larger and opposite
- Leaves are sessile, lanceolate
- Softly hairy on both surfaces
- Dark green is usual color
- But lower leaves pale yellow
  - The stem is usually round, smooth to slightly rough
- Approximately 1-2 cm diameter
- Can grow up to 1.5 m
- Stem are hallow and break easily
- Color is green to reddish green

- Moderately branched
    - The capitula are surrounded by leafy involucres bracts
- Outer bracts being leaf like
- Inner smaller and finally merges with flattened paleas
    - The fruit is achene, typical of the composite, small.
    - Seed is 3-5mm length and 1.5mm width, lanceolate in shape
    - The testa is hard, glossy, and usually black
    - Normally 1000 seeds weighs 3-5g
    - There are 15-30 seeds/head
        - Sometimes more with immature seeds

The Climate

- It is temperate region crop
- Adapted to semi-tropical
- Performance is better between 500 -1000m elevation though suits up to 2500m
- Moderate Temp during growth
    - 18-23°C
    - >30°C growth adversely affected
    - Indian strains are less affected by temp compared to Ethiopian
- Frost will kill the young plant
- 1000-1300 mm RF can be tolerated but not >2000mm
- Peak flowering should not coincide with heavy rain
    - High wind – seed shattering
- Tolerates excess moisture and drought

The soils

- On wide range of soils
- Light textured soil but well drained heavy soil is also suitable
- pH 5.2 – 7.3
- Can tolerate water logging
    - Under waterlogged soil it develops aerenchyma cells
- It can grow in saline but increased salinity
    - Flowering gets delayed
- It can under dry soil
    - but not a dry land crop

Management

- Field
    - It is small seed hence requires fine seed bed
- Season
    - Aug-Sep
    - After a Kharif crop or early Rabi
- Varieties
    - No 71
    - IGP 76
- Spacing & Seed rate
    - 5 to 8 kg

        - Row width varies from
            - 20 to 30cm
        - Between plants
            - 10 or 15 cm
    - Method of sowing
        - Most common is broadcasting
        - Drilling by seed drill is advanced and more useful
        - Depth of sowing 1-3cm
    - Seed treatment
        - With fungicides
        - Void mixing with fertliers

Nutrient management

- Cultivated in poor soils with less input due to
    - Poor economy of the farmer
    - Poor economic return of the crop
- Response to fertilizers in rainfed is poor
- A schedule of
    - 20:20:0 is recommended
        - N in two splits, at sowing and 30 DAS
        - K is recommended in Karnataka @ 10kg
    - 40:40:0 is recommended in Orissa

Weed management

- Niger grows rapidly and covers quickly the surface
- One or two weedings – sufficient
- Dodder (Cuscuta) infested areas are there (Orissa)
    - Cuscuta free seeds
    - Herbicide Chlorpropham G at dodder germination @ 4kg /ha
    - Pronomide @ 2kg/ha as pre-emergence soil treatment or as foliar spray 20 DAS

Water management

- Very rarely grown as irrigated in India
- Crop is sensitive to moisture stress at early stage
- Schedule according to soil and climate
- Further research needed in this area
- Check basin or border strip is ideal methods

Maturity & harvest

- Duration varies 80-145 days
- Delayed harvest leads to shattering
- Seeds are loose in head, hence over maturity leads to grain shattering (25%)
    - When the leaves dry up, harvest it
- Harvesting like gingelly,
    - When the bud moisture is 45-50%
- Stacking in the floor for a week and drying and cleaning, as usual

Yield potential

- Normally 300-500kg but up to 1000kg/ha
- When intercropped

- 400 kg with sunflower
- 100 kg with sorghum

Cropping systems

- Sequential cropping
  - Little millet or finger millet – Niger
- Intercropping
  - Niger + sunflower (4:2)
  - Niger + soybean (2:1)
  - Niger + peanut (2:2)
  - Niger + blackgram (3:3)
  - Niger + castor

Cropping systems

- Preceding pulse is more remunerative than sole crops

Some more edible oil seeds

Oil Palm

Elaeis guineensis

- Originated in West Africa
  - But has planted successfully in tropical regions within 20 degrees of the equator
- An oil produced to 21.5million t in 2000
- Area grows annually by 2%
- World's largest producer and exporter - Malaysia - 47%
- Indonesia is the second largest world producer -36%
- Both are expanding their palm oil production
- Both pulp and seed contains oil
  - Pulp contains 20%
  - Seed 1.6%

Simarouba

Simarouba glauca

- Paradise tree
- Edible oil 42% by seed and 65% kernel
- Introduced into India

Olive *(Elaeagnus angustifolia L.)*

- Olive oil is an oil derived from the fruit of the olive tree, which originated in the Mediterranean area.
- It has a very high content of monounsaturated fats.
- Nowadays, olives are ground to tiny bits, obtaining a paste that is mixed with water and processed by centrifugation, separating the oil from the pomace (the other remaining substances).
- Edible commercial olive oil can be divided into several categories according to its chemical characteristics and the production method:
  - Extra Virgin Olive Oil,
  - Virgin Olive Oil, and

    - Olive Oil.
- The first two, virgin olive oils, are obtained only by physical extraction from the fruits.
- Non virgin olive oil is obtained by the chemical refining of a low-quality non-edible grade of virgin olive oil called "lampante" olive oil

The list enlarges this way:

- Corn oil
- Soybean oil
- Rice bran oil
- Coconut oil

Lesson 10

SUGARCANE

Importance

- 62% world's sugar is met from cane
- Sugar requirement is projected at 150 million tonnes for the world
- India alone requires 16-20 million t
- Sugar industry is the largest agro-based industry next only to textiles in India
- At present there are 450 sugar factories
- Average productivity is 14.2 million t (1998)
- Average sugar recovery of 11%

By products in sugarcane industry

- There are many end uses - probably more than 150
- But many of them are of negligible economic interest
- 38 end-products are potentially important
- But four main byproducts of the sugarcane are:
    - Cane tops
    - Bagasse
    - Filter mud / press mud and Spent Wash
    - Molasses
- Cane tops
    - Cane tops have no real market value
    - They can be compared to fair quality fodder with an average feed value,
    - when fresh, of about 2.8 MJ of metabolizable energy per kilo of dry matter.
    - However cane tops should be collected and transported from the cane fields to the feedlot
- Bagasse
    - It is the fibrous residue of the cane stalk left after crushing and extraction of the juice
        - It consists of fibres, water and relatively small quantities of soluble solids - mostly sugar
    - Utilizations are:
        - Electricity
        - Particle board
        - Paper
        - Furfural
            - It is a colorless, inflammable, volatile, aromatic liquid
            - 25 tonnes of bagasse to produce 1 tonne of furfural
            - Furfural has many industrial uses:
            - Selective solvent for the refining of lubricating oils
            - As an intermediate in the production of nylon and resins
        - Methane
- Filter mud / pressmud

- The precipitated impurities contained in the cane juice, after removal by filtration, form a cake of varying moisture content called filter mud
- This cake contains much of the colloidal organic matter anions that precipitate during clarification, as well as certain non-sugars occluded in these precipitates

- Filter mud / pressmud…
  - The use of filter mud
    - As animal feed has not proved economically rewarding, the main constraints being the magnitude of the drying process involved and the low digestibility of the dried scums
    - As soil nutrient there is limitations
      - Higher values of C.O.D. and B.O.D .
      - Wax percentage in substantial quantity which prevents microbial action
      - High concentration of various chemicals which are detrimental to survival of beneficial microflora
      - Bio-degradation being exothermic reaction survival of microbes except thermophiles is difficult
      - Due to above mentioned difficulties, bio-degradation of pressmud and spent wash is a difficult process

- Molasses
  - Molasses is the final effluent obtained in the preparation of sugar by repeated crystallization
  - It is the residual syrup from which no crystalline sucrose can be obtained by simple means
  - The yield of molasses is approximately 3.0 percent per tonne of cane
    - but it is influenced by a number of factors (2.2 to 3.7 percent)
    - The specific gravity varies between 1.39 and 1.49, with 1.43 as indicative average
  - The composition of molasses varies but, on average, would be as follows:
    - Water 20%
    - Other carbohydrates 4%
    - Sucrose 35%
    - Nitrogenous compounds 4.5%
    - Fructose 9%
    - Non-nitrogenous acids 5%
    - Glucose 7%
    - Ash 12%
    - Other reducing sugars 3%
  - For distillery industry
  - Alcohol and related products
  - Export to some developed countries as raw materials
  - It is an ingredient to animals feed

Origin

- India is considered as native to thin cane

- Tropical thick canes from larger islands of Oceana with New Guinea as possible nucleus
    - Brandes (1956) – three different movements
        - Introduction to Solomon islands - 8000 BC
        - Westerly direction to Indonesia and Philippines – 6000 BC
        - Fiji, Tonga, Samoa, the Cook islands & Hawaii – 600-1100 AD

World Scenario (Area, production, productivity, in million ha, tonne and t/ha)

Country	Area	Production	Productivity
Brazil	4.92	338.7	68.7
India	3.96	265.0	66.9
China	1.21	85.7	71.3
Pak	1.14	53.0	46.7
Asia	8.67	536.7	61.9
S. America	6.05	419.6	69.4
N. C. America	3.21	166.7	52.0
Africa	1.43	85.7	57.9
World	19.90	1254.9	63.1

Indian Scenario (Area, production, productivity, in million ha, tonne and t/ha)

State	Area	Production	Productivity
UP	2.10	124.8	59.4
Maharastra	0.52	41.8	81.0
TN	0.27	26.9	99.3
Karnataka	0.25	21.9	85.9
AP	0.20	14.9	75.1
Punjab	0.17	11.0	63.8
Gujarat	0.16	11.4	68.8
Haryana	0.16	9.0	55.0
Bihar	0.14	6.3	45.2
MP	0.06	2.2	38.1
India	3.96	265.0	66.9

Species of sugarcane

- Cultivated
    - *Saccharum officinarum*
    - *S. barberi*
    - *S. sinense*
- Wild species
    - *S. spontaneum*
    - *S. robustum*

The plant

- Grass family with tillering capacity
- Above ground parts are
    - Stem of stalk with nodes and internodes
    - Leaves

    - Inflorescence
- Roots
    - Sett roots developed from root primordial
    - Shoot root , thicker branched
    - Buttress roots, fibrous branched

Varieties

- After the introduction of hybridization programme in early 20th century many improved varieties are available
- Varieties for region and season are available in plenty
- SBI, Coimbatore in collaboration with NARS has set up breeding programme
- Breeders of NARS will visit and at a specified period and carry materials

Seasons

- There are four main seasons in TN
    - Early – Dec-Jan
    - Mid-season – Feb-Mar
    - Late – Apr – may
    - Special season – June-July
- All India
    - Spring – Feb-Mar
        - *Suru* in Maharastra, *Eksali* in Gujarat & AP
    - Autumn – Sep-Oct-
        - 13-15 months, supplies sugar for early crushing
    - Adsali – July Aug
        - 16-18 months
        - Increase in yield & sugar recovery
        - Though advantageous area is declining due to water problem
    - Late planting – beyond March, reduction in duration and yield

Soils

- Cultivated in wide range of soils
- Moderately heavy medium deep (1-2m) loams are better than
    - Heavier and shallow soils
- The soil must be of good depth and drainage
- No salt and compaction

Seed bed

- **Preparation of good seed bed is essential**
    - Since the same field is retained for 2-3 years
    - Deep ploughing / sub-soiling is needed
- **Field Layout**
    - In India - by adopting two systems viz.,
        - Ridge and furrows system
        - Flat system.
    - There are some special systems
        - Trench system
        - Deep Trench system
        - Paired - row system
        - Ring or pit system etc.

Planting materials

- **Vegetative propagation**
  - Known as seed pieces or setts
  - Buds on sugarcane germinate and give plants
  - Planting materials may be
    - Single bud sett or Chip bud
    - Two budded setts
    - Three budded
    - Seedlings raised from nursery
    - Seedlings raised by poly bags or
    - Tissue cultured seedlings
  - For sett planting
    - Sugarcane setts are prepared from nursery cane
    - Nursery cane is younger than (6-8 months) juice cane

Ideal cane sett

- Ultimate plant stand and yield depends on the type of seed material used. The characteristics of good seed cane material are
  - Free from disease and pest infestation
  - Age of seed crop is around eight months
  - Setts should have healthy buds without any damage in handling and transport
  - Buds with higher moisture content, adequate nutrients, higher amount of reducing sugars
  - Cane should be free from aerial roots and splits
  - Pure in quality

Preparation of setts

- Use of sharp knife to cut setts
- Treat the setts immediately with fungicide solution
- Machine cutting and mechanical planting is also followed in developed counties
- **Seed rates & spacing**
- Depends up on the spacing
- Spacing varies due to
  - Climate
  - Method of establishment
- In TN
  - 50,000 three budded setts
  - 75,000 two budded setts
  - 187,500 single budded setts
- Row spacing may vary
  - 0.9m to 1.5m and 2.4m

Method of planting

Flat Planting

- In this method, shallow (8-10 cm deep) furrows are opened with a local plough or cultivator at a distance of 75 to 90 cm
- There should be adequate moisture in the field at the time of planting
- The setts are planted in them end to end

- Furrows are covered with 5-7 cm soil
- In most parts of northern India and some tracts of Maharastra, cane is planted by this method

Furrow Planting

- In this method furrows are made with a sugarcane ridger about 10-15 cm deep in northern India and about 20 cm in south India
- Setts are planted end to end
- The furrows are covered with 5-6 cm soil, leaving upper portion of furrows unfilled
- Immediately after covering the setts water is let into furrows
- This method is practiced in parts of eastern UP and in Peninsular India, particularly in heavy soils

Trench 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 cm are dug with the help of ridger or by manual labour
- Trenches should be about 20-25 cm deep
- Fertilizers (NPK) are spread uniformly in the trenches and mixed thoroughly in the soil
- The setts are planted end to end in trenches
- The tractor-drawn sugarcane planter is a very suitable device for planting cane in trenches

Modified trench system

- Ridges and furrows are opened at 120 cm using a tractor drawn ridger
- The furrow bottom is widened
- As the crop grows while each manuring, only slight earthing up is done so that a trough is maintained through the crop growth
    - Here irrigation is given in the cane row itself
- The system has been found highly useful under :
    - Saline water irrigated and saline soil conditions
    - The salts are leached down from the root zone
    - Higher cane yield compared to conventional ridges and furrows
    - FYM or pressmud application and trash mulching in this system can further improve cane yield

<u>Special methods of establishment</u>

Single bud direct planting

- In this system single bud setts are planted directly in the field in the furrows at 30-45 cm spacing
- This method is highly economical and sowing of seed material.
- The buds should be healthy

Transplanting technique (STP technique)

- Seedlings are raised in a nursery bed using single bud setts.
- About 6 weeks old seedlings are transplanted

- Advantages by adopting this system are
    - Saving in the seed cost
        - Only about 2-3 t/ha against the normal 8-10 tonnes/ha.
    - Synchronous tillering leading to uniformly maturity
    - Sufficient time availability to prepare the main field
    - Saving of 2-3 irrigations
    - Possibility of increased cane yield
    - Better weed management
    - Efficient fertilizer management

Partha" method

- A technique developed by Mr. S.V. Parthasaradhy an eminent sugarcane scientist.
- Suggested for water logged or excess soil moisture conditions (coastal Andhra Pradesh and Tamil Nadu during N-E monsoon period)
- In this method
    - three eye budded setts are planted in a slanting position, 60° to the vertical, in the wet furrow or half-way on the ridges
    - Usually one eye bud is thrust into the soil and the remaining two will be above, which will sprout
    - Once the monsoon recedes, the *in situ* sprouted setts are pressed down into the soil and made to lie horizontally
    - Soil is put to the base
    - At this stage, the crop is manured

Measures to obtain higher germination

- Using disease free healthy setts
- Careful preparation of setts without damaging the buds or setts
- Planting freshly prepared and treated
- Trash mulching under
    - moisture stress and hot weather and late planted conditions
- Seed treatment using a fungicide

Manures for Sugarcane

- Apply FYM / Compost during field preparation
- Inorganic fertilizers:
    - For Coastal and flow irrigated areas
        - 270 : 112.5: 60 N: P2O5: K2O kg /ha
            - N & K applied in three equal quantities at
            - 30, 60 and 90 DAG
            - N may be coated with neem cake @20%
    - For Lift irrigated areas
        - 225 : 112.5: 60 N: P2O5: K2O kg /ha
    - For Jaggery producing areas
        - 175 : 112.5: 60 N: P2O5: K2O kg /ha
- For those soils deficient in …
    - In iron : 100 kg ferrous sulphate /ha
    - In Zinc : 37.5 kg Zinc sulphate
- Foliar application and drip fertigation can
    - Reduce N dose

    - Increase cane yield
    - Save ground water pollution by fertilizers
- Azospirillum application can enhance the growth
- Band placement of fertilizer is another method by which losses can be minimized

Irrigation

- To support and sustain a vigorous nursery crop, irrigating at optimum levels in important
- Any shortage in the irrigation would lead to reduced sett yield
- Moisture stress would pre-dispose the crop to the attack of some pests and diseases
- Irrigation at IW/CPE ratio of 1.0 is ideal
    - According to moisture depletion irrigating at 25% depletion of available soil moisture (ASM) may be ideal
    - This in practical terms means:
        - Once in 6-7days in a loamy soil and
        - At around 10-12 days in heavy day soil

Weed control

- A weed-free environment is absolutely essential
- Deep ploughing and removal of perennial weeds
- Pre-emergence application of
    - Atrazine 1.75kg or Oxyflurofen 0.75 lit/ha on 3-4 days of planting using knapsack sprayer
- Post-emergence application of
    - Gramaxone 2.5 lit + 2-4,D Sodium salt 2.5 lit/ha as directed spray on 21 DAP
- Hand weeding before each manuring
- Other cultural operations and precautions

Cultural operations

- Important cultural operations in sugarcane in addition to weeding, manuring and irrigation are
    - Earthing up
    - Detrashing
    - Propping and
    - Flowering control

Earthing-Up

- This practice is followed where furrows are practiced
- Earthing up are 2-3times during crop period.
    - The first earthing-up is known as "partial earthing-up and
        - To cover the fertilizers
        - To provide anchorage to root system
    - The second operation is "full earthing-up".
        - Full earthing-up is done after final manuring (90-120 days coinciding with peak tillering)
        - The soil from the ridge is thrown on both sides towards cane rows and the furrows will become as ridges and ridges as furrows
        - The furrows so formed are used for irrigation

Wet earthing up

- Done around 6months age of the crop
- The furrows are irrigated and the wet soil from furrows is taken and plaster the ridges
    - It checks late tillering and watery shoots
- Heavy earthing up is useful during floods
    - When the flood water recedes, the excess water from earthed-up soil drains out quickly thus providing aeration

Hoeing

- This operation is done where soil crust formation is very common
- In sub tropics hoeing is done after germination is over using a bullock drawn or a tractor - drawn harrows

Hoeing

- While carrying out this operation some of the germinated setts may be uprooted and they are pressed down manually

Detrashing

- On an average a stalk may produce30-35 leaves
- All are not useful for effective photosynthesis
    - Only the top 8-10 leaves are sufficient
    - Most of the bottom leaves are dried will not participate in photosynthesis
    - At the same time they drain out the food materials which otherwise could be used for stalk growth
- Therefore it is important to remove the dry and lower leaves
- This operation is known as detrashing
- Detrashing helps in clean cultivation
- Easy movement of air within the crop canopy
- Reduce certain pests like scales mealy bugs, white fly etc.,
- Easy entry into the field
- Avoids bud germination due to accumulation of water in the leaf sheath
- Easy to take up cultural operations including sprayings
- Easy to harvest, obtaining clean canes for milling
- Detrashed leaves can be used for
    - Mulching in the furrows or
    - Used for composting
    - Infested leaves with pest or disease may be burnt out

Propping

- Tying the canes by using the lower bottom leaves to check lodging of cane
- Propping can be either done for each row or two rows can be brought together and tied
- It is for:
    - Prevention the lodging
    - Extensively followed in coastal belt where cyclone effect is very severe
    - Lodging also very common in
        - Tall varieties
        - Top growth is heavy and where the growth habit is not erect, and
        - The varieties with less fibre content

Lodging leads to several problems

- Cane breakage and thus loss of stalk number at harvest loss
- Lodged canes are easily infested by certain pests and diseases
- Damage by rats and rodents
- Bud sprouting leads to reduced cane quality
- Aerial root formation affects cane quality
- difficult to irrigate and harvest the cup

To prevent lodging

- Heavy earthing up
- Propping
- Paired row planting with earthing up
- Deep trench planting
- Selection of varieties resist lodging
- Raising wind breaks along the field borders
- Application of potassium

Removal of water shoots

- Water shoots are late formed tillers or side shoots which are robust and fast growing.
- They originate mainly due to excess water supply, heavy and late manuring, inadequate earthing up
- These water shoots contain lot of water, low sucrose and more of reducing sugars
- Water shoots affect the growth of adjacent stalks
- They harbor insect pests and when they are milled sugar recoveries are low because of reduced juice quality
    - Therefore removal of water shoots whenever they appear
    - Water shoots can be used as cattle feed

Control of flowering

- In commercial sugarcane cultivation, flowering is not desirable
- Once the plant flowered the cane growth stops and starts ripening
- If not harvested immediately reversion of sugars, increase in fibre, pith formation, cane breakage etc.
- The deterioration is much faster if it is summer
- Solution
    - Non-flowering or shy flowering varieties can be used where flowering is a severe problem
    - Controlled irrigation
    - Change of planting period
    - Use of growth regulating substances
        - Spraying of ethrel at 500ppm, twice or 1000ppm once at floral initiation

Ratoon Management

- The crop raised from planting cane sett is called plant crop
- After the harvest of plant crop stubble sprouts and gives rise to succeeding crop called as ratoon crop
- The practice of taking up ratoon crop is called ‘ratooning’

Ratooning ability

- Is generic, based upon ability ratoon varieties are classified as:
    - Good or poor ratooner
    - Co 1148, Co 419, Co 740 are some examples for good ratooners
- Ratooning has following advantages:
    - Reduction in the cost of field preparation, planting material, operation cost
    - Saving in field duration – ratoon matures earlier than plant crop
    - Ratoon may give equal yield that of plant crop

Ratooning is common practice

- Number ratoon varies
    - In Cuba 10-11 crops
    - South Africa & USA 4-6 crops
    - Hawaii, Brazil and Australia 2-3
    - In India ratoon yield is generally poor since
        - Very little attention to manure ratoon
        - 30-40% area is under ratoon in India
        - The average productivity is low

Ratoon management

- Select variety suitable during plant crop
- Plant crop should be harvested at right maturity
    - Delayed harvest to be avoided
- Harvesting close to the ground with sharp cutting
    - Stubble shaving to 4-6cm is recommended if no uniform cut at harvest
- Remove the trash but do not burn it
- Irrigated the field properly
- Shoulder breaking or off-barring to remove decayed stubbles
- Gap filling with sprouted setts or seedlings
- Ratoon is less efficient in N utilization hence 25% additional N from 5-7 days after ratooning is desirable
- P & K should be judiciously
- Spraying of FeSO4 @ 2.5kg/ha in 150 litres on 15th day if chlorotic symptom is noticed
    - If persists repeat twice at 15 days interval
    - In the last spray add 12.5kg urea
- After cultivation practices to be done more effectively
- Ratoon requires more plant protection
    - Grassy shoot disease, ratoon stunting

Maturity and harvest

- Ripening of sugarcane refers to rapid synthesis and storage of sucrose in the stalk
- Accumulation of sugar in the stalk starts soon after completion of elongation phase
- Glucose produced during photosynthesis is not utilized for conversion but stored as sucrose
- When the concentration exceeds 16% in the juice and 85% purity the cane is said to be matured
- As the crop advances in maturity:
    - Water content decreases

    - Sucrose content increases
    - Reducing sugars decreases
        - Both organic and inorganic non-sugars also decreases
    - At peak maturity sucrose content is at maximum and non-sugars at minimum
- Assessing maturity
    - Use of hand refractometer - Brix reading
    - Assess the maturity by HR meter survey – 18-25% indicates optimum maturity
    - When the reading between top and bottom is 1:1 – is right time to harvest
        - If delayed
            - Sucrose content decreases
            - Non-sugars increases
            - Fibre content increases
- Ripening is influenced by number of factors
    - Climate
    - Nutrition
    - Variety
- Cool dry weather is the key factor
    - Bright sunshine
    - Day temp 28-30C
    - Night temp 12-14C
        - RTD (Relative temp disparity) decides
- Ripeners
    - Spray Sodium metasilicate 4kg in 750 litres /ha 6 months after planting
    - Repeat at 8th & 10th months
        - and not at declining phase
    - Polaris and Ethrel are most extensively used in Hawaii
        - Polaris @ 5 kg in 600 l /ha

Cropping systems

- Intercropping
    - Since a slow grower during initial 2-3 months may be an intercrop raised
    - The crop should not affect cane yield
    - Marketability, ability and feasibility decides the short crops
    - Pulses, potato, onion etc are some
- Sequential cropping - Rotations
    - After sugarcane 1 or 2 or 3 crops
        - Rice based cropping system for one year
        - Wheat based
        - Sugarcane-banana- rice based crop rotations

Lesson 11

TROPICAL SUGARBEET

Beta vulgaris spp. *Vulgaris var altissima Doll*

Importance of sugarbeet

- Tropical sugarbeet is a biennial sugar producing tuber crop, grown in temperate countries
- This crop constitutes 30% of total world production and distributed in 45 countries.
- Now tropical sugarbeet hybrids are gaining momentum in tropical and sub tropical countries including Tamil Nadu as a promising energy crop and alternative raw materials for the production of ethanol.
- Apart from sugar production, the value added products like ethanol can also be extracted from sugarbeet.
- The ethanol can be blended with petrol or diesel to the extent of 10% and used as bio-fuel.
- The sugarbeet waste material *viz.,* beet top used as green fodder, beet pulp used as cattle feed and filter cake from industry used as organic manure.

Tropical sugarbeet now emerged as commercial field crop because of the favourable characters like

- tropical sugarbeet hybrids suitable for Tamil Nadu
- Shorter duration of 5 to 6 months
- needs moderate water requirement of 60-80 cm.(iv) higher sugar content of 12 – 15% (v) improve soil conditions because of tuber crop and
- grow well in saline and alkali soil.
- The harvesting period of sugarbeet coincides with March – June, the human resource of sugar factory in the off season may efficiently utilized for processing of sugarbeet in the sugar mills, which helps in continuous functioning of sugar mills.

Hybrids and duration

The tropical sugarbeet hybrids suitable for cultivation in Tamil Nadu are

- Cauvery,
- Indus and
- Shubhra.
- The duration of these tropical hybrids will be 5 to 6 months depending on climatic conditions prevailing during crop growth period.

Climate and season

- Tropical sugarbeet require good sunshine during its growth period.
- The crop does not prefer high rainfall as high soil moisture or continuous heavy rain may affect development of tuber and sugar synthesis.
- Tropical sugarbeet can be sown in September– November coincide with North East monsoon with a rainfall of 300 – 350 mm well distributed across the growing period which favours vegetative growth and base for root enlargement.
- The optimum temperature for germination is 20 – 25^0C,
- for growth and development 30 - 35^0C and

- for sugar accumulation in 25– 35^0C.

Season

- September to November and harvested during March and May.

Field preparation

- Well drained sandy loam and clayey loam soils having medium depth (45" cm) with fairly good organic status are suitable.
- Tropical sugarbeet require deep ploughing (45 cm) and followed by 2 – 3 ploughing to obtain a good soil tilth condition for favorable seed germination.
- Ridges and furrows are formed at 50 cm apart.

Manures and Fertilizers

Manures and Fertilizers	Basal Application	Top dressing
Manures	12.5 tonnes /ha	-
Biofertilizers		
Azospirillum	2 kg /acre (10 pockets)	-
Phosphobacteria	2 kg /acre (10 pockets)	
Fertilizers		
Nitrogen	75kg /ha	37.5 kg / ha each at 25 & 50 DAS
Phosphorus	75kg /ha	
Potassium	75kg /ha	--

Seeds and sowing

- Optimum population is 1,00,000-1,20,000 /ha.
- Use only pellated seeds 1,20,000 Nos /ha which require 6 pockets (3.6kg / ha.- One pocket contains 20000 seeds (600 g)]
- The recommended spacing is 50 x 20 cm.
- The pellated seed is dibbled at 2 cm depth in the sides of ridges at 20 cm apart

Weeding and Earthing up

- The crops should be maintained weed free situation up to 75 days.
- Pretilachlor 50 EC @ 0.5 kg /ha or Pendimethalin @3.75lit /ha can be dissolved in 300 litres of water and sprayed with hand operated sprayer on 0-2 day after sowing,
- Followed by hand weeding on 25^{th} day and 50th day after sowing.
- The earthing up operations coincides with top dressing of N fertilizer.

Irrigation

- Tropical sugarbeet is very sensitive to water stagnation in soil at all stages of crop growth
- Irrigation should be based on soil type and climatic condition.
- Pre-sowing irrigation is essential since at the time of sowing, sufficient soil moisture is must for proper irrigation.
- First irrigation is crucial for the early establishment of the crop.
- For loose textured sandy loam soil irrigation once in 5 to 7 days and for heavy textured clay loam soil once in 8 – 10 days is recommended.
- The irrigation has to be stopped atleast 2 to 3 weeks before harvest.
- At the time of harvest if the soil is too dry and hard it is necessary to give pre harvest irrigation for easy harvest. Light and frequent irrigation is recommended for maintaining optimum soil moisture

Pest and diseases

- Pests - Aphids, Tobacco caterpillar and Flea beetles

Diseases

- Root and crown rot, *Cercospora* leaf spot and Root knot nematode

Integrated pest and disease management

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed
- Summer ploughing and exposing the field to sunlight
- Crop rotation for 3 years with Marigold or gingelly or sunnhemp for root rot and nematode
- Soil application of *Trichoderma viride* or *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM before planting
- Sow castor as trap crop around and within fields to attract adult *Spodoptera* moth for egg laying
- Set up light traps (1 mercury / 5 ha) for monitoring *Spodoptera litura*
- Setting up pheromone -Pherodin SL @ 12/ha for *Spodoptera litura*
- Removal and destruction of *Spodoptera* egg masses, early stage larvae formed in clusters
- Hand picking and destruction of grown up *Spodoptera* caterpillar

Need based

- Spraying *Spodoptera* nuclear polyhedrosis virus at 1.5 x 1012 POB/ha
- Spray NSKE 5% for aphids flea beetles and for early instar caterpillars
- Use of poison bait pellets prepared with rice bran 12.5 kg, jaggery 1.25 kg, carbaryl 50% WP - 1.25 kg in 7.5 lit water for *Spodoptera litura*
- Spray any one of the following insecticides using a high volume sprayer covering the foliage and soil surface
- Chlorpyriphos 20 EC - 2 ml / lit,Dichlorvos 76 WSC - 1 ml/lit, Fenitrothion 50 EC - 1 ml/lit, Spray malathion 50 EC (2 ml/lit) for flea beetle and leaf webber, Spray Imidacloprid 200 SL (0.2 ml/lit) or methyl demeton 25 EC (2 ml/lit) or dimethoate 30 EC (2 ml/lit) for aphids
- Applying neem cake @ 150 kg/ha for root rot
- Foliar spray of Mancozeb 2.5 g / lit or Chlorothalonil 2 g / litre of water for *Cercospora* leaf spot
- Neem cake @ 1 t/ha or carbofuran @ 33 kg/ha as spot application on 30 days after sowing for nematode management

Harvest and yield

- The Tropical sugarbeet crop matured in about 5 to 6 months. The yellowing of lower leaf whirls of matured plant, Nitrogen deficiency and root brix reading of 15 to 18% indicate the maturity of beet root for harvest.
- The average root yield of tropical sugarbeet is 80 – 100 tonnes / ha.
- Harvesting should be timed so as the roots reach the factory within 48 hours for processing.
- Till such time the roots should not be harvested.

Lesson 12
FIBRE

What is a fiber?

- Sometimes, just a single cell (sclerenchyma) that is long and dead at maturity.
- Gives structural support to plant stems.
- Ones used for cloth are usually derived from herbaceous plants (but see bark cloth, below)
- Fibers often are associated with the vascular bundle of a stem.
- Sometimes the entire vascular bundle, that includes fibers as well as xylem and phloem is considered the "fibre" for spinning, such as in linen

Plant vs. animal

- Animal fibers such as wool and silk are composed mainly of protein (keratin and fibroin)
- Plant fibers are composed chiefly of cellulose
- But also may have lignin, tannins, gums, pectins and other polysaccharides
- Cellulose is very strong - tensile strength rivals steel

VEGETAL FIBRES

- FAO includes 12 primary crops and
- Five derived agricultural products

FIBRES OF ANIMAL ORIGIN

- Same uses as vegetal fibres,
- But are of much higher value

Vegetable fires

- COTTON
- FLAX - *Linum usitatissimum*
    - Flax is cultivated for seed as well as for fibre
    - The fibre is obtained from the stem of the plant
- HEMP - *Cannabis sativa*
    - *Synonyms*
    - *hemp,marijuana, bhang, ganja, hashish*
    - This plant is cultivated for seed & fibre
    - The fibre is obtained from the stem
- KAPOK - *Ceiba pentandra*
- JUTE
    - White jute (*Corchorus capsularis*)
    - Red jute, tossa (*C. olitorius*)
- JUTE-LIKE FIBRES
    - China jute *(Abutilon avicennae)*
    - Congo jute, malva, paka *(Urena lobata; U. sinuata)*
    - Indian flax *(Abroma augusta)*
    - Kenaf, Mesta *(Hibiscus cannabinus)*
    - Rosella hemp *(H. sabdariffa)*
    - Sunn hemp *(Crotalaria juncea)*
- RAMIE

    - China grass, white ramie *(Boehmeria nivea)*
    - Rhea, Green ramie *(B. tenacissima)*
- SISAL *Agave sisalana*
    - Sisal fibre is obtained from the leaves of the plant
- AGAVE FIBRES
    - Haiti hemp (Agave foetida)
    - Henequen (A. fourcroydes)
    - Ixtle, Tampico (A. lecheguilla)
    - Maguey (A. cantala)
    - Pita (A. americana)
    - Salvador hemp (A. letonae)
- MANILA HEMP Musa textilis
    - The fibre is obtained from stalks of certain banana trees
- COIR Cocos nucifera
    - Coir fibre is obtained from the fibrous covering of the mesocarp

Animals Fires

- WOOL
    - A natural fibre taken from sheep or lambs
- GOAT HAIR
    - Hair from cashmere, angora (mohair) and similar goats
- HAIR OF HORSES
- SILK WORM

Lesson 13
COTTON
Gossipium sp

Cotton

- It is white gold
- Backbone of textile industry
- Contributes 7% of GDP
- Providing employment to 60 million people in India
- 45% world's fibre need is met from
- 10% of world's edible oil

Importance of cotton

- It is cultivated primarily for lint
- Raw cotton is also used for medical and surgical purpose
- Linters are used cushions, pillows etc
- Also used for high grade paper, rayon, films, explosives
- Stalk is a fuel
- Seed crushed for edible oil
- Cakes and meals are excellent cattle feed

Cotton – World production Scenario (1996-97)

Country	Area -M ha	Lint -M tonnes	kg lint /ha
India	9.2	3.0	327
USA	5.2	4.1	792
China	4.7	4.2	890
Pak	3.2	1.6	497
Uzbekistan	1.5	1.0	689
World	33.8	19.4	574

+ Argentine, Turkey, Brazil, Turkmenistan, Greece, Australia, Egypt

Cotton – Indian Scenario (1996-97)

State	Area -M ha	Lint -M tonnes	kg lint /ha
Maharastra	3.10	Lint is 30% of Kapas0.56	182
Gujarat	1.52	0.43	282
AP	1.01	0.48	477
Punjab	0.74	0.27	367
Karnataka	0.67	0.15	229
Haryana	0.65	0.23	354
Rajasthan	0.65	0.24	364
MP	0.53	0.32	605
TN	0.26	0.09	360
India	9.17	2.97	327

Note: Lint is around 30% of kapas

- Cotton is cultivated in 9 states in India

- Area is classified as:
- Northern – Punjab, Haryana, NW Rajasthan & W. UP (hirsutum-arboreum)
- Central – Maharastra, MP, Gujarat & S. rajasthan (herbaceum – arboreum-hirsutum)
- Southern – Karnatak, AP & TN – (hirsutum- arboreum- herbaceum)

Origin

- Old world cotton with 'A' genome may be from Southern Ethiopia
- *G. arboreum* and *G. harbaceum*
- Called as 'desi' cotton
- New world cotton 'D' genome
- *G. barbadense,(Egyptian) G hirsutm* (American) are New world cotton

Cultivars and hybrids

- Lot of work on varietal improvement as early as 1900
- Hybrids are available at plenty
    - Hirsutum varieties are famous
        - MCU series
            - MCU 5, 7, 9, 10, 11, 12
        - LRA 5166
    - Arboreum
        - K 9, 10, 11
    - Barbedense
        - Suvin (Anjali), Surabi
    - Hybrids
        - Jayalakshmi, TCHB 213, HB 224,

The plant

- Root
    - Tap root system
    - Grows more than 1.6 m
- Shoot and branches
    - Monopodium and sympodia
    - It is similar in all except arboreum
        - In arboreum growth continues in monopodium
- Leaf
    - Spirally arranged on the main stem
- Fruiting structure
    - Begins as flower bud or square
    - After flowering t becomes a fruit called boll

Growth stages

- Germination phase -4-7 days
- Early vegetative phase
- Squaring- it may be from 35-70DAS depending upon
    - The variety
    - Location and
    - Management
- Flowering
    - 20-35 days after first square formation

    - It continues for 60-80 days
    - However peak flowering is 70-100 DAS
- Boll development
    - Within 15-18 days boll attains 90% size
    - Mature size is attained within 25 days
    - Cotton fibre develops from the outermost cells of the seed-coat
    - Fibre elongation is complete by day 21-24
    - Secondary wall thickening strengthens the fibre and continues up to 30-40 days after anthesis

Climate

- A mean average temp of <15°C for crop growth
- Optimum temp for vegetative growth is 21°C
- For fruiting a day temp of 27-30°C with large diurnal variation
- Frostless period of 180-200 days
- Well distributed seasonal rainfall
- Open sunny weather

Soils

- A soil to a depth of not less than 60cm
- Sandy, sandy loam, black soils
    - When the rainfall is heavy - a coarse textured soil
    - When moisture is problem then clay soil

Season

- North Zone
    - 1st week of May
    - For the new varieties 3rd week to 1st week of June
- Central zone
    - 3rd week of June to 1st week of July
    - Irrigated may start from March
- Southern zone
    - June in Karnataka
    - Jun / July in red soil of AP
    - August in TN

Field preparation

- Fine tilth is not a pre-requisite
- Application of FYM / compost
- Chiseling may be to break hard pan
- Forming ridges and furrows is ideal

Spacing and seed rate

Variety / Hybrid	Spacing	Seed - Fuzz	Seed- Delinted	Seed Naked
MCU5, 9, 11, SVPR 2, LRA 5166	75 x 30	15	7.5	-
KC 2	45 x 15	20	15	-
SUVIN	90 x 45	-	-	6
Jayalakshmi, HB 224, TCHB 213	120 x 60	3.75	2.5	-
MUC 7, SVPR 1, ADT 1	60 x 30	15	7.5	-

Sowing

- Dibble the seeds at 3cm depth
- No of seeds
    - Fuzzy seeds
        - Hybrids - 2
        - Varieties -3
    - Delinted seeds
        - Hybrids – 1
    - Varieties - 2

In organic fertilizer – kg /ha

Variety / Hybrid	**N**	**P_2O_5**	**K_2O**
MCU5, 9, 11, SVPR 2, LRA 5166	80	40	40
MUC 7, SVPR 1, ADT 1	60	30	30
SUVIN, Jayalakshmi, HB 224, TCHB 213	120	60	60

- P & K as per soil test
- Time of application for Group I & II
    - ½ N + P+K basal
    - ½ at 40-45 DAS
- For Group III
    - N as three equal splits as basal, 40-45 and 60-65 DAS
- If the previous crop if heavily fertilized (for crop like ragi) reduce N level by 25%
- If basal not applied fertilizer may be applied at 25th DAS
- Application of 'azospirillum' saves 25% N requirement

Weed management

- Herbicide application
    - Pre-emergence application of
        - Fluchloralin 1.0 kg
        - Pendimethalin 1.0 kg
    - Hand weeding at 30-45 DAS

Irrigation

- Cotton can be irrigated at
    - 75% depletion available soil moisture in clay
    - 50% ASM at sandy loam soils
- Early irrigation is important to have proper plant growth
- An mild stress before flowering is advantageous
- After flowering very crucial
    - Deficit results in fruit abscission
    - Excess leads to excess vegetative growth
- Methods of irrigation
    - Flooding through furrows
    - Surge may be followed
    - Drip fetigation is also possible

After cultivation

Thinning and gap filling

- Gap filling on 10th day

- Seedlings raised from by polyethylene bag may be useful
- Thin the seedlings to single plant on 15th day

Earthing up

- Digging and earthing up is essential for soil aeration

Nipping

- If monopodia continues more than 15 nodes

Harvesting

- Hand picking is usual practice
- Strippers – spindle or brush type is used in developed countries
  - Periodical
  - Early morning
  - Without bracts or with minimum
- May be machinery
  - Method of sowing needs change
  - Varietals preference
  - One time harvest
  - Weather at maturity (RF) plays vital role
- Seed cotton should be collected from fully opened bolls
- After harvesting should be dried in clean threshing floor
- Should not be mixed with other varieties
- Hand picking and cleaving the pest infected kapas will enhance the quality

Quality parameters

- Ginning percentage
- Color
- Trash
- Fibre quality
- Fibre length
- Fibre fineness
- Fibre sterngth
- Spinning performance
- Oil content (14-26%) of the seed etc.
  - Absence of gossypol, gossy purprin, gossy pulvin

Very Important management

- Pests and disease control

Cropping system

- Rainfed areas
  - Mono cropped
  - Mono with mixed crops
    - Pulses, millets, groundnut
- Irrigated
  - Cotton – wheat
  - Cotton – pulse – millets
  - Rice - cotton

Rice fallow cotton

- It is cotton cultivated in rice fields immediately after the harvest of rice when the field is in waxy condition when the season is optimum.
- No field preparation is needed to sow the crop.
- It may also be called minimum tillage crop.
- Management of previous rice crop including land leveling, P & K management, weed management, water management, and height of harvest of rice stubbles etc decides the efficiency and growth characters of cotton crop.
- Season
    - Jan 15th –Feb 15th
- Field
    - Immediately after the harvest of rice
    - Sowing at waxy soil condition
- Season
    - Jan 15th –Feb 15th
- Field
    - Immediately after the harvest of rice
    - Sowing at waxy soil condition
- Varieties
    - MCU 7, SVPR 1, ADT 1 LRA 5166
- Spacing
    - 60 x 30 and (75 X 30 for LRA)
- Fertilizers
    - 60:30:30
- Gap filling and thinning
    - Gap filling from 7th day onwards
    - Thinning on 15th day
    - Hand weeding around the plant
        - From 15th day
- Digging the rows and earthing up
    - From 21st day
- Irrigation
    - After drying of the soil dug between the rows
- Fertilizer application
    - Around 35th day
    - Followed by 1st irrigation
- Earthing up
    - Around 40th day after the moisture dried and soil loosened for second time
- 2nd irrigation may be around 50-60 DAS
- Plant protection
    - As per the need

Lesson 14
JUTE
Corchorus capsularis
C. olitorius

Importance

- Raw jute in the trade & industry refers both jute and meta
- It is one of the bast fibres in India
- Plays vital role in Economy
- Employment, industry, foreign exchange are three spheres
- States like WB, Bihar, Orissa & E. UP
    - 4 million small and marginal farmers are engaged
    - Labour intensive during processing
- It was tried an alternate to hemp
- Next to cotton
- Fibre for manufacture of packaging materials
    - Package materials to food grains, sugar, cement, fertilizers, cotton, salt, vegetables etc
- It is gaining importance again since there is awareness in eco-friendly
    - Meaning discouraging synthetic materials

Area, Production, Productivity of allied fibres of Jute – World (Million ha, tonne & t/ha)

Country	Area	Production	Productivity
India	0.96	1.66	1.73
Bangladesh	0.52	0.83	1.60
China	0.23	0.44	1.94
Thailand	0.09	0.13	1.45
Indonesia	0.01	0.01	1.00
World	1.93	3.27	1.69

Area, Production, Productivity of allied fibres of Jute – India (Million ha, tonne & t/ha)

State	Area	Production	Productivity
WB	0.57	1.192	2.10
Bihar	0.14	0.214	1.57
Assam	0.90	0.150	1.68
Orissa	0.01	0.002	1.58
India	0.96	1.660	1.73

Origin

- C. olitorius
    - Primary origin – Africa
    - Secondary origin – India
- C. capsularis
    - Indo-Burma

Capsularis vs Olitoius

Characters	Capsularis	Olitorius
Height	5-12 feet tall	5-15feet
Waterlogging	Can withstand	Normally Cannot
Duration	3-5 months	4-5 months
Stem	Cylindrical	Cylindrical
Branches	Branched or unbranched	Branched but less vigorous
Capsule	Rounded, 5 locular, seeds 7-10 in two rows in each locules, without transverse partitions, 35-40 in each fruit	Elongated, 5-6 locules, seeds 25-40 in single row in locule, with transverse partitions, 125-200 seeds/pod
Seed wt	300 seeds/g	500seeds /g

Climate

- Hot and humid climate
  - Temp 27 – 40°C
  - Humidity 65-90%
- Short day and low temp leads to
  - premature flowering in olitorius
- Jute growing areas are divided into zones
  - 9 Zones according to climate

Soils

- Well drained fertile light textured soil
  - for olitorius
- Heavy soils and wetland soils
  - for capsularis
  - Alluvial is more suitable for capsularis
- All soils except sandy and heavy clay

Season

- Best season for higher fibre yield is:
  - when the day is longer
  - In Northern hemisphere Mar- Sep
- Winter season is less favourable for fibre
- Jute seeds are sown anytime between March - May
- The crop prefers a hot & humid climate and low laying areas

Field preparation

- Deep ploughing
- Dry seed bed

Methods of sowing

- Broadcasting
- Line sowing by seed drill

Seed rate, Spacing, Plants

Jute type	Line sowing (kg)	Broadcasting (kg)	Spacing (cm)	Plants/m2 (No)
Olitorius	5	7	25 x 5	80

Capsularis	7	10	30 x 5	67

Varieties

Olitorius

- JRC 212, JRC 321, JRC 7447

Capsularis

- JRO 524, JRO 878, JRO 7835

Intercultural operations

- Raking
  - Or harrowing twice for broadcast crop
    - 5-6cm height and a week later
  - Raking improves tilth, reduces weed and thin the stand
- Hoeing
  - May be wheel hoeing for row cropping
- Weeding
  - 3-4 weeks after sowing, depending upon the intensity
  - Fluchloralin 1.5kg/ha sprayed 3 DAS

Manures and fertilization

- 5 t compost / FYM
- 20:20:20 N, P2O5 & K2O kg /ha
- For traditional area
  - N may be 40 kg in two splits
  - Basal plus top at 3-4 weeks after germination

Irrigation

- Generally rainfed
- Irrigation is needed id sown in March
  - One pre-sowing irrigation
  - Followed by 2-3 irrigations

Harvesting

- Any time between 100-150 days
- Better quality when harvested early
- Higher quantity if harvested later
- Ideal harvest when the crop is in small pod stage (120-135 days)
- The plants are cut close to ground with sickle
- Plants are cut from the bottom
- Leaves are stripped off from the top
- Accumulated in bundles

Retting

- Retting is the process of extraction of the fibre
- Bundles are then submerged in water for 7 to 10 days
- Retting takes place due to joint action of water, aquatic and plant surface organisms, mostly bacteria
- The cambium and the cortex gets decomposed

Stripping

- The labourer holds the stem in one bunch and taps the rood end lightly with a mallet.
- This frees the fibre at the foot of the stalk.

- The fibre is then grasped & by lashing & jerking the stem in the water the rest of the fibre loosens and comes off

Drying

- Jute fibres are kept hanging on makeshift hangers for drying
- This process takes about 2 to 3 days
- Now the fibre is ready to be marketed. Here Grading becomes imperative depending on the fineness, color, density, clearness etc, they are all score. Higher the score the better the price.

Grading

- Jute is then brought to JCI godowns
- The bundles are scanned and jute fibres are categorized as per grades (TD1 to TD7)
- Grade wise these are stocked at separate locations

Pressing

- Grade wise bundles are subjected to machine press to convert them in Bales
- Even the ropes used to tie the bales are prepared from the jute wastes
- The bales are finally stored in the warehouse as per their grades for sale

Cropping Systems

- Followed with rabi season winter crops
- Wheat, rice, millets, chickpea etc

Lesson 15
MESTA
Hibiscus cannabinus
H. sabdarffa var. altisima

***H. cannabinus* (HC)-**

- Also called Kenaf

***H. Sabdariffa* (HS)**

- Roselle, Roselle hemp, Java jute, Thailand mesta

- In India both are called as Mesta
- Both are long vegetable fibre
- Closely allied to jute fibre
- HC Mesta
  - Yields better quality fibre
  - Sown in May
- HS Mesta
  - Rainfed sown in June to July middle
  - Sown in AP, Maharastra,, Karnataka & TN

Crop Management

- Almost same as that of jute
- Seed rate 18-20kg
- Spacing 30 cm between rows
- Broadcast application and laddering after sowing
- Thinning and removing the weeds by intercultural operations
- Can tolerate drought but not flood
- N may be up to 40 kg in 2 splits
- Harvest at 50% flowering for quality
- 1.5 to 2.2 t / ha of fibre yields

AGVAVE

- Sisal is an aloe-like plant from the Agaves family
- The plant grows semi-arid regions
- provides a substantial source of income to the local communities
- The fibre is strong, rough, yet smooth
  - weave directly into baskets,
  - hat, sisal mat, sisal wall-hanging, sisal lampshade
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Lesson 16

TOBACCO

Nicotiana tabacum

Origin

- May be from America
- Christopher Columbus in 1492
  - Carried some dried leaves to Spain?
- But some others believe
  - 1560 a Spanish physician brought as medicine
- Jean Nicot, French Ambassador to Portugal introduced from Lisbon to French
- The botanical name Nicotine have been derived from his name
- In India introduced only in 17th Century

World Scenario (Figures in Million ha and tonne)

Country	Area	Production	Productivity
China	1.44	2.52	1.75
India	0.45	0.64	1.42
USA	0.30	0.74	2.43
World	4.45	7.07	1.59

Indian Scenario - 1998–(Figures in Million ha and tonne)

State	Area	Production	Productivity
AP	0.20	0.19	0.98
Gujarat	0.11	0.18	1.66
Karnataka	0.07	0.06	0.87
UP	0.02	0.15	6.83
Bihar	0.02	0.01	0.72
WB	0.01	0.01	0.57
TN	0.005	0.008	1.46
India	0.45	0.64	1.42

- Classification
  - Nocotiana is broadly classified in to three sub-groups
    - rustica
    - tabacum
    - Petunioides
  - In India tabacum is widely cultivated and discussed here

	Type	**Area**
1	FCV (Flue cured Virginia)	AP, Karnataka
2	Bidi	Gujarat, Karnataka,
3	Cigar & Cherrot	TN, WB
4	Hookah	Assam, WB, Bihar, UP, Punjab
5	Chewing & snuff	TN, WB, Bihar, Assam, UP, Punjab
6	Natu, Burley, Lanka, HDBRG	AP
7	Pikka	Orissa

Tobacco varieties cultivated in TN

- Cigar & Binder
  - Vellaivazhai (VV 2)
  - Kuruvazhai (KV 1)
- Country cheroot
  - Narrow leaf Oosikappal ((I 737)
  - Broad leaf Oosikappal (OK 1)
- Chewing tobacco
  - Sun cured
    - Monnai (I 64)
    - Vazhaikappal (I 115)
    - Vaadamugam(VD 1)
    - Vattakkappal (VKT 1)
    - Vedaranyam (VR 2)
  - Smoke cured
    - Periya vaadamugam (PV 7)
  - Pit cured
    - Vattakkappal (VTK 1), Vadamugam (VD 1)

Climate

- It is tropical in origin but successfully grown in temperate also
- 100-120 day frost free days
- Average temp of 26°C
- Sensitive Waterlogging
- Rainfall / irrigation during active vegetative growth is essential

Season

- Rabi planting
  - 1st Fortnight of October
  - In Vedaranyam after 15th Dec
  - In Andra Pradesh
    - Mid Oct to Mid Nov
    - Early sowing ends with heavy rain

Nursery

- Well drained soil / raised bed
- 2.5m-2 for 1.0g seed
- 1.0g seed contains 10,000 seeds
- Seeds to seedling is very wide (10 :1)
- To transplant 20,000 seedlings 200,000 seeds in 50m-2 is more than sufficient
- Farmers use more than this area and seed rate
- Rabbing the nursery soil to prevent pest and disease is essential
- Manuring the nursery
- Irrigation by rose can
- Seedling age
  - 7 weeks old
  - Pull out seedlings are pencil thickness
  - After pulling out selected seedlings top dress the remaining seedlings

Field preparation

- Soils of well drained
- Deep summer ploughing
- Ridges an furrows
- Apply heavy FYM 25 t/ha before last ploughing

Spacing

- Chewing tobacco
  - 75 x 75 (17,777 plants/ha)
- Cigar tobacco
  - 75 x 50 (26,666 plants/ha)
- Cheroot tobacco
  - 60 x 45 (36,730 plants/ha)

Planting

- Transplant single seedlings of pencil thickness
- Irrigate the field prior to planting
- Make a hole and plant
- Cool hours or evening is preferable
- Gap filling within 7-10 days

Manuring

- N 100 kg/ha as Ammonium sulphate
  - If brackish water restrict to 75kg
  - 50% on 45th day and 50% 60 DAP
- Phosphorous
  - 100 kg P2O5 as SSP at planting
- Potash
  - Chewing – 50 kg K2O
  - Cigar & Cheroot – 100 kg K2O
    - In two splits along with N

Weeding and Intercultural operations

- Hand weeding three weeks after transplanting
- At 45 DAT soil mulching to make the ridge flat
- A week later deep furrowing to heavy irrigation at Grand growth period

Control of Orabanche

- Remove as and when shoot appear
- Removed shoots are to be burnt
- Trap crops
  - Greengram, gingelly, sorghum
- Chemical weed control
  - Fluchloralin @ 1.0 l/ha or
  - Oxyflourfen 0.5 l/ha
  - as pre-plant incorporation a week prior to planting

Toping

- Chewing tobacco: Top, leaving 10 leaves

Desuckering

- Removal of side shoots manually at weekly interval

- Application of neem oil emulsion at 35% after topping completely suppresses the suckers
- Neem oil 1.75 l + sandivit 0.5 l + water 2.75 l is needed for 1000 plants

Maturity & harvest

- Bulging of the intervenial portions of the leaf
- Appearance of brown spot on the leaves
- Cut the plant in the afternoon and allow it to wilt overnight

Cropping systems

- Mono-cropping is discouraged
    - Crop rotation helps to maintain the soil fertility
- Intercropping is possible
    - Onion and coriander (greens) are more suitable

POST HARVEST TECHNOLOGY FOR TOBACCO

Tobacco curing methods

- Curing is a carefully controlled process used to achieve the texture, colour and overall quality of a specific tobacco type. During the cure, leaf starch is converted into sugar, the green colour vanishes and the tobacco goes through colour changes from lemon to yellow to orange to brown like tree leaves in autumn. There are four main curing methods.

Flue-cured Tobacco

- The most common curing process is known as flue-curing
- Used mainly in the manufacture of cigarettes, the most common type of flue-cured tobacco is Virginia
- This tobacco is also known as 'bright tobacco' because the heat-drying process gives the leaves a bright, golden colour
- Originally from the south-eastern U.S. state of the same name, it is today the most grown tobacco variety in the world
- Flue-cured tobacco is dried in a closed building with furnace driven heat directed from flues or pipes that extend from a furnace into the barn.
- The temperature of the furnace is gradually raised until the leaves and stems are completely dried.
- Flue-curing takes about a week and fixes the natural sugar of the leaf, which has a high sugar and a medium-to-high nicotine content.
- Today, many farmers find that bulk curing flue-cured tobacco is far more cost-effective.
- Racks of tobacco are placed in bulk barns where heat and ventilation are controlled while air is forced through the leaves.
- Flue-cured varieties require warm weather, humidity, light rainfall and a sandy, loam soil for their four-month growing season.

Air-cured Tobacco

- Some tobacco leaves are air-cured following their harvest.

- Air-cured tobacco is traditionally cured hanging in structures with a roof, but with open sides to allow air to freely circulate.
- As with flue-curing, the aim of air-curing is the timely removal of moisture from tobacco leaves. This process takes four to eight weeks:
- If cured too fast, the leaf will become patchy, if cured too slowly, the leaf will rot away.
- Commonly, air-cured tobacco is subdivided into dark air-cured and light air-cured tobacco.
- Burley is the second most popular tobacco in the world, belonging to the light air-cured variety.
- Burley, also known as White Burley tobacco, is primarily used to make cigarettes and aromatic blends, whereas dark air-cured tobaccos are mainly used in the production of chewing tobacco and snuff.
- Burley is a slightly smaller plant than the flue-cured Virginia type, but with similarly broad leaves.
- Once picked, its leaves are dried naturally – or ‘air-cured' – without the use of extra heat.
- This gives the leaves a light brown to mahogany appearance and very low sugar content.
- Burley tobaccos are somewhat cigar-like in taste and appearance, lending themselves to the production of flavoured, blended cigarettes commonly referred to as "American".
- Burley tobacco can be grown in limestone soils and requires only light fertiliser.

Fire-cured Tobacco

- Although curing methods may vary, all fire-cured tobaccos are subjected to wood smoke to dry the leaves. It is the type of wood used to smoke the tobacco leaves and the amount of smoke exposure that gives fire-cured tobacco leaves their distinctive flavours.
- Fire-cured tobacco, generally darker in colour, is used mostly for pipe tobacco mixtures, snuff, and chewing tobacco and has a low sugar but high nicotine content. Fire curing uses an enclosed barn similar to that used for flue-curing. Small fires are built on the floor, and the leaves cure in a smoke-laden atmosphere. Whereas flue-curing takes about a week, fire curing, using far lower temperatures, may take from a few days up to 4 weeks.
- Fire-cured tobacco is dried with low-burning wood fires on the floors of closed curing barns. The leaves have low sugar content but high nicotine content. Fire-cured tobacco is a robust variety of tobacco used as a condimental for pipe blends, cigarettes, chewing tobacco, snuff and strong-tasting cigars.

Sun-cured Tobacco

- A comparatively small amount of tobacco is sun-cured. Leaves are exposed to the sun to remove most of their moisture before being air-cured to complete the process. Of all sun-cured tobaccos, the best known are the so-called Oriental tobaccos of Turkey , Greece , Yugoslavia , and Balkans.

- A more labour-intensive product to harvest, Oriental tobacco is characterised by high aroma from small leaves, being low in both sugar and nicotine.
- The leaves are mostly sun-cured. Usually, the larger the leaf, the milder the aroma. Hence Oriental tobacco is regarded as expensive to harvest by many tobacco manufactures. Oriental tobaccos are often grown in poorer soils in southern Europe and the Middle East.

Grading

- Whereas after other curing processes tobacco is exposed to air to standardise the moisture content of the tobacco or "redry", Oriental tobaccos are stored in bales and allowed to ferment. After storage, moisture is added to this type of tobacco. Pure – Turkish cigarettes contain 100% unblended Oriental tobacco – or blended, Oriental tobacco is mostly used in cigarettes, cigars, pipe, snuff or chewing tobacco.
- After curing, the farmer grades the leaves into different leaf positions, qualities and colours and packs his grades into what is known as a farmer bale of 30-50kg. He then takes his bales to a buying centre or auction for sale.